Beyond Dividing the Pie: Multi-Issue Bargaining in the Laboratory*

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Abstract

We design a laboratory experiment to study bargaining when parties need to agree on multiple issues. We find that bundling—the ability to make price offers on combinations of issues rather than separately—is critical for reaching agreement. We also find that giving bargainers access to more information about each other's valuations and costs does not raise efficiency, because the boost in agreement rates in small-surplus negotiations is offset by increased risk-taking and conflicting fairness preferences in large-surplus negotiations. Finally, we show that successful negotiations are characterized by an alternating offer structure, which emerges endogenously. It involves offers that split the difference between the two most recent demands, and it displays a higher probability of agreement vis-à-vis other formats of bargaining observed in our data.

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1 Introduction

Bargaining and negotiations are at the core of modern market economies. In the economic literature, the typical environment is one where a buyer and a seller bargain over the terms of trade for a single object—often referred to as *dividing-the-pie* bargaining.[1] This benchmark case can be extended in different directions to better understand negotiations as they occur in daily life. In this study, we are interested in situations where bargaining revolves around *multiple* issues. Labor contracts make for a textbook example. While the wage is a central component, modern labor contracts are multifaceted and involve attributes such as bonus payments, flexible work hours, remote work, and employee perks. Other instances of multi-issue bargaining are international tariff and climate change negotiations (Nordhaus, 2015; Bagwell et al., 2020), procurement (Engelbrecht-Wiggans et al., 2007), supply-chain contracting (Davis and Hyndman, 2018), hospital-supplier bargaining (Grennan and Swanson, 2020), and legislative decisions (Baranski et al., 2020).

Unlike dividing-the-pie bargaining, multi-issue bargaining requires parties to determine which issues to include and which to exclude from an agreement (e.g., Fisher et al., 1981; Bazerman and Neale, 1993). Put differently, in addition to discovering a mutually acceptable price, bargainers need to negotiate the *scope* of an agreement. This makes multi-issue bargaining more complex. But parties also have more flexibility. They can bundle issues together, leverage some issues to reach a better deal on others, or leave out issues that seem to preclude agreement. While bundling plays a central role in, for instance, monopoly pricing (e.g., Stigler, 1963; Crawford and Yurukoglu, 2012), multi-unit auctions[2] (e.g., Klemperer, 2002; Engelmann and Grimm, 2009), or agenda-setting (e.g., Inderst, 2000; Lang and Rosenthal, 2001), it is relatively unexplored in the context of bargaining. We fill this gap in the literature by examining the impact of bundling in multi-issue bargaining. We ask: Is it critical for efficiency that bargainers can make price offers on combinations of items or is it sufficient to bargain over issues individually? What negotiation strategies do bargainers adopt when bundling is possible?

The second key change between single- and multi-issue bargaining is the range of possible information structures. With a single issue, bargainers' valuations for the object are either private information or known. A rich theoretical and empirical literature (see footnotes 1

[1] When information is complete, these models are studied extensively, ranging from the case of a take-it-or-leave-it offer (e.g., Güth et al., 1982; Binmore et al., 1989) to alternating-offer bargaining. In the latter, predictions reflect the patience of the bargaining parties while, in theory, still generating immediate and therefore efficient agreement (e.g., Stahl, 1972; Rubinstein, 1982). When information is incomplete, inefficiency typically prevails (e.g., Chatterjee and Samuelson, 1983; Ausubel et al., 2002).

[2] Though there are obvious differences between multi-item bargaining and auctions (e.g., collusion), a common question is whether package bidding/bundling can improve performance. Brunner et al. (2010) find an affirmative answer, but the evidence is not fully conclusive (Matoušek and Cingl, 2018). Goeree and Holt (2010) study how to design package bidding in computationally manageable ways.

and 5, as well as the discussion around Contribution 2 below) examines how information affects bargaining outcomes. Naturally, we are interested in the effect of information also in the multi-issue context. With multiple issues, however, there are new, qualitatively distinct information structures. Particularly, we study an *intermediate information* structure in which valuations/costs for individual issues are private information, but where the *aggregate surplus* of an agreement (the sum of the gains from trade over all issues) is known to both parties. We ask: How valuable is intermediate information? Does it result in significant changes in agreement rates and efficiency compared to when valuations are private information? Does bargaining behavior change in the theoretically expected ways when moving from private over intermediate to complete information?

Overall, the multi-issue setting raises important questions centered around which bargaining protocols and information structures can foster beneficial exchange. To shed light on these questions, we study multi-issue bargaining in a laboratory experiment. This allows us to test recent theoretical predictions in a controlled fashion. It is also a natural next step in the literature, given the fruitful exchange between (single-issue) bargaining theory and experiments in the past four decades.

Experimental framework: Our experiment features an unstructured bargaining setting in which subjects can continuously make, accept and reject offers. Negotiations involve three issues, which we call items. In expectation, 50% of the items contain a positive surplus such that bargainers must figure out which items should or should not be traded. Across treatments, we vary the information structure: *No Information* (private valuations/costs), *Intermediate Information*, and *Complete Information*. We also vary the bargaining protocol through which people interact: *Bundling*, where price offers can be made on any combination of items, versus *Item-by-Item*, where price offers are made separately for each item.

Motivation for intermediate information: Intermediate information—private valuations for individual issues but a known aggregate surplus—is a natural case to focus on. Bargaining theory predicts that the willingness to incur time and effort costs, e.g., forgone outside options or travel costs, reveals information about the aggregate surplus (e.g., Fudenberg and Tirole, 1983; Cramton, 1991; Bochet and Siegenthaler, 2021). In a single-issue setting, the aggregate surplus is given by the surplus of a single item. In a multi-issue setting, however, information about the aggregate surplus may not reveal much about valuations/costs for the different items.

A familiar example of the intermediate information structure is when a dean negotiates an offer with a prospective faculty hire. Both parties typically have a common understanding of the value created were the relationship to be formed. Yet, asymmetry of information prevails. The researcher is unaware of the dean's ability to adjust the offer on different issues, e.g., salary, teaching load, or competitive benefits. The dean is unaware of the desirability of each of these issues to the researcher. It is also apparent why bundling can be a useful negotiation tool: It allows parties to connect, for instance, a salary-related request with another issue such as the teaching load.

A recent experiment by Jackson et al. (2020) also examines multi-issue bargaining, focussing on the number of items in a negotiation and communication. In contrast, we study the richness of the bargaining protocol and the effect of different information structures in multi-issue bargaining. Jackson et al. (2020) show that, for certain distributions of valuations/costs, information about the aggregate surplus is revealed endogenously, thus further indicating that intermediate information is a key case to consider.

Finally, the intermediate information structure also bears a direct connection to the negotiation literature, specifically to the concept of value creation (e.g., Fisher et al., 1981; Frankel, 1998; Bac, 2001; Susskind, 2014), see also Baranski (2016, 2019). There, the idea is that negotiation parties, perhaps implicitly, follow a two-step procedure. They first create value by establishing a common understanding of the aggregate surplus, for example by exploring the scope of issues that can be included in an agreement. It is only then that they engage in distributive bargaining. The intermediate information structure can thus be nicely interpreted as the point where negotiations transition from a phase of value creation to value claiming.[3]

Theory: Our hypotheses for behavior in the different treatments are based on the existing theoretical bargaining literature. It is well-known that the no information treatments preclude efficiency, because incentive constraints cause trade failures for small-surplus items (e.g., Myerson and Satterthwaite, 1983; Chatterjee and Samuelson, 1983). Theoretically, trade failures should be mitigated under complete information—although the data will reveal that this is not true due to increased risk-taking and conflicting fairness preferences. The predictions for the intermediate information structure are remarkable: All weak Perfect Bayesian equilibria are efficient, but only when the bargaining protocol allows for bundling of issues (Jackson et al., 2016, 2020). That is, achieving efficiency is possible even without information about individual issues, but it requires a sufficiently rich bargaining protocol.

We highlight three key broad contributions of our study to the bargaining literature.

Contribution 1: *Importance of bundling and the equivalence of intermediate and complete information.* We show that in the presence of multiple issues, bundling is key for reaching agreement. Specifically, we find that when the bargaining protocol allows for bundling, agreement rates under intermediate information are nearly identical to those under complete information and significantly different from those under no information. The

[3]Formal bargaining theory offers elegant models for the value claiming phase but the formalization of the value creation phase remains a largely unexplored open question.

same does not hold when bundling is not available. Stated differently, only when the bargaining protocol is sufficiently rich is intermediate information enough to eliminate trade failures caused by information asymmetry. While these effects are in line with the theory our experiment is designed to test, our data demonstrates empirically how bundling enables coordination of offers across issues to circumvent information asymmetry. We also uncover important deviations from theory, specifically that offers are more aggressive for bundles than for individual items.

Contribution 2: *Behavioral cost of better information.* We find surprising evidence that giving bargainers access to more information about each other's valuations and reservation costs does *not* raise efficiency. On the one hand, better information (i.e., intermediate information and complete information) often promotes agreement rates in small-surplus negotiations, where incentive constraints can preclude trade under incomplete information.[4] However, more information has a *detrimental* effect on trade in large-surplus negotiations, because it induces increased risk-taking and conflicting fairness preferences (e.g., Crawford, 1982; Roth et al., 1988; Embrey et al., 2015; Fanning, 2016; Fanning and Kloosterman, 2019). Indeed, in the complete information treatments, we observe a strong correlation between subjects' elicited fairness/risk preferences and inefficiency. On balance, in terms of efficiency, the two countervailing effects that occur with improved information cancel each other out.[5]

This contribution is consistent with and further illuminates the mechanisms documented in Larsen (2020), who studies bargaining in the wholesale used-car industry. There, bargaining can occur subsequent to an auction, which allows the estimation of bounds on agents' valuations based on the auction outcome. He estimates that the ex-ante and ex-post efficient outcomes lie close to one another such that information asymmetry should not stand in the way of efficiency in this market. Actual bargaining outcomes, however, fall short of full efficiency by 12-23%, suggesting that inefficiency is caused by behavioral factors and the specific equilibria agents play. Both the cause and magnitude of inefficiency that Larsen (2020) documents is in line with our findings for the complete information treatments. We show, additionally, that when there is less information (the ex-ante and ex-post efficient outcomes lie further apart), the magnitude of inefficiency does not change. But the *source*

[4] This is in line with a large experimental literature exploring one-sided (e.g., Forsythe et al., 1991; Cason and Reynolds, 2005; Bochet and Siegenthaler, 2018; Camerer et al., 2019) and two-sided (e.g., Valley et al., 2002; Ellingsen et al., 2009) incomplete information bargaining.

[5] Experiments on single-issue bargaining have documented extensively the importance of behavioral factors; see e.g., Roth (1995), Cooper and Kagel (2016), Fehr and Schmidt (1999), Bolton and Ockenfels (2000), and Andreoni and Miller (2002). Most closely related to our Contribution 2 is Babcock et al. (1995), who show that an increase in surplus affects agreement rates negatively under complete and positively under incomplete information, although in their setting not to the point where incomplete information is as efficient as complete information.

of the trade failures changes, from risk/fairness preferences under complete information to binding incentive constraints under incomplete information.[6]

Contribution 3: *Endogenous emergence of alternating-offer bargaining.* A remarkable feature of our data is that alternating-offer bargaining emerges endogenously. That is, despite our unstructured bargaining setting where offers can be made in any order and timing, most offer sequences exhibit an alternating-offer pattern. In addition, bargaining pairs that alternate offers are significantly more likely to reach an efficient agreement. We provide two further noteworthy behavioral regularities. First, bundled offers are consistently characterized by more aggressive demands than single-item offers, which contrasts with the theoretical predictions. Second, we show that concessions frequently correspond to split-the-difference offers, which are offers that meet the other party's most recent demand halfway. Such offers are also instrumental in reaching agreement.

The latter result on split-the-difference offers corroborates Backus et al. (2020), who document an identical pattern for eBay's Best Offer platform (single-issue bargaining). That we find the same behavior in the lab is remarkable and speaks to the robustness of the finding, particularly because we observe it for single-item offers and bundles as well as in all information structures that we study. Because eBay's Best Offer platform by design features alternating-offer bargaining, the endogenous emergence of alternating offers in our data cannot be observed in or compared to Backus et al. (2020).

It is often understood that the details of the bargaining institution through which individuals interact can greatly affect efficiency and the distribution of payoffs. Our results offer interesting insights for empirical market design by highlighting the details that matter. Contribution 1 shows that when negotiations are complex (captured through the number of issues), bargaining institutions that allow for bundling promote agreement rates. Contribution 3 shows that when it comes to the rules governing who can make an offer when, a more laissez-faire approach to the design of the institution may still achieve positive outcomes: Bargaining tends to be characterized by alternating offers even in an unstructured environment and alternating offers facilitate exchange. Our results thus also confirm the salience of the alternating-offer game (Stahl, 1972; Rubinstein, 1982) as a workhorse model of bargaining.

Our experiment also bears useful implications for information design. Contribution 2 in particular demonstrates the benefits *and* costs of better information. Remarkably, reducing information asymmetry may backfire when surpluses are large. When giving bargainers

[6] In the field, it is difficult to manipulate information or to even know agents' valuations. This is both highlighted and partly circumvented in Larsen (2020) and Ambrus et al. (2018). The latter study the cause of bargaining delay using a historical data set of captives ransomed from North African pirates. Their data contains the amounts of earmarked money that the captive's friends and relatives collected for rescuing the captive, which is used as a proxy for the ransoming teams' valuation for freeing the captive.

access to more information is desirable—for example, when individuals have difficulties identifying mutually profitable terms of trade due to relatively small surpluses—Contribution 1 shows that revealing information about the aggregate surplus of an agreement (as opposed to information about individual issues) may often be enough. This is a valuable insight, because going from private information to intermediate information may be easier to achieve than going all the way to a situation with complete information.

The remainder of the paper is organized as follows. Section 2 discusses the theoretical background. Section 3 presents the experimental design. In Section 4, we present the empirical results. Section 5 provides two robustness checks. Finally, Section 6 concludes.

2 Theoretical Background

We consider bargaining between two agents, a buyer and a seller, who negotiate a deal involving a set of items $N = \{1, 2, \ldots, n\}$. The buyer has a valuation v_i for each item $i \in N$, drawn from a finite set $V \subset \mathbb{R}$ according to a probability mass function f. The seller has a reservation cost c_i for each item $i \in N$, for simplicity also drawn from f.

Time advances in discrete periods $t \in \{0, 1, \ldots\}$. In each period, the proposer offers a finite number of offers, where an offer (K, p_K) consists of a set of items $K \subseteq N$ and a corresponding price p_K at which the set of items is traded if the offer is accepted. If bundling is possible, an offer can include all possible subsets of items; if bundling is not possible, an offer is for a single item, i.e., $|K| = 1$. The responder observes all offers and chooses which ones to accept, with the obvious restriction that two offers containing the same item cannot both be accepted.

There are time frictions. After any period, the next period is entered with probability $\delta \in [0, 1)$, otherwise the bargaining process stops. Let $\mathcal{K}$ be the set of accepted offers when the bargaining process stops. For a given offer (K, p_K), let $v_K = \sum_{i \in K} v_i$ and $c_K = \sum_{i \in K} c_i$, respectively, be the sum of the buyer's valuations and the seller's reservation costs over the items in K. The payoffs realized when bargaining concludes are $\Pi_B = \sum_{K \in \mathcal{K}} (v_K - p_K)$ for the buyer and $\Pi_S = \sum_{K \in \mathcal{K}} (p_K - c_K)$ for the seller.

The presence of multiple items introduces information structures that lie between the interim (private values) and ex-post (complete information) stage. In particular, even with significant uncertainty over valuations and costs for individual items, agents can be informed about the potential total surplus of an agreement. Let the possible surplus from item i be denoted by $S_i = \max(v_i - c_i, 0)$. Correspondingly, the aggregate or *total surplus* over all items is $TS \equiv \sum_{i \in N} S_i$. The following theorem due to Jackson et al. (2020) states a key prediction for our experiment.

Theorem 1 *Consider a multi-issue bargaining problem with a commonly known total surplus* $TS > 0$*: (i) if bundling is possible, then in all weak perfect Bayesian equilibria*[7] *agreement is reached immediately and the full surplus is realized. Moreover, the distribution of payoffs is the same as in complete information bargaining; (ii) if bundling is not possible, then all equilibria are inefficient.*

Theorem 1 predicts that the value of information about the total surplus in promoting agreement rates depends on the availability of bundling. Notice that we did not specify whether the initial proposer is the buyer or the seller, and how proposer roles change over time. The theorem holds for all cases. For example, if the total surplus is commonly known, bundling is possible, and the buyer is the proposer in all periods, then an immediate agreement is achieved allocating the entire surplus to the buyer. If players alternate in making offers, the initial proposer's payoff equals $\frac{TS}{1+\delta}$ and the responder's payoff equals $\frac{\delta TS}{1+\delta}$, equivalent to the outcome predicted in complete information alternating offers bargaining (Rubinstein, 1982). If the first player makes a take-it-or-leave-it offer (i.e., $\delta = 0$), the proposer's payoff equals TS and the responder's payoff equals 0.

We present an example to demonstrate the role of bundling and a commonly known total surplus in multi-issue bargaining.

Example 1 *There are three items: A, B and C. For each item, the buyer's valuation and the seller's cost are drawn from the uniform distribution on* $[0, 1]$*. The buyer makes a set of take-it-or-leave-it offers to the seller, i.e.,* $\delta = 0$*. Suppose the buyer's realized valuations are* $(v_A, v_B, v_C) = (0.5, 0.5, 0.5)$ *and the seller's reservation costs are* $(c_A, c_B, c_C) = (0.4, 0.9, 0.4)$*. The total surplus of* $TS = 0.2$ *is realized when items A and C are traded and item B is not traded.*

(i) Item-by-Item & Unknown Total Surplus: *When bundling is not possible and the total surplus is not known, the buyer's maximization problem is given by* $\max_{p_i} Prob[c_i \leq p_i] \times (v_i - p_i) = \max_{p_i} p_i(v_i - p_i)$ *for each item i. This corresponds to three separate single-issue problems, as bundling is not possible and no aggregated information is available. The solution is* $p_i^* = v_i/2$*, which in our example implies that the optimal set of offers is* $(\{A\}, 0.25)$*,* $(\{B\}, 0.25)$*,* $(\{C\}, 0.25)$*. Note that the seller will not accept any of these offers. Bargaining is inefficient.*

(ii) Bundling & Unknown Total Surplus: *The buyer's optimal set of offers when bundling is possible but the surplus is unknown is given by* $(\{A\}, 0.25)$*,* $(\{B\}, 0.25)$*,* $(\{C\}, 0.25)$*,* $(\{A, B\}, 0.67)$*,* $(\{A, C\}, 0.67)$*,* $(\{B, C\}, 0.67)$*, and* $(\{A, B, C\}, 1.12)$*. The opti-*

[7] A weak perfect Bayesian equilibrium is a strategy profile and a consistent belief system for which the strategy satisfies sequential rationality. A belief system is consistent if beliefs are generated from the strategy profile through Bayes' rule whenever possible (i.e., for any history that is reached with positive probability).

mal offers follow the same logic as in case (i) except that the buyer can also offer bundles.[8] *The offered price for the efficient bundle* $\{A, C\}$ *of 0.67 falls short of the seller's reservation cost of 0.8. Bargaining is again inefficient. However, if the reservation costs of the seller were lower, e.g.,* $c_A = c_C = 0.3$*, then the efficient bundle would be traded in case (ii), while the offers on single items in case (i) would still be too low to generate trade. That is, bundling can potentially promote efficiency.*

(iii) Item-by-Item & Known Total Surplus: *If the surplus is known but no bundles can be offered, the only set of offers that would guarantee an efficient outcome for all realizations of the reservation costs of the seller is* $(\{A\}, 0.5)$, $(\{B\}, 0.5)$, $(\{C\}, 0.5)$*. This cannot be optimal as it implies a payoff of 0 for the buyer. Therefore, bargaining is inefficient even when* TS *is commonly known.*[9] *Note that the buyer's offer for each item* i *must be at least* $v_i - TS = 0.3$*, because lower offers would always fall short of the seller's reservation cost. Offering* $(\{A\}, 0.3)$, $(\{B\}, 0.3)$, $(\{C\}, 0.3)$ *would lead to an efficient outcome if the entire surplus is concentrated on a single item (but not otherwise), thus potentially promoting efficiency compared to case (i).*

(iv) Bundling & Known Total Surplus: *If bundling is possible and the surplus is commonly known, the buyer's optimal set of offers is* $(\{A\}, 0.3)$, $(\{B\}, 0.3)$, $(\{C\}, 0.3)$, $(\{A, B\}, 0.8)$, $(\{A, C\}, 0.8)$, $(\{B, C\}, 0.8)$*, and* $(\{A, B, C\}, 1.3)$*. The offers are constructed by summing the buyer's valuations over the items contained in an offer and subtracting* TS*. The seller's best response is to accept* $(\{A, C\}, 0.8)$ *and earn a payoff of 0 (or* ϵ*); all other offers imply a negative payoff for the seller. The buyer receives the entire total surplus (as* $\delta = 0$*) and bargaining is fully efficient.*

Case (*iv*) shows that bargaining is efficient when the total surplus is known and bundling is allowed. Importantly, this result does not depend on the particular parameters of the problem. It holds for all distributions and for all realizations of valuations and reservation costs, as implied by Theorem 1. If $\delta > 0$, equilibria follow a similar idea as with take-it-or-leave-it offers and efficiency is still guaranteed. The difference is that the initial proposer would only demand a fraction of the surplus due to the possibility of counteroffers.

Cases (*i*) to (*iii*) demonstrate that without information about the total surplus or without the possibility of bundling (or both), bargaining is in general inefficient. It does not come as a surprise that the presence of asymmetric information causes inefficiencies (e.g.,

[8] For each bundle K the buyer maximizes $Prob[c_K \leq p_K] \times (v_K - p_K)$ where c_K is distributed according to the Irwin-Hall distribution $\frac{1}{n!}\sum_{i=0}^{\lfloor p_K \rfloor}(-1)^i\binom{n}{i}(p_K - i)^n$, the cumulative distribution function of a sum of n continuous uniform random variables on the interval $[0, 1]$.

[9] Characterizing optimal offers is a difficult problem in (*iii*). Information about the surplus changes the buyer's belief about the seller's reservation costs, and the updating is conditional on the buyer's own valuations for the different items. For our purposes, it is sufficient to know that all offers must be in the range $[0.3, 0.5)$ and hence inefficiency is unavoidable.

Table 1: Treatments

Treatments	Subjects
Unstructured Bargaining	
1. *No Information/Item-by-Item*	70 (7)
2. *No Information/Bundling*	100 (10)
3. *Intermediate Information/Item-by-Item*	70 (7)
4. *Intermediate Information/Bundling*	100 (10)
5. *Complete Information/Item-by-Item*	70 (7)
6. *Complete Information/Bundling*	100 (10)
Ultimatum Game	
Treatments 1-6 but with take-it-or-leave-it offers (one per item/bundle)	240 (24)
Noisy Information	
Treatments 2, 4, 6 but with imprecise information about total surplus	180 (18)

Sessions were run at the Laboratory for Research in Behavioural Experimental Economics (LINEEX) at the University of Valencia in June 2016, May 2017, and November 2020. The total number of participants is 930. The number of independent matching groups is given in parentheses.

Chatterjee, 1982; Myerson and Satterthwaite, 1983). Interestingly, bundling of issues is also critical for reaching efficiency, as it helps bargainers identify the optimal scope of an agreement.

3 Experiment Design

Our experimental treatments allow us to test the key theoretical predictions for bargaining over multiple issues. Specifically, we implement six main treatments in an unstructured bargaining setting. The treatments vary the offer protocol (*Item-by-Item* versus *Bundling*) and the information structure (*No Information*, *Intermediate Information* and *Complete Information*). We implement additional treatments to study multi-issue ultimatum games and a situation when the surplus is known only approximately.

3.1 Items, Valuations, and Costs

In each round of the experiment, subjects are randomly matched into pairs, assume the role of either a buyer or a seller, and engage in a negotiation to strike a deal on up to three items: A, B and C. For each item i the buyer's valuation v_i and the seller's reservation cost c_i are drawn from the discrete uniform distribution $\mathcal{U}\{0, 33\}$. Thus, in expectation half of the items contain a positive surplus and should be traded. The maximum total surplus is $3 \times 33 = 99$, which occurs if $v_i = 33$ and $c_i = 0$ for each item. The minimum total surplus is 0, which occurs if $v_i \leq c_i$ for each item. In expectation, the surplus per item is 5.66; thus the expected total surplus across the three items is 16.98. If an offer on a set of items K at price p_K is accepted, the buyer earns $v_K - p_K$ and the seller earns $p_K - c_K$, where $v_K = \sum_{i \in K} v_i$ and $c_K = \sum_{i \in K} c_i$.

3.2 Information Structures

Three information structures are considered. In all cases, the buyer and seller are informed about their own valuations/reservation costs. In *No Information*, bargainers only know the distribution from which the valuations/reservation costs of the other party are drawn (discrete uniform between 0 and 33), but do not receive any information about the realized values. In *Intermediate Information*, players are also informed about the total surplus, given by $TS = \sum_{i \in \{A,B,C\}} \max(v_i - c_i, 0)$. Finally, in *Complete Information*, each player is in addition informed about the other party's valuation/reservation cost for each item. Although under complete information the total surplus can be inferred from the information about individual items, in the experiment we explicitly inform the participants about the value of TS. This guarantees that complete information is strictly more informative than intermediate information.

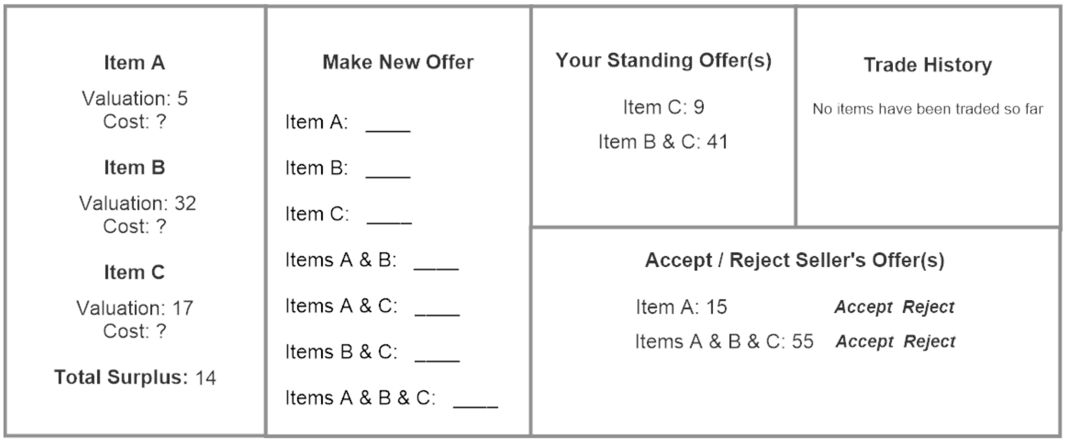
3.3 Offer Protocol

The offer protocol plays an important role for the predicted equilibrium outcomes. In particular, bargainers' ability to make offers on bundles of items can be necessary for reaching efficiency. We consider *Item-by-Item* bargaining, where only offers on individual items A, B and C are possible, and compare it to the *Bundling* protocol, where bargainers can make offers on all possible combinations of items. In particular, there are 7 combinations of items: each individual item A, B and C as well as the bundles $\{A, B\}$, $\{A, C\}$, $\{B, C\}$ and $\{A, B, C\}$. In the negotiation interface shown in Figure 1, the difference between the two offer protocols is that with item-by-item bargaining the four bottom rows in panel 'Make New Offer' are unavailable.

3.4 Negotiation Interface

We study unstructured bargaining. At any point in time, both bargainers can (i) make offers on items which have not yet been traded, (ii) accept or reject the other party's standing offers, and (iii) cancel offers that have not yet been accepted. No structure is imposed on the bargaining process except that it is anonymous and all interactions occur through offers, i.e., there is no chat or face-to-face communication. Naturally, an item can be traded only once. For example, if the proposer offers a price for item A and a price for bundle $\{A, B\}$,

Figure 1: Diagram of Decision Screen



Notes: Example of buyer's decision interface with bundling and intermediate information. The left panel shows the buyer's valuations and the total surplus; the seller's reservation costs are unknown to the buyer. In panel 'Make New Offer', the buyer can make offers for single items and bundles. Own offers that have not yet been accepted/rejected are shown in panel 'Your Standing Offer(s)'. Offers from the seller can be accepted/rejected in the 'Accept/Reject Seller's Offer(s)' panel. All accepted offers are listed under 'Trade History'. The interface looks similar under no information, except that the total surplus is unknown, and complete information, except that in addition the seller's costs are known.

only one of these offers can be accepted. On the other hand, an offer for item A and an offer for bundle $\{B, C\}$ can both be accepted. The game ends if all items are traded, or both sides independently agree to end the negotiation, or there is a bargaining breakdown. We allow for an initial minute without a risk of experiencing a bargaining breakdown to give subjects time to negotiate and form expectations. After the first minute, the breakdown occurs with a probability of 4% every 10 seconds.[10]

Figure 1 illustrates the experimental interface for the treatment in which the offer protocol allows for bundling of items and the information structure where subjects know the total surplus but not the other party's values and costs (intermediate information).

3.5 Behavioral Hypotheses

Our hypotheses are grounded in the theoretical bargaining literature. Incomplete information is a well-known source of inefficiency. Myerson and Satterthwaite (1983) and Chatterjee and Samuelson (1983) show that even under an optimal trading mechanism, small-surplus items will not change hands due to incentive constraints. Case (i) in Example 1 also illus-

[10]The breakdown probability after the first minute induces moderate pressure to reach an agreement. Subjects knew the breakdown probability and we explained that bargaining lasts at least 1 minute, continues beyond 2 minutes with a probability of 78% (according to the breakdown probability), beyond 3 minutes with a probability of 61%, and so on. The game ends for sure after 12 minutes, but this point was never reached.

trates this point. Hence, we expect that in our *No Information* setting, it will be difficult for subjects to trade small-surplus items, which for our distribution of valuations and costs are items with a surplus of 8 or less.

Hypothesis 1 (Agreement Failures in Incomplete Information) *Agreement rates under complete information are higher than under no information. The driving force for this difference are trade failures for small-surplus items ($S \leq 8$) under no information.*

The second and third hypotheses are specific to the multi-issue context and follow from Theorem 1.

Hypothesis 2 (Equivalence of Intermediate and Complete Information) *Agreement rates under intermediate information/bundling are identical to those under complete information.*

Hypothesis 3 (Richness Condition) *In the intermediate information bargaining setting, agreement rates for the bundling offer protocol are higher than for the item-by-item offer protocol.*

A key strength of Theorem 1 is its applicability to a wide range of bargaining settings, including take-it-or-leave-it offers, alternating-offer bargaining, when one side makes offers repeatedly, or any mixture of these. It is thus an appropriate theoretical benchmark for our unstructured bargaining environment.

Alternatively, we note that the Nash bargaining solution has frequently been used to generate predictions for behavior in unstructured bargaining environments such as ours, at least when information is complete (e.g., Roth and Schoumaker, 1983; Bolton and Karagözoğlu, 2016; Embrey et al., 2021; Karagözoğlu, 2019). Harsanyi and Selten (1972) and Myerson (1979) provide an extension of the Nash bargaining solution to incomplete information. Applying their solution, we can derive variants of Hypotheses 1 and 2 but not Hypothesis 3, as offer protocols play no role in Nash bargaining.[11]

3.6 Procedures

The experiment was conducted at the Laboratory for Research in Behavioural Experimental Economics (LINEEX) at the University of Valencia between 2016 and 2020. The software was programmed in z-Tree (Fischbacher, 2007). As shown in Table 1, there are six main

[11] The solution of Harsanyi and Selten (1972) and Myerson (1979) maximizes a generalized Nash product over the incentive-feasible allocations. Incentive-feasible allocations cannot be fully efficient in our *No Information* setting. With intermediate information, however, there exist incentive-compatible and fully efficient mechanisms. The symmetry of players in our setting implies a share of 50% of the total surplus for each side.

treatments with unstructured bargaining (results reported in Section 4) plus additional treatments on multi-issue ultimatum bargaining and when information bargainers' receive is noisy (results reported in Section 5). For our main treatments, we gathered data from either 100 subjects in 10 independent matching groups or 70 subjects in 7 independent matching groups, implemented in 3 separate sessions per treatment. The total number of participants is 930. Each subject participated in one treatment only. Payments were made privately in cash at the end of a session. Average earnings were €28 per subject including a show-up fee of €5. Sessions lasted on average 120 minutes and never longer than 150 minutes.

At the start of a session, written instructions were distributed (available in online Appendix D). The instructions explained the bargaining setting, how valuations and costs are generated, and how subjects' payoffs are computed. All subjects completed a comprehension test. Subjects were then divided into matching groups of size 10. Each session had ten periods/iterations of the bargaining game. In each period, subjects in a matching group were randomly re-matched into pairs. There were no identifiers. For each pair the role of the buyer and the seller was randomly assigned. At the end of a period, subjects received feedback about valuations, reservation costs, and earnings. All periods were paid.

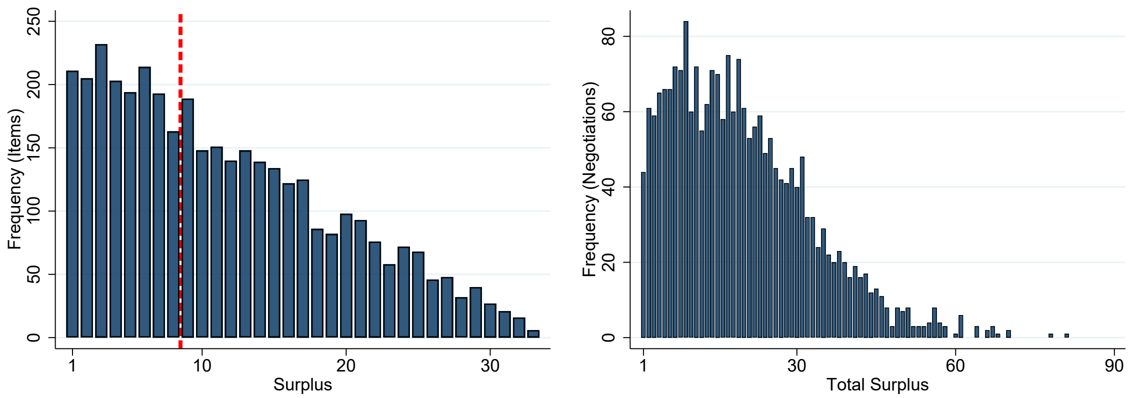
To elicit risk preferences, at the end of a sessions subjects had to choose one among the following six lotteries: 80% chance of winning €2, 70% chance of winning €3, 60% chance of winning €4, 50% chance of winning €5, 40% chance of winning €6, and 30% chance of winning €7. Each subject then received the selected amount with the corresponding probability. The lottery choices order subjects by risk preference, with the first lottery revealing the greatest risk aversion and the last one being the most risk loving choice.[12] We also elicited fairness preferences by having subjects play an ultimatum bargaining game after the main experiment. Person A had to distribute €5 between herself and person B. Person B had to specify a minimum offer they are willing to accept, before knowing Person A's proposed split. If Person A proposed a split that covers Person B's minimum acceptable offer, the split was implemented. Otherwise both earned 0. Both subjects in a pair made decisions in both roles.

4 Results

Section 4.1 contains the main results and hypotheses tests. In Section 4.2, we discuss efficiency. Section 4.3 provides an analysis of the bargaining process.

[12]The median choice was lottery 3 (60% chance of winning €4) and lotteries 1 and 6 were rarely chosen. There are no significant differences in the distribution of lottery choices across treatments.

Figure 2: Surplus Histograms



(a) Item-Level Surplus

(b) Negotiation-Level Surplus

Notes: ***(a)*** Frequency of item surplus (S) conditional on $S > 0$. Items to the left of the vertical dashed line ($S \leq 8$) are not traded in the optimal trading mechanism. ***(b)*** Frequency of total surplus (TS) across the three items in a negotiation conditional on $TS > 0$.

4.1 Agreement Rates for Small-Surplus Items

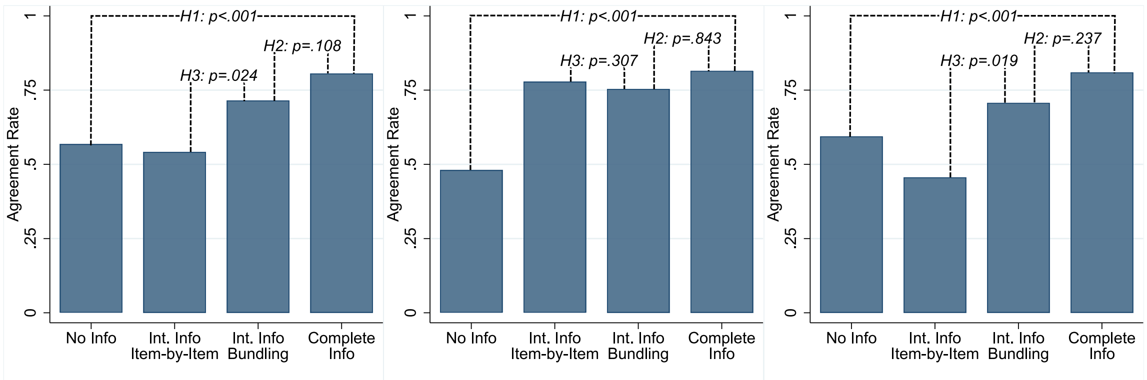
Figure 2a shows the distribution of item surplus conditional on an item having a positive surplus, $S > 0$. A small-surplus item is defined as an item that is not traded in the optimal mechanism in the no information treatments. In our setting, these are items with a surplus of $S \leq 8$, i.e., items to the left of the dashed line in Figure 2a. To test our main hypotheses, we focus on small-surplus items, because this is where theory predicts that more information will improve agreement rates.

Figure 3a shows the empirical agreement rates for small-surplus items. The agreement rate is the number of positive-surplus items that are traded divided by the total number of positive-surplus items. The p-values stem from two-sided Wilcoxon rank-sum tests.[13] For the intermediate information structure, the bundling and item-by-item treatments are shown separately. For the no information and complete information structures, the bundling and item-by-item treatments are pooled. This allows us to test our three hypotheses (see Section 3.5), as they distinguish between offer protocol only for intermediate information.[14]

[13]We use two-sided Wilcoxon rank-sum tests for all non-parametric treatment comparisons. The unit of observation for these tests is the average outcome in an independent matching group. That is, the statistical tests between *No Info* and *Complete Info* in Figure 3 are based on 34 matching groups (17 per information condition). The comparison between *Intermediate Info/Bundling* and *Complete Info* is based on 27 matching groups (10 and 17, respectively). The comparison between *Intermediate Info/Item-by-Item* and *Intermediate Info/Bundling* is based on 17 matching groups (7 and 10, respectively).

[14]We will confirm in Table 2 that there are no significant differences between the bundling and item-by-item treatments in *No Info* and *Complete Info*.

Figure 3: Agreement Rates for Small-Surplus Items



(a) All Negotiations (b) Efficient Scope = 1 Item (c) Efficient Scope > 1 Item

Notes: Agreement rate for small-surplus items ($0 < S \leq 8$) for ***(a)*** all negotiations, ***(b)*** when only one item has a positive surplus, ***(c)*** when two or three items have a positive surplus. P-values testing hypotheses *H1*, *H2* and *H3* stem from two-sided Wilcoxon rank-sum tests for average outcomes across the independent matching groups.

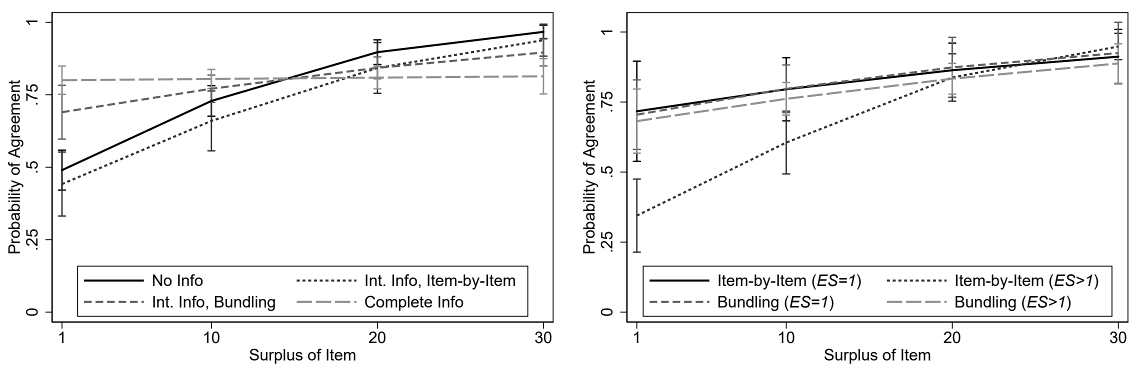
Figures 3b and 3c, respectively, show the agreement rates for small-surplus items for the subset of negotiations with an efficient scope of one (one positive-surplus item) or greater than one (two or three positive-surplus items). This is a useful way of slicing the data, because theoretically the availability of bundling is particularly important when multiple items need to be traded.

We find clear support for Hypothesis 1. The agreement rate for small-surplus items is 57% in *No Info* and 81% in *Complete Info* ($p < .001$), see Figure 3a. The result also holds separately when the efficient scope equals one ($p < .001$) or is bigger than one ($p < .001$). Thus, in line with the theoretical predictions, private information renders efficient bargaining more difficult when the surplus of an item is small; though about half of the small-surplus items are still exchanged despite private information. We summarize in the following result.

Result 1 *The agreement rate for small-surplus items ($S \leq 8$) is significantly larger in the complete information treatments than in the no information treatments.*

The data also supports Hypothesis 2 on the equivalence of *Intermediate Info/Bundling* and *Complete Info*. The agreement rate for small-surplus items is 72% in *Intermediate Info/Bundling* and 81% in *Complete Info* ($p = .108$). Hence, while small-surplus items are traded more often under complete information than under intermediate information with bundling, the difference is relatively small and not significant at the 10% level. We will confirm the similarity of outcomes in these bargaining environments through the regressions

Figure 4: Probability of Agreement over Surplus



(a) All Treatments

(b) Intermediate Info by Efficient Scope

Notes: Probability of agreement depending on item surplus for ***(a)*** all treatments and ***(b)*** *Intermediate Info/Item-by-Item* and *Intermediate Info/Bundling* separated by efficient scope (*ES*) equal to or greater than one. Predicted probabilities and 95% confidence intervals are from random effects logistic regressions with period dummies and with standard errors clustered on matching groups.

presented in Table 2. The result again holds independently of the efficient scope, i.e., it holds in all three subfigures of Figure 3. Another way to test Hypothesis 2 is to compare agreement rates with intermediate information (when bundling is possible) to those under no information. We find that agreement rates for small-surplus items are indeed significantly higher in *Intermediate Info/Bundling* than *No Info* ($p = .018$). We summarize in the following result.

Result 2 *The agreement rate for small-surplus items in intermediate information/bundling is not significantly different from the complete information treatments and is significantly larger than in the no information treatments.*

Finally, we find clear support for Hypothesis 3. The agreement rate for small-surplus items is 72% in *Intermediate Info/Bundling* and 54% in *Intermediate Info/Item-by-Item* ($p = .024$). Hence, the availability of bundling is crucial for efficient exchange of small-surplus items when bargainers have intermediate information. As can be seen in Figure 3b ($p = .307$) and Figure 3c ($p = .019$), this effect stems entirely from negotiations with more than one positive-surplus item. We summarize with the following result.

Result 3 *The rate of trade for small-surplus items in intermediate information/bundling is significantly larger than in intermediate information/item-by-item. The effect is driven entirely by negotiations for which efficiency requires exchanging multiple items.*

We further examine the hypotheses using logistic regressions. This allows us to observe the effect of item surplus when varying it continuously rather than looking at $S \leq 8$.

In Figure 4, we provide the predicted agreement probabilities from the logistic regressions depending on item surplus. Figure 4a confirms that *No Info* and *Intermediate Info/Item-by-Item* have a significantly lower agreement probability for small-surplus items than *Intermediate Info/Bundling* and *Complete Info*. The differences disappear for items with a surplus greater than 10, and seem to reverse for items with a surplus greater than 20. Predicted agreement probabilities are not significantly different between *Intermediate Info/Bundling* and *Complete Info*. These results support Hypotheses 1 to 3. Figure 4b focuses on the effect of the efficient scope in the intermediate information structure. In line with the non-parametric analysis, the entire increase in the probability of agreement with bundling compared to the item-by-item offer protocol (Hypothesis 3) stems from negotiations with multiple positive-surplus items ($ES > 1$).

In Table 2 columns (1) to (3), we report the results of three logistic regressions on the probability of agreement to separate out all treatments and to include additional control variables. Model (1) includes all negotiations, model (2) includes negotiations with an efficient scope of one, and model (3) includes negotiations with an efficient scope greater than one. The variable *Risk Tolerance* corresponds to a subject's lottery choice in the task we implemented after the main experiment. Lotteries range from one to six, indicating increasing risk tolerance (see Section 3.6). The variable *Selfishness* equals 1 if, in the ultimatum game task implemented after the main experiment, a subject proposed a distribution that allocates strictly more than half of the pie to herself, and 0 otherwise (see Section 3.6).

Model (1) in Table 2 again confirms Results 1 to 3. In particular, for small-surplus items, both complete information conditions as well as *Intermediate Info/Bundling* promote agreement rates compared with both no information conditions and as well as *Intermediate Info/Item-by-Item*—see the significantly positive coefficients that are not interacted with surplus (the reference group is *No Info/Bundling*). Models (2) and (3) confirm that the difference between *Intermediate Info/Bundling* and *Intermediate Info/Item-by-Item* stems from negotiations with an efficient scope greater than one. Crucially, the odds ratios of the interaction terms with item surplus (S) that are significantly below 1 show that the advantage of the complete information treatments and *Intermediate Info/Bundling* disappears for larger item surpluses. This is in line with Figure 4a.

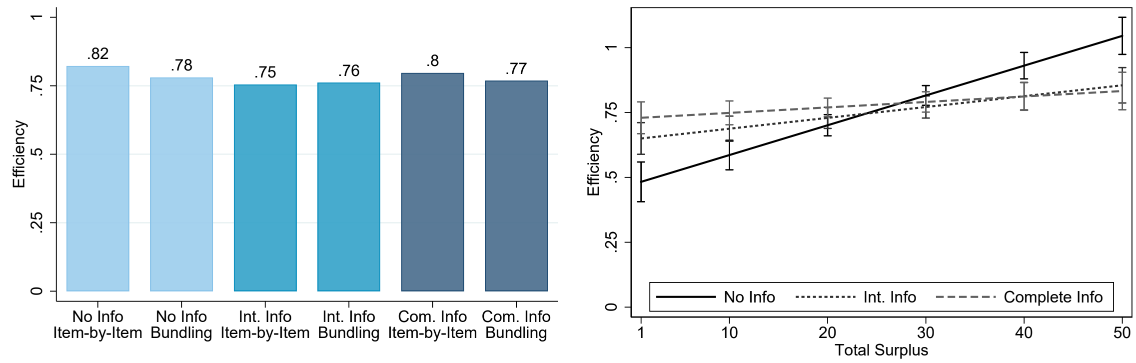
Two additional insights from model (1) in Table 2 are noteworthy. First, both risk attitudes ($p = .017$) and fairness attitudes ($p < .001$) affect the probability of agreement. Specifically, higher risk tolerance and a larger degree of selfishness in the ultimatum game, on average, lower the probability of agreement in the multi-issue bargaining game (reported coefficients are odds ratios). We will examine risk tolerance and selfishness in detail in Section 4.3. Second, the regression results confirm that agreement probabilities, and their dependence on item surplus, are similar between the bundling and item-by-item treatments

Table 2: Regressions—Probability of Agreement and Efficiency

	(1) Prob. of Agreement	(2) Prob(Agr.) if $ES = 1$	(3) Prob(Agr.) if $ES > 1$	(4) Realized Surplus	(5) Efficiency
Int. Info/Bundling	2.751***	3.829***	2.497**	-0.300	0.151***
	(0.925)	(1.761)	(1.030)	(0.668)	(0.0454)
Com. Info/Bundling	3.661***	6.604***	3.267***	-0.304	0.175***
	(1.058)	(3.525)	(1.116)	(0.624)	(0.0489)
No Info/Item-by-Item	0.964	1.015	0.940	0.690	-0.0105
	(0.274)	(0.515)	(0.306)	(0.644)	(0.0889)
Int. Info/Item-by-Item	0.857	4.538***	0.432**	-0.661	0.206***
	(0.291)	(2.617)	(0.171)	(0.979)	(0.0711)
Com. Info/Item-by-Item	8.677***	8.304***	9.300***	0.265	0.328***
	(2.953)	(4.248)	(4.768)	(0.861)	(0.0523)
Surplus (S)	1.129***	1.129***	1.131***		
	(0.0242)	(0.0379)	(0.0256)		
Total Surplus (TS)				0.883***	0.0115***
				(0.0219)	(0.00164)
Int. Info/Bundling ∗ S or TS	0.934***	0.935	0.933**		-0.00586***
	(0.0240)	(0.0432)	(0.0289)		(0.00196)
Com. Info/Bundling ∗ S or TS	0.910***	0.873***	0.918***		-0.00692***
	(0.0216)	(0.0404)	(0.0231)		(0.00194)
No Info/Item-by-Item ∗ S or TS	1.013	1.001	1.019		0.000400
	(0.0295)	(0.0513)	(0.0443)		(0.00293)
Int. Info/Item-by-Item ∗ S or TS	0.990	0.928*	1.021		-0.00862***
	(0.0266)	(0.0390)	(0.0310)		(0.00226)
Com. Info/Item-by-Item ∗ S or TS	0.865***	0.864***	0.865***		-0.0116***
	(0.0203)	(0.0342)	(0.0297)		(0.00216)
Risk Tolerance	0.899**	0.867*	0.907*	-0.187	-0.00839
	(0.0401)	(0.0699)	(0.0508)	(0.173)	(0.00863)
Selfishness	0.685***	0.834	0.643***	-0.937**	-0.0515***
	(0.0740)	(0.135)	(0.0887)	(0.409)	(0.0187)
Period	0.946*	0.958	0.945	0.0221	-0.00387
	(0.0316)	(0.0484)	(0.0364)	(0.101)	(0.00543)
Constant	2.153**	1.013	2.744**	-1.182	0.513***
	(0.782)	(0.590)	(1.089)	(1.222)	(0.0766)
Items	3,039	766	2,273	3,039	3,039
Negotiations	1,777	766	1,011	1,777	1,777
Matching Groups	51	51	51	51	51

Notes: * significant at 10%, ** significant at 5%, *** significant at 1%, Standard errors in parentheses. Random effects regression for probability of agreement (logistic) and realized surplus/efficiency (linear) with standard errors clustered on matching group level. For models (1) to (3), reported coefficients are odds ratios. Reference group: *No Info/Bundling*. Risk Tolerance and Selfishness are taken from the buyer in a negotiation (results are similar for sellers). All regressions control for item valuations.

Figure 5: Efficiency



(a) Overall Efficiency

(b) Efficiency Conditional on Total Surplus

Notes: In figure ***(a)*** efficiency is calculated as the sum of realized surplus in a matching group divided by the maximum surplus possible in the matching group, and then averaged for each treatment. In figure ***(b)*** predicted probabilities with 95% confidence intervals are from linear random effects regressions with dependent variable efficiency on the negotiation-level (realized surplus divided by total surplus) with standard errors clustered on matching groups.

for both the no information and the complete information structure. The pooling of treatments in Figures 3 and 4a, which was motivated by the theoretical predictions, is thus also empirically justified.

4.2 Efficiency

Efficiency is defined as the sum of realized surplus divided by the total surplus that is possible in a negotiation (or matching group when performing non-parametric tests with matching group averages as the unit of observation). In this section, to analyze efficiency, we will therefore focus on the total surplus available across all three items in a negotiation. The predictions on agreement rates for small-surplus items, in theory, imply the same treatment differences for efficiency. The reason is apparent: Items with a surplus greater than 8 are predicted to be traded and hence all treatment differences in efficiency must be due to agreement rates for small-surplus items.

The data, however, clearly reject the idea that agreement rates for small-surplus items translate to efficiency. As shown in Figure 5a, efficiency lies between 75% and 82% in all treatments and the differences are not significant; if anything, *No Info* performs best.[15] The reason why efficiency is not lower in the no information treatments is that they perform

[15] Pooling by information, Wilcoxon rank-sum test p-values are $p = .173$ between No Info and Intermediate Info, $p = .263$ between No Info and Complete Info, and $p = .459$ between Intermediate Info and Complete Info.

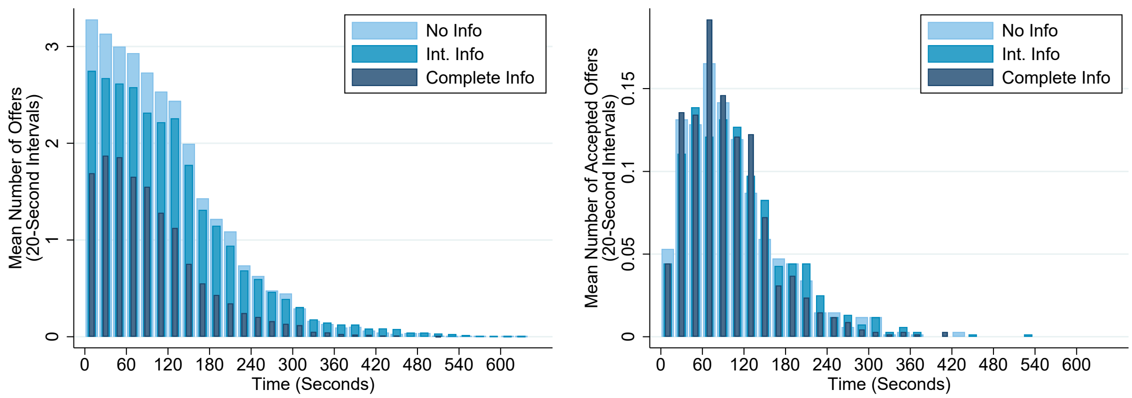
markedly better when the total surplus is large. This is shown in Figure 5b. There, as expected, efficiency is low in the *No Info* conditions when the total surplus in a negotiation is relatively small. But efficiency in *No Info* exceeds the one in the intermediate and complete information conditions when the total surplus is large. The reversal in efficiency between these treatments occurs at a total surplus of about 25. The histogram of total surplus in Figure 2b shows that negotiations with a total surplus greater than 25 are frequent, so the efficiency reversal matters.

The regressions reported in models (4) and (5) in Table 2 confirm these findings on efficiency. Model (4) regresses the realized surplus in a negotiation (the sum of realized payoffs) on the treatments, controlling for total surplus to also account for potential between-treatment heterogeneity in the draws of buyer valuations and seller costs. As can be seen, there are no significant differences in realized surplus between treatments. In model (5), to analyze how efficiency depends on the size of the total surplus, we first compute efficiency for each negotiation by dividing the realized surplus by the total surplus and then regress this measure on the treatments and the total surplus. As can be seen, treatments with information about the total surplus (intermediate and complete information) are about 15% points more efficient than no information when the total surplus is small. However, the significantly positive effect of Total Surplus (*TS*) for the reference group *No Info/Bundling* shows that there efficiency increases by more than 1% point per one point increase in total surplus. With intermediate and complete information the interaction term with *TS* is significantly negative, which means that there efficiency does not change much depending on *TS*. This is fully line with Figure 5b. We summarize in the following result.

Result 4 *When the total surplus is unknown (no information), efficiency in negotiations with a small total surplus is about 50% and increases to near full efficiency when the total surplus is large. When the total surplus is known (intermediate and complete information), efficiency is between 75% and 80% and is, moreover, independent of the total surplus. Overall, there are no significant differences in efficiency between the treatments.*

Intuitively, the larger the total surplus in a negotiation, and thus the larger the range of prices for which trade is mutually profitable, the more likely bargaining is to overcome disagreement due to incomplete information. This part of the result is fully in line with theory. The deviation from theory occurs when the total surplus is known. About 25% of the total surplus is then left on the table. It would be intuitive if the factors that prevent agreement for small total surpluses under intermediate or complete information would also be mitigated as the total surplus increases. Indeed, in this case the costs of trade failure become increasingly large (e.g., Slonim and Roth, 1998; Andersen et al., 2011). Yet, the hurdles that prevent trade in these conditions remain firmly in place. The key question

Figure 6: Timing of Proposed and Accepted Offers



(a) Offers over Time

(b) Acceptances over Time

Notes: Figure ***(a)*** shows the mean number of proposed offers (single-item and bundled offers) per 20-second interval averaged by information structure. Figure ***(b)*** shows the mean number of accepted offers.

is to identify what these hurdles are. The answer is found by looking more closely at the negotiation process.

4.3 Negotiation Process

We now delve deeper into the data and provide a discussion of the negotiation process. We split the discussion into several parts.

Timing: We begin with an overview of the timing of proposed and accepted offers. Figure 6a shows that on average 3.2 offers are made in the first 20 seconds of the no information treatments. With complete information, offer frequency is approximately half of that. The intermediate information treatments lie between the other two information conditions. The number of offers decreases over time as items are traded and negotiations are concluded, but activity remains high for two to three minutes. Figure 6b shows that the distribution of *accepted* offers is strikingly similar across information conditions. We conclude that through a higher bargaining activity, treatments with less information can maintain the same pace of successful trades as the complete information treatments.

Bundling and ambitious demands: The theory of bargaining under intermediate information makes predictions about the optimal proposal strategy that we can test. As explained in case (*iv*) of Example 1, the price for any bundle offered by a buyer/seller should correspond to the sum of the buyer's valuations/seller's costs over the items contained in the bundle minus/plus a constant share of the total surplus. The constant share reflects

Table 3: Demanded Share of Total Surplus

	No Information			*Intermediate Information*			*Complete Information*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Total Surplus (TS)	0.576***	0.206***	0.153***	0.524***	0.308***	0.268***	0.487***	0.417***	0.410***
	(0.0248)	(0.0238)	(0.0207)	(0.0273)	(0.0281)	(0.0220)	(0.0265)	(0.0445)	(0.0473)
Two-Item Bundle ∗ TS	0.0638*	0.148***	0.156***	0.0851**	0.117***	0.128***	0.0709***	0.0854***	0.0902***
	(0.0348)	(0.0327)	(0.0260)	(0.0300)	(0.0246)	(0.0224)	(0.0197)	(0.0301)	(0.0325)
Three-Item Bundle ∗ TS	0.285***	0.381***	0.349***	0.257***	0.348***	0.332***	0.121**	0.154***	0.154***
	(0.0585)	(0.0524)	(0.0480)	(0.0358)	(0.0403)	(0.0363)	(0.0472)	(0.0494)	(0.0509)
Item-by-Item ∗ TS	0.00225	0.0944***	0.0906***	0.0545*	0.140***	0.141***	0.0582*	0.0926**	0.0917**
	(0.0340)	(0.0300)	(0.0228)	(0.0294)	(0.0354)	(0.0310)	(0.0301)	(0.0433)	(0.0424)
Proposal Time (sec.)			-0.0269***			-0.0224***			-0.00778***
			(0.00209)			(0.00155)			(0.00161)
Risk Tolerance			0.0802			0.187			0.306***
			(0.133)			(0.256)			(0.103)
Selfishness			-0.429			1.132**			0.0455
			(0.545)			(0.490)			(0.413)
Constant		5.508***	8.524***		2.746***	3.826***		0.922**	1.793**
		(0.377)	(1.009)		(0.333)	(0.803)		(0.407)	(0.896)
Offers (N)	9,731	9,731	9,731	9,275	9,275	9,275	5,742	5,742	5,742
Matching Groups	17	17	17	17	17	17	17	17	17

Notes: * significant at 10%, ** significant at 5%, *** significant at 1%. Ordinary least squares regressions for *No Info*, *Intermediate Info*, *Complete Info* with standard errors clustered on matching group level. Models (3), (6), (9) include period dummies.

what proposers think they can negotiate for themselves. Further, all items with a positive surplus are predicted to be exchanged in a single trade. For example, if items A and C contain surplus but not item B, then bundle $\{A, C\}$ should be traded at once. Trading the items separately, at two prices, can lead to inefficiency, because after the first trade occurs bargainers no longer know the total surplus that remains on the table.

To test these predictions, in Table 3 columns (4)-(6) on intermediate information, we provide regressions where the demanded share of total surplus is the dependent variable and the total surplus interacted with the bundle sizes are the independent variables. Model (4) does not include a constant, thus the coefficients can be interpreted as the average demanded share of total surplus. Model (5) includes a constant. Model (6) includes additional controls. We find that on average demanded shares correspond to about 52.4% of the total surplus for single-item offers. Demanded shares significantly increase for two- and three-item bundles. As explained above, the more ambitious demands in bundled offers are not in line with the theoretical predictions for intermediate information.

Bundled offers are common, although not as common as single-item offers. Across all treatments that allow for bundling, 40% of the offered items are offered in a bundle. The timing of when offers are made is similar between bundled and single-item offers ($p = .575$). However, bundled offers are on average accepted significantly later than single-item offers. The median acceptance time in *Intermediate Info/Bundling* is 90.4 seconds for single-item offers and 106.2 seconds for bundled offers ($p = .046$). As a result, among the negotiations with two or three positive-surplus items and where full efficiency is achieved, only 28% occur via a single bundle offer. In online Appendix A, we also show that in *Intermediate Info/Bundling* the eventually accepted share of total surplus is not larger for bundle offers than for single-item offers. To sum up, these observations imply that for bundles there is a stronger discrepancy between offered and accepted offers and thus reaching agreement is more challenging. We summarize in the next result.

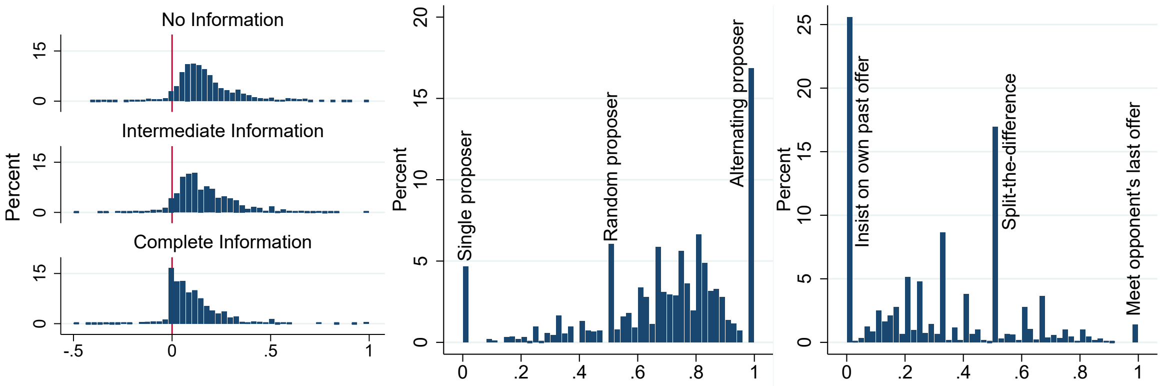
Result 5 *Offers for bundles of items in intermediate info/bundling are significantly more aggressive than offers for single items. In contrast to theory, most negotiations thus do not conclude via a single offer on the efficient bundle of items.*

Emergence of institution: In columns (3), (6), (9) in Table 3, we can further see that the demanded share of the total surplus decreases over time (*Proposal Time*) but that the effect is slowest under complete information. To explore this further, Figure 7a shows the distribution of a simple measure for compromise. Let π_n denote the proposer profit associated with the n_{th} offer in a sequence of offers for a given item/bundle. We compute $\mathbf{\Delta} = (\pi_{n-1} - \pi_n)/\pi_{n-1}$. Thus, $\mathbf{\Delta} < 0$ would mean that the demanded profit increased from the $(n-1)_{th}$ to the n_{th} offer; $\mathbf{\Delta} = 0$ indicates insistence on the previous offer; $\mathbf{\Delta} > 0$ implies a reduction in the demanded profit. As can be seen, demanded profits decrease for most offers in all information conditions. However, over 15% of the offers insist on the previously demanded profit in *Complete Info*, while less than 5% do so in *No Info* ($p = .012$) and *Intermediate Info* ($p = .016$).

Theoretical models assume different rules to determine proposers. There may be a single proposer, or the proposer may be determined randomly for each offer, or bargainers may alternate in making proposals. Our experiment allows us to see if any of these proposer rules emerge endogenously and how they affect agreement rates. To that end, we define an alternating offer as an offer in a sequence of offers for a particular item/bundle that is made in direct response to an offer of the other player. For example, suppose Ann makes the 1st, 3rd, 5th and 6th offer in an offer sequence while Bob makes the 2nd and 4th offer. Then, the 2nd, 3rd, 4th, and 5th offer are four alternating offers but the 6th offer is not an alternating offer. We do not consider the 1st offer, as it is neither alternating nor not alternating (hence we only look at offer sequences of length 2 or more). Let $\mathbf{A}$ denote the proportion of alternating offers in an offer sequence. In the example with Ann and Bob, $\mathbf{A} = 0.8$. Note that $\mathbf{A} = 0$ occurs when only one side makes offers while $\mathbf{A} = 0.5$ would be consistent with a random selection of proposers.

Figure 7b shows the distribution of $\mathbf{A}$. It is apparent that alternating-offer bargaining is the dominant mode of interaction: 17% of the trade sequences are fully alternating ($\mathbf{A} = 1$,

Figure 7: Bargaining Patterns



(a) Change in Demand ($\mathbf{\Delta}$) (b) Alternating Offers ($\mathbf{A}$) (c) Split-the-Difference ($\mathbf{\Sigma}$)

Notes: Figure ***(a)*** shows a histogram for the reduction in demanded profit between two offers in an offer sequence for a particular item/bundle ($\mathbf{\Delta}$). Figure ***(b)*** shows a histogram for the proportion of alternating offers in an offer sequence ($\mathbf{A}$). Figure ***(c)*** shows a histogram of the split-the-difference measure ($\mathbf{\Sigma}$).

median sequence length: 5.19 offers) and for 80% of the negotiations we have $\mathbf{A} > 0.5$ (median sequence length: 15.72 offers). Other modes occur at $\mathbf{A} = 0.5$ (median sequence length: 9.16 offers) or at $\mathbf{A} = 0$ (median sequence length: 4.12 offers).[16] In online Appendix A, we show that alternating-offer bargaining is the main mode of interaction independent of the information condition. We view the endogenous emerge of alternating-offer bargaining as one of the main contributions of our study.

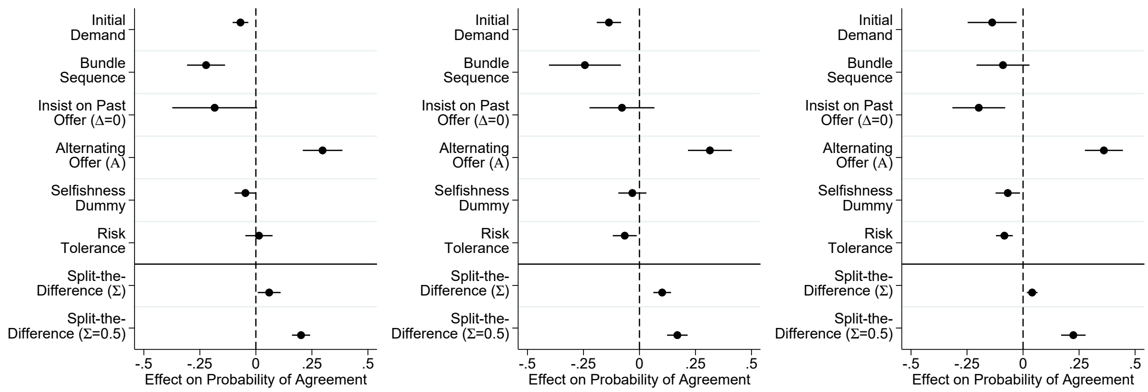
Consider a fully alternating sequence of offers of length T, $(p_1, ...p_T)$, between Ann and Bob. An interesting question is how bargainers react to each other's offers. For every offer p_t, $t > 2$, we define $\mathbf{\Sigma} = (p_t - p_{t-2})/(p_{t-1} - p_{t-2})$. The numerator is the difference between a player's, say Bob's, current and previous offer. The denominator is the difference between Ann's current and Bob's previous offer. If $\mathbf{\Sigma} = 0$, Bob insists on his previous offer and if $\mathbf{\Sigma} = 1$, Bob meets Ann's previous offer. Importantly, when $\mathbf{\Sigma} = 0.5$, Bob makes an offer that lies halfway between his previous offer and Ann's current offer.[17]

Figure 7c shows the distribution of $\mathbf{\Sigma}$. We find that most offers either insist on the previously proposed price or meet the other party halfway to achieve a split-the-difference deal. The spike at $\mathbf{\Sigma} = 0.5$ is in line with Backus et al. (2020) who show the prevalence of

[16]The unit of observation is a sequence of offers for a given item or bundle of items (maximum seven offer sequences per negotiation). In principle, a bargainers could respond to an offer for one item/bundle by making an offer on another bundle. However, we observe clear alternating-offer and split-the-difference patterns for offers on the same bundle, which suggests that bargainers predominantly responded to an offer with a counteroffer on the same bundle.

[17]The definition of $\mathbf{\Sigma}$ can be generalized to offer sequences that are not fully alternating. We explain how to do this in online Appendix A, and show that the results remain qualitatively the same. The split-the-difference pattern is thus relevant also for offer sequences that are not fully alternating.

Figure 8: Negotiation Process and Agreement Probability



(a) No Information (b) Intermediate Information (c) Complete Information

Notes: Marginal effects and 95% confidence intervals (cluster-robust standard errors) from linear random effects models on the probability of agreement of different bargaining process variables. The unit of observation is an offer sequence for the coefficients above the horizontal line and a single offer for coefficients below the horizontal line.

split-the-difference offers for eBay data. To us, it is remarkable that this bargaining pattern can be identified so clearly in a laboratory environment. The way people interact via offers to reach compromise seems to be the same in the lab and the field, at least in terms of split-the-difference offers.

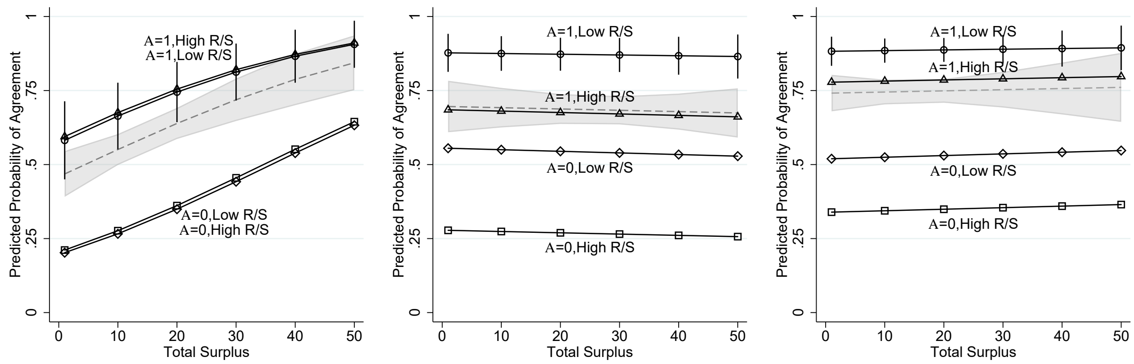
We summarize these observations in the next result.[18]

Result 6 *Bargainers endogenously behave as alternative proposers and achieve compromises via split-the-difference offers.*

Impact of risk/fairness preferences and alternating offers: Bundling, risk tolerance/selfishness, and alternating offers are all important characteristics of the negotiations we observe in our data. But how do these factors affect the probability of agreement? Figure 8 presents for each information condition regression coefficients relating these factors to the probability of agreement. We also include the initial demand in an offer sequence as a regressor, following Camerer et al. (2019)'s findings. The coefficients above the horizontal line stem from a regression where the unit of observation is an offer sequence, because this is the level on which $\mathbf{\Delta}$ and $\mathbf{A}$ are defined. The marginal effects below the horizontal line use an offer as the unit of observation, the level on which $\mathbf{\Sigma}$ is defined. The split-the-difference dummy equals 1 if $\mathbf{\Sigma} \in [0.475, 0.525]$.

[18] In online Appendix A, we further explore the alternating-offer and split-the-difference bargaining patterns. We find that: (*i*) they are observed in all treatments; (*ii*) split-the-difference offers are particularly common for early offers in a sequence; (*iii*) the patterns are observed for both single-item and bundle offer sequences.

Figure 9: Counterfactual Agreement Probabilities



(a) No Information (b) Intermediate Information (c) Complete Information

Notes: Predicted agreement probabilities from random effects logistic regressions depending on total surplus, risk tolerance/selfishness (*R/S*), and $\mathbf{A}$. Triangle markers correspond to a "worst-case" with $\mathbf{A} = 0$ and high R/S, i.e., average risk tolerance between the buyer and seller is 5 out of 6 (the 95th percentile) and at least one of the bargainers in a pair is classified as selfish; diamond markers assume $\mathbf{A} = 0$ and low R/S, i.e., average risk tolerance is set to 2 out of 6 (the 5th percentile) and neither bargainer is classified as selfish; circle and square markers provide the same variations for $\mathbf{A} = 1$. The light dashed line shows the prediction at the means of all variables together with the 95% confidence intervals.

We highlight two results from Figure 8 that we consider the most important, because they can potentially be used to design better trading institutions. First, offer sequences with a larger percentage of alternating offers are substantially more likely to result in agreement and split-the-difference offers are particularly likely to be accepted. Second, both risk tolerance (defined as the average risk tolerance of the buyer and seller) and the selfishness dummy (which equals 1 if either the buyer or the seller is classified as selfish) reduce agreement probability with intermediate and complete information, though the selfishness dummy is significant only for complete information.

To assess the magnitude of these effects, in Figure 9 we show counterfactual agreement probabilities.[19] The line with square markers corresponds to a hypothetical "worst-case" negotiation. This negotiation is characterized by high risk tolerance (95th percentile of all negotiations), a selfishness dummy equal to 1—in the figure this is referred to as *High R/S*—and the percentage of alternating offers is $\mathbf{A} = 0$. The line with diamond markers keeps $\mathbf{A} = 0$, but assumes that risk tolerance is low (5th percentile of all negotiations) and the selfishness dummy equals 0. As can be seen, removing risk and conflicting fairness preferences leads to a substantial improvement in agreement probability in *Complete Info*

[19] Notice that in order to assess agreement probabilities for offer sequences, we have to take into account that an item does not have to be traded individually if it is already traded in a bundle, and a bundle does not have to be traded when the items it contains are traded in subsets. Hence, the counterfactuals are based on estimations from offer sequences whose items were not traded via other trades in the negotiation.

and *Intermediate Info*, but has virtually no effect in *No Info*. A similar effect for risk and fairness holds when $\mathbf{A} = 1$, see the difference between the triangle and circle markers.

Further, the importance of alternating offers for successful agreements is apparent for all information conditions. This can be seen by the increase from the square to the triangle markers as well as from the diamond to the circle markers in Figure 9. Because most negotiations in our experiment *are* characterized by alternating offers, the predicted agreement probability at the means of all variables—the dashed line with shaded 95% confidence interval in Figure 9—are closer to the upper two counterfactual predictions for which $\mathbf{A} = 1$.

Comparing Figures 9a, 9b, and 9c shows that risk preferences and conflicting fairness preferences are key factors that prevent higher efficiency levels for the intermediate and complete information structures. Inefficiency for the no information conditions, on the other hand, is mainly due to the inability of bargainers to discover a mutually beneficial price in negotiations with a small total surplus. We summarize this with our final result.

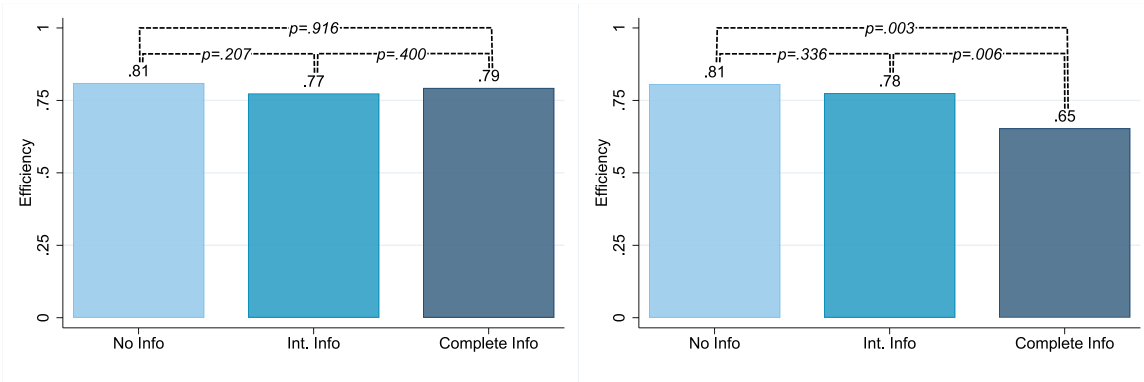
Result 7 *With intermediate and complete information, alternating-offer bargaining and risk/fairness preferences significantly affect agreement rates. In the no information conditions, alternating-offer bargaining and total surplus significantly affect agreement rates while risk/fairness preferences have no effect.*

5 Cost of Improved Information in Other Bargaining Institutions

Laboratory experiments face a challenge of external validity. This is a second-order issue when testing theoretically predicted effects, e.g., our Hypotheses 1 to 3, because the theory should apply in particular in the controlled environment of the labratory. When studying strategies, such as the alternating-offer bargaining pattern we document, there is less theoretical guidance and it is useful to combine the findings from our controlled environment with field data. Backus et al. (2020) provide a fascinating look at bargaining on eBay, and also find that alternating-offer bargaining and split-the-difference offers have a crucial impact on the likelihood of agreement. We were also able to connect the behavioral factors we documented to field data (Larsen, 2020).

However, Result 4 on the similarity of efficiency across treatments calls for further investigation, as it is neither theoretically predicted nor is there an established empirical literature pointing in the same direction. It is difficult to validate Result 4 in the field. It would require information about bargainers' valuations as well as exogenous variation in the information bargainers have access to. To offer a robustness check within the laboratory setting, we investigate two other bargaining institutions.

Figure 10: Efficiency and Information in Other Bargaining Institutions



(a) Ultimatum Bargaining (b) Noisy Information

Notes: Efficiency is calculated as the sum of realized surplus in a matching group divided by the sum of maximum surplus possible in the matching group and then averaged for each treatment.

5.1 Multi-Issue Ultimatum Bargaining

In the ultimatum game, a proposer makes a take-it-or-leave-it offer to a responder on how to share a surplus. If the responder accepts, the proposal is implemented. If the responder rejects, both parties earn a payoff of zero. When there are multiple issues, the proposer can submit *a set* of take-it-or-leave-it offers. In our setting with three items, there can thus be at most 7 offers, one for each individual item and each bundle. All offers are sent to the responder at the same time. The responder observes the set of offers and chooses which non-overlapping subset of offers to accept. That the responder can select multiple non-overlapping offers ensures that the bargaining protocol is sufficiently rich for the theoretical hypotheses from Section 3.5 to continue to hold.[20]

We conducted additional sessions on multi-issue ultimatum bargaining. Specifically, we collected data from 240 subjects (24 independent matching groups), 80 subjects for each information condition.[21] Ultimatum bargaining has historically been the most explored bargaining institution in the experimental sciences (e.g., Güth et al., 1982; Nowak et al., 2000). More importantly, for our purposes, one may expect ultimatum bargaining to lower efficiency in the incomplete information environments compared with unstructured bargaining. The reason is that, by design, back-and-forth offers, and hence gradual price discovery, are no longer possible. Price discovery is less crucial with complete information. The

[20]The richness condition in Jackson et al. (2020) requires that there exists a set of offers that, when accepted, allocates a fraction αTS to the proposer and $(1-\alpha)TS$ to the responder.

[21]For each information condition, we conducted 4 sessions with bundling and 4 with item-by-item offers. We confirm in these sessions the result that bundling is instrumental for reaching agreement when the efficient scope involves multiple items.

ultimatum game is thus a useful setting to test the robustness of Result 4.

As shown in Figure 10a, efficiency levels in ultimatum bargaining are again close to 80% for all information conditions. The small treatment differences are insignificant. In online Appendix B, we show that, as in the main treatments, more information promotes efficiency in small-surplus negotiations, but hinders agreement in large-surplus negotiations. The hurdles that prevent agreement under intermediate and complete information remain in place, in particular conflicting fairness preferences. Crucially, efficiency in *No Info* is *not* lowered when removing the possibility of repeated offers. The reason is that proposers lower their initial demands significantly below those in *Intermediate Info* and *Complete Info* (on average by 15% points of the total surplus), compensating for the informational incompleteness. We conclude that Result 4 carries over to ultimatum bargaining.

5.2 Noisy Information

We also conducted additional sessions using the unstructured bargaining environment but in a situation where information is noisy. Specifically, negotiators learn that their own valuations/costs for the three items lie in an *interval* (of size 5) but they do not known their true valuations/costs until after the bargaining game. Each value in the interval is equally likely. In *Intermediate Info*, negotiators also learn the *expected* total surplus associated with the buyer's valuation and the seller's cost intervals. In particular, we compute the expected surplus based on the realized intervals of valuations/costs and reveal this number to the bargainers. In *Complete Info*, negotiators in addition know the intervals of valuations/costs of the other party. We collected data from 180 subjects (18 independent matching groups) in this bargaining environment, 60 per information condition with bundling being possible in all sessions.

There are two main reasons why we consider this to be a setting worth exploring. First, it feels natural to assume that bargainers are uncertain about the exact valuation/cost they have for an item. One way to think about this is that items have a common value component, that is, the value of an item depends on how agents other than the bargaining pair will value it. Second, as with the ultimatum game, we expected that these treatments will favor the complete information condition and thus provide a good robustness test for Result 4. This is because we expected uncertainty about the exact valuations would reduce the impact of conflicting fairness preferences in *Complete Info* and also align the effects of risk preferences across conditions. These behavioral factors have been show to reduce efficiency under complete information but not incomplete information.

As shown in Figure 10b, the empirical results reveal that with noisy information efficiency is significantly *lower* in *Complete Info* than in *No Info* ($p = .003$) or *Intermediate Info* ($p = .006$). In online Appendix C, we show why this happens. For large-surplus items the additional uncertainty has almost no impact on agreement rates and the behavioral factors still adversely impact agreement probability. In particular, agreement rates with complete information remain below 75%. However, noisy information leads to a significant reduction in efficiency for low-surplus items in treatments with complete information, because there the additional noise is relatively large compared to the possible gains from trade. The key takeaway is that bargaining impasses under complete information are not an artefact of high information precision. Adding a small but non-negligible amount of uncertainty does not alleviate the detrimental impact of behavioral preferences.

There is another benefit we get from the noisy information treatments, which is that we can test if the results on the negotiation process from our main treatments replicate. We find that they do. In online Appendix C, we show that the number of offers made is almost double in *No Info* than in *Complete Info*, with *Intermediate Info* lying between the two, that the timing of offer acceptances is the same across treatments, and that bundled offers are significantly more aggressive than offers on single items. Most importantly, we show that negotiations are characterized by alternating-offer bargaining with frequent split-the-difference offers and that such offer sequences are significantly more likely to result in agreement than offer sequences that exhibit other bargaining formats.

6 Conclusion

The presence of multiple issues when studying bargaining adds an important layer of realism, as many real-life negotiations are richer and more complex than dividing-the-pie bargaining. We provide evidence from a controlled lab experiment to understand the effects of different information structures and trading institution in multi-issue bargaining. We also identify behavioral factors that characterize successful negotiations.

Our findings suggest the following rules for the design of bargaining institutions:

(*i*) In multi-issue bargaining, the bargaining protocol should allow for bundling of items, as item-by-item bargaining is less likely to lead to agreement when the surplus is distributed over multiple items.

(*ii*) Improving information among the negotiators about each other's valuations and costs for the different items promotes trade of *small-surplus* items. But in multi-issue bargaining, providing information about the total surplus in a negotiation, as opposed to more detailed information about each item, can suffice to achieve this effect.

(*iii*) Improving information among the negotiators about each other's valuations and costs tends to complicate agreement for *large-surplus* items, because relatively risk-tolerant bargainers are more likely to delay agreement under complete information and because distributional/fairness concerns start to negatively affect negotiations.

(*iv*) Therefore, establishing clear fairness norms is likely to promote agreement rates. Moreover, bargaining institution should not reward risk-taking by bargainers that is solely aimed at exploiting one's relatively higher willingness to risk disagreement (of course, risk-taking should often be rewarded when it concerns the fundamentals of a project). For example, exogenous deadlines should be avoided if possible.

(*v*) Negotiations most likely result in agreement when bargainers alternate in making offers. Split-the-difference offers (meet the other's offer halfway) are particularly likely to create an atmosphere of cooperation. We showed that bargainers tend to use these patterns endogenously, so there may often be no need to impose a rigid bargaining structure.

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THE FOLLOWING PAGES CONTAIN APPENDICES A TO D.

ALL APPENDICES ARE FOR ONLINE PUBLICATION ONLY.

Online Appendix A, B, C — Beyond Dividing the Pie: Multi-Issue Bargaining in the Laboratory

Olivier Bochet   Manshu Khanna   Simon Siegenthaler

Appendix A provides supplementary analysis for the main treatments with unstructured bargaining. Appendix B provides supplementary analysis for the treatments with ultimatum bargaining. Appendix C provides supplementary analysis for the treatments with noisy information.

A Unstructured Bargaining

Table 1 provides regressions of the demanded share of total surplus depending on the total surplus interacted with the bundle sizes. In contrast to the main text, here we provide the results focusing on accepted offers only. Models (1), (4) and (7) do not include a constant, thus the coefficients can be interpreted as the average realized share of total surplus. Models (2), (5) and (8) include a constant. Models (3), (6) and (9) include additional controls. Table 1 shows that the realized share of total surplus is not larger for bundles than for single-items in the *No Info* and *Intermediate Info* treatments.

Figure 1 shows the distribution of the proportion of alternating offers A across offer sequences. The histograms show that alternating-offers bargaining is the most important mode of interaction in all information treatments, and for both single-item and bundle offer sequences.

Figure 2 shows the distribution of Σ to highlight split-the-difference bargaining patterns. The histograms show that:

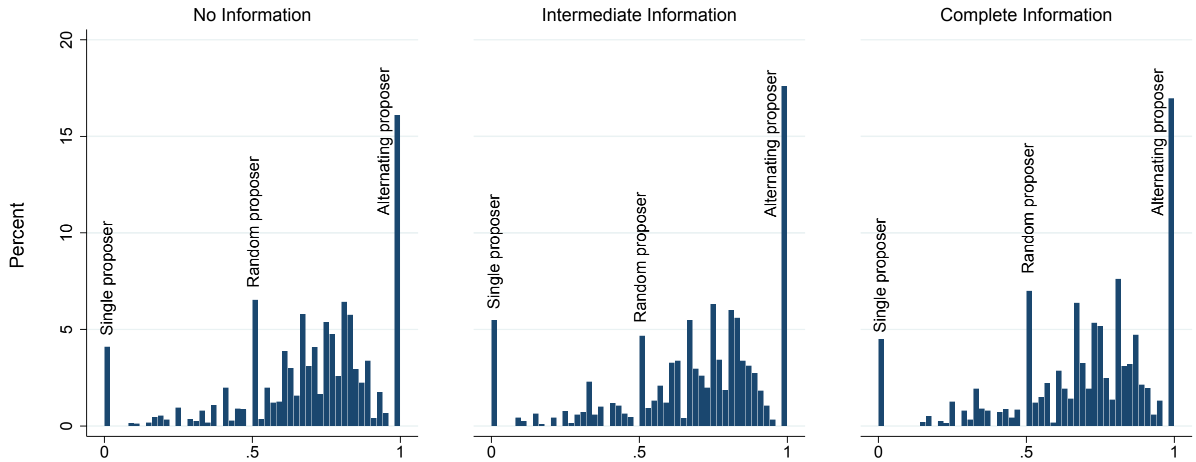
(i) There are no significant treatment differences (see 2a);

(ii) The patterns are observed for both single-item and bundle offer sequences (see 2b);

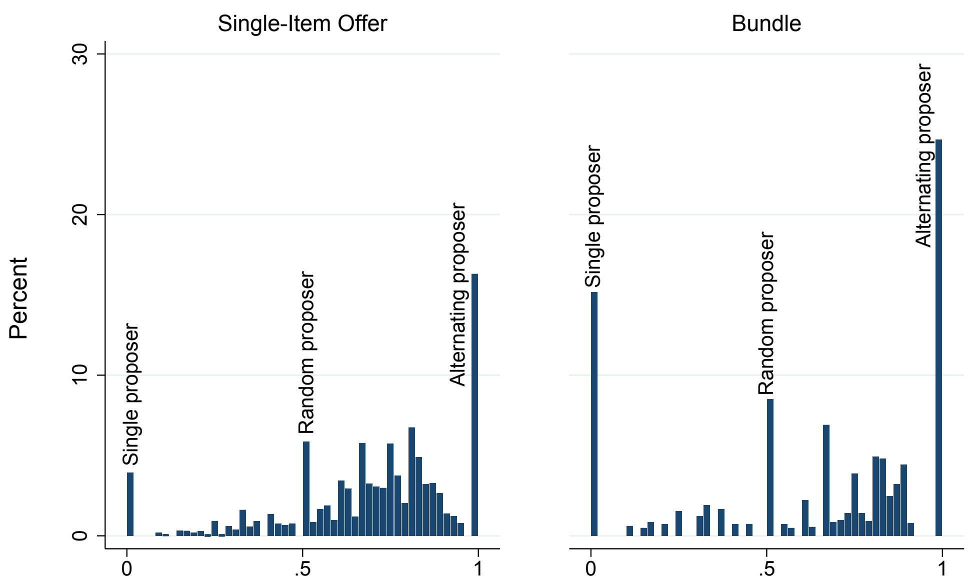
(iii) Split-the-difference offers are common for early offers in a sequence (see 2c).

Next, we extend the analysis of variable Σ to offer sequences that are not fully alternating. We do so by removing from the non-fully alternating offer sequences the non-alternating offers. Specifically, in an offer sequence, for each set of consecutive offers made by a player, we keep the last offer and remove the others. Suppose Ann makes the 1st, 2nd, 5th and 6th offer in an offer sequence while Bob makes the 3rd, 4th offer. Then, Ann's 2nd and 6th offer and Bob's 4th offer will be part of the sequence we used for subsequent analysis. Generating these offer sequences allows us to define Σ for offer sequences that are not fully alternating and thus provides a robustness check for the split-the-difference bargaining patterns presented for the fully alternating sequences. Figure 3 shows that including offer sequences that are not fully alternating does not change the results qualitatively. Most offers that do not insist on the previously proposed price meet the price proposed by the other party halfway to achieve a split-the-difference deal.

Figure 1: Histograms for Alternating Proposers



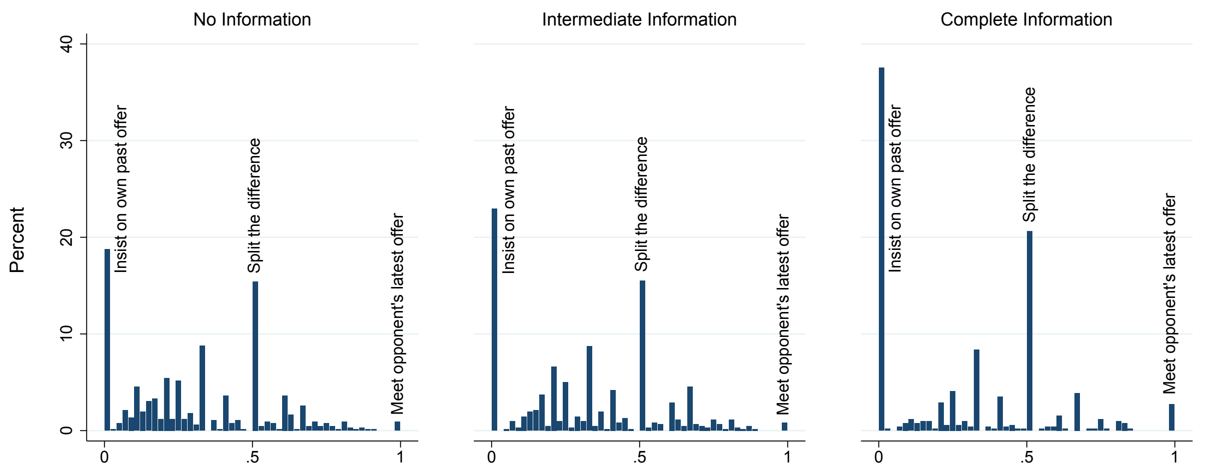
(a) Information



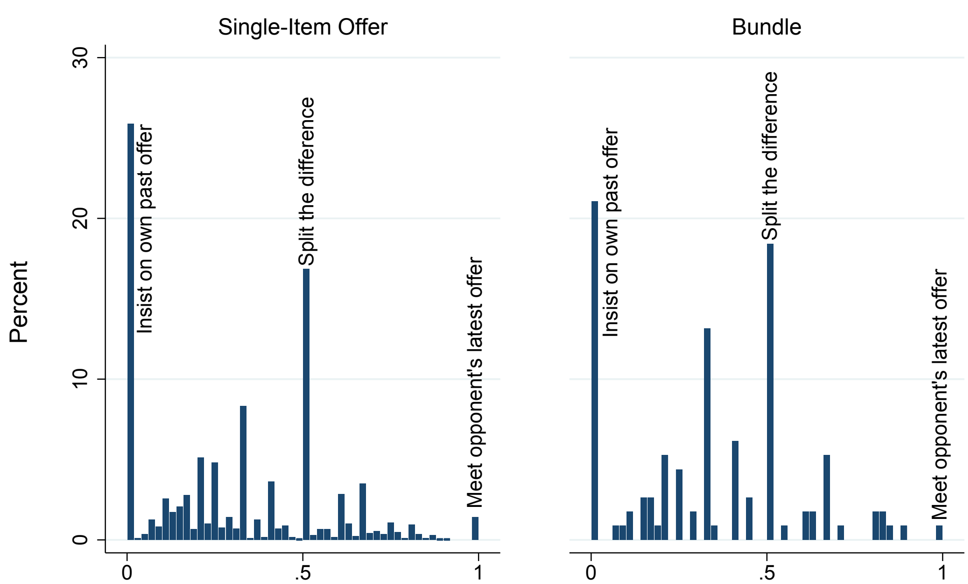
(b) Bundling

Notes: Figures show histograms for the proportion of alternating offers in a negotiation (A).

Figure 2: Histograms for Split-the-Difference

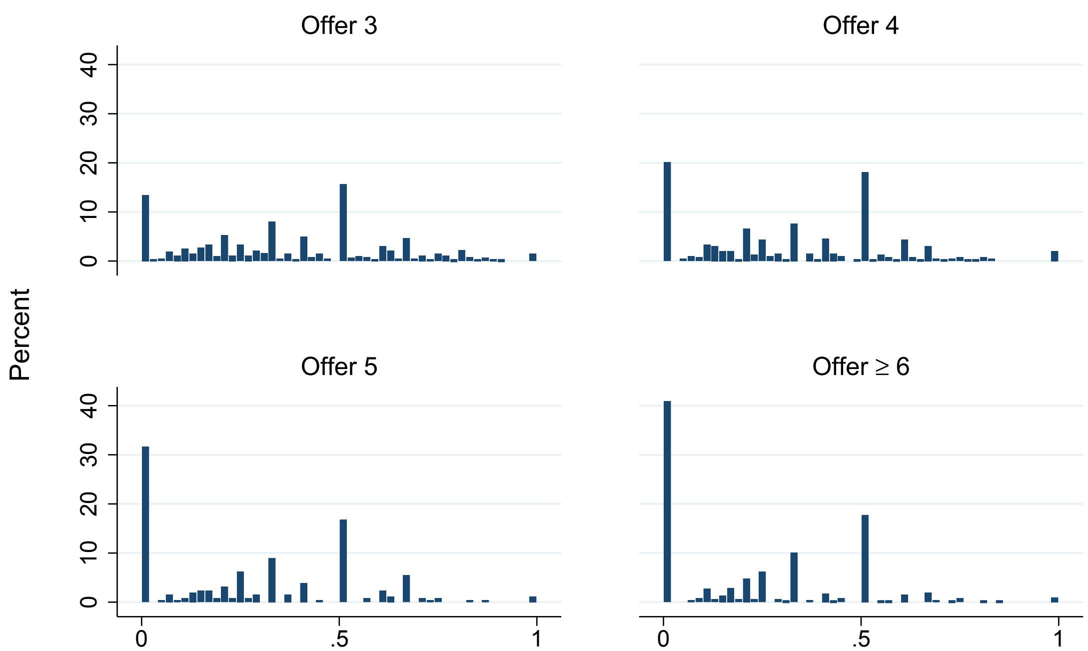


(a) Information



(b) Bundling

Figure 2: Histograms for Split-the-Difference



(c) By Offer Number

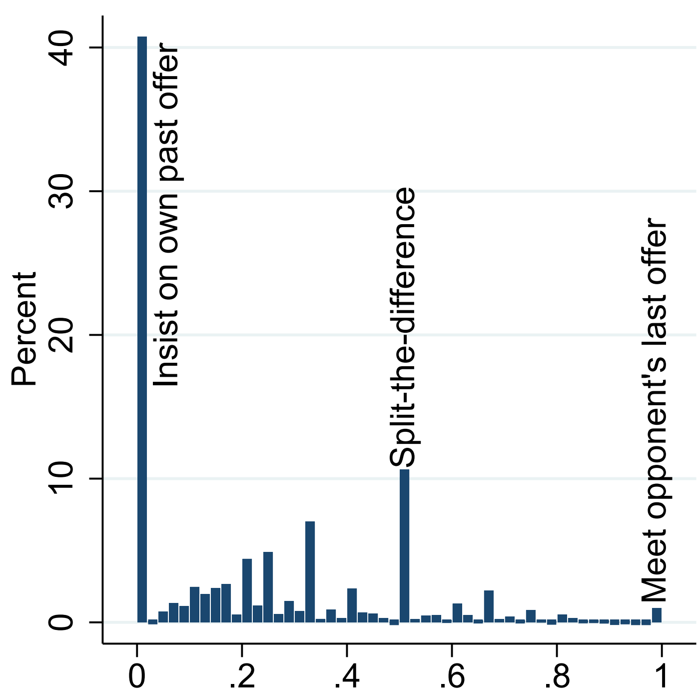
Notes: Figures shows a histogram of the split-the-difference measure (Σ).

Table 1: Realized Share of Total Surplus

	No Information			*Intermediate Information*			*Complete Information*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Total Surplus (TS)	0.440***	0.415***	0.345***	0.391***	0.342***	0.322***	0.336***	0.300***	0.292***
	(0.0217)	(0.0377)	(0.0451)	(0.0395)	(0.0571)	(0.0583)	(0.0237)	(0.0307)	(0.0281)
Two-Item Bundle ∗ TS	-0.0129	-0.00212	0.0159	0.0361	0.0487	0.0589	0.117***	0.125***	0.123***
	(0.0319)	(0.0275)	(0.0243)	(0.0393)	(0.0419)	(0.0421)	(0.0362)	(0.0337)	(0.0342)
Three-Item Bundle ∗ TS	-0.129	-0.110	-0.0951	0.115	0.131	0.149	0.0505	0.0649*	0.0634*
	(0.0954)	(0.0784)	(0.0778)	(0.103)	(0.105)	(0.103)	(0.0414)	(0.0337)	(0.0330)
Item-by-Item ∗ TS	0.0455	0.0499*	0.0546**	0.0495	0.0564	0.0561	0.0504*	0.0599**	0.0636**
	(0.0284)	(0.0278)	(0.0242)	(0.0478)	(0.0471)	(0.0478)	(0.0271)	(0.0278)	(0.0251)
Proposal Time (sec.)			-0.0176***			-0.0106***			0.00662***
			(0.00425)			(0.00226)			(0.00250)
Risk Tolerance			-0.141			0.162			-0.00425
			(0.276)			(0.203)			(0.157)
Selfishness			0.301			1.154**			-0.506
			(0.567)			(0.487)			(0.412)
Constant		0.508	3.923**		0.890*	0.680		0.659**	0.114
		(0.538)	(1.624)		(0.457)	(1.150)		(0.307)	(0.748)
Offers (N)	377	377	377	407	407	407	460	460	460
Matching Groups	17	17	17	17	17	17	17	17	17

Notes: * significant at 10%, ** significant at 5%, *** significant at 1%. OLS regressions for *No Info*, *Int. Info*, *Complete Info* with standard errors clustered on matching group level. Models (3), (6), (9) include period dummies.

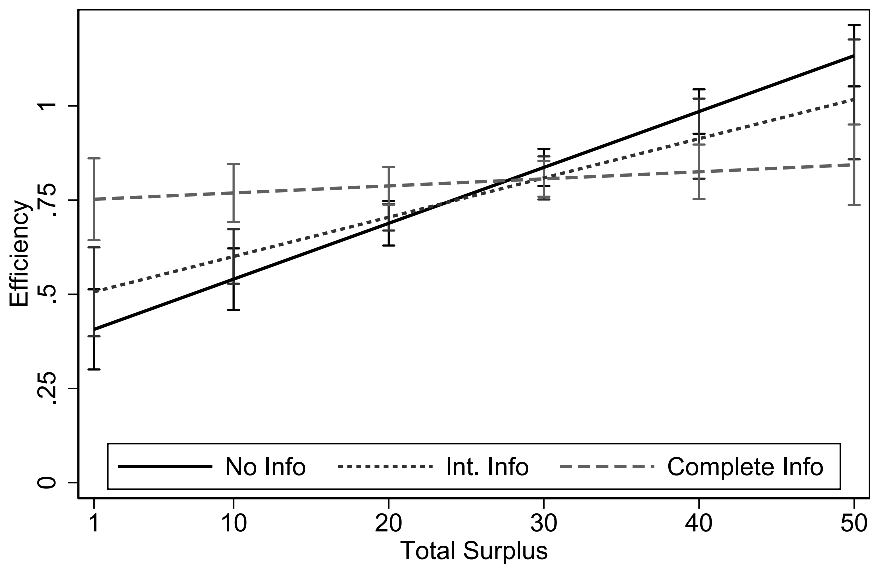
Figure 3: Histogram for Split-the-Difference Including Non-Fully-Alternating Offer Sequences



B Ultimatum Bargaining

Figure 4 shows that, as in the main treatments, improved information facilitates trade of small-surplus items and thus raises efficiency, but improved information plays the opposite role for large-surplus items. Table 2 shows that fairness preferences are among the main hurdles that prevent agreement under complete information, as the selfish dummy has a significant and negative effect on the probability of agreement.

Figure 4: Multi-Issue Ultimatum Bargaining: Efficiency



Notes: Efficiency is calculated as the sum of realized surplus divided by the sum of maximum surplus in a matching group and then averaged for each treatment. Predicted probabilities with 95% confidence intervals are from linear random effects regressions with dependent variable efficiency on the negotiation-level (realized surplus divided by maximum surplus available in a given negotiation) and standard errors clustered on matching groups.

Table 2: Ultimatum Bargaining: Regressions—Probability of Agreement and Efficiency

	Agreement
Int. Info	0.358
	(0.246)
Complete Info	0.715***
	(0.211)
Surplus	0.0486***
	(0.00508)
Int. Info ∗ S	-0.0172**
	(0.00775)
Complete Info ∗ S	-0.0469***
	(0.00761)
Selfishness	0.230***
	(0.0709)
Int. Info ∗ Selfishness	-0.378**
	(0.164)
Complete Info ∗ Selfishness	-0.424***
	(0.102)
Risk Tolerance	-0.0226
	(0.0348)
Int. Info ∗ Risk Tolerance	0.0255
	(0.0473)
Complete Info ∗ Risk Tolerance	0.0679
	(0.0447)
Period	-0.00389
	(0.0100)
Constant	0.540***
	(0.170)
Items	832
Matching Groups	24

Notes: * significant at 10%, ** significant at 5%, *** significant at 1%. Standard errors in parentheses. Random effects for probability of agreement (linear) with standard errors clustered on matching group level. Reference group: *No Info*. The variable Surplus corresponds to the surplus of an item. Risk Tolerance is taken from the proposer in a negotiation. Selfishness is a dummy variable that indicates if at least one of the bargainers in a pair is classified as selfish.

C Unstructured Bargaining with Noisy Information

Figure 5 shows that noisy information leads to a reduction in efficiency for small-surplus items in *Complete Info* compared to the main treatments, thus making the efficiency gains from information disappear for small-surplus items as well.

In the main text we presented results regarding the negotiation process for our main treatments. Now we show that the results replicate well in the treatments with noisy information.

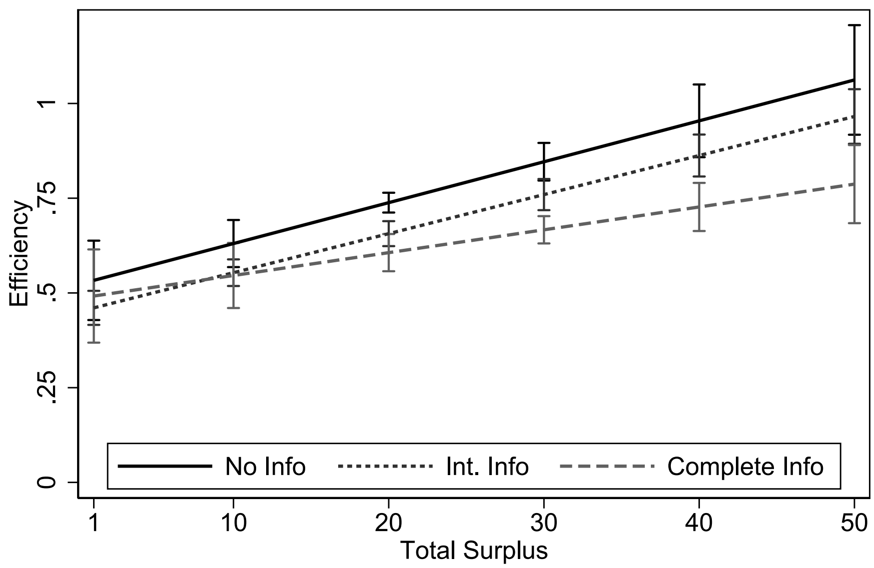
(i) Figure 6 shows the number of offers made is almost double in *No Info* than in *Complete Info*, with *Int. Info* lying between the two. The timing of offer acceptances is the same across treatments.

(ii) Table 3 shows that bundled offers are significantly more aggressive than offers on individual items.

(iii) Figure 7 most negotiations are characterized by alternating offers bargaining, with frequent split-the-difference offers.

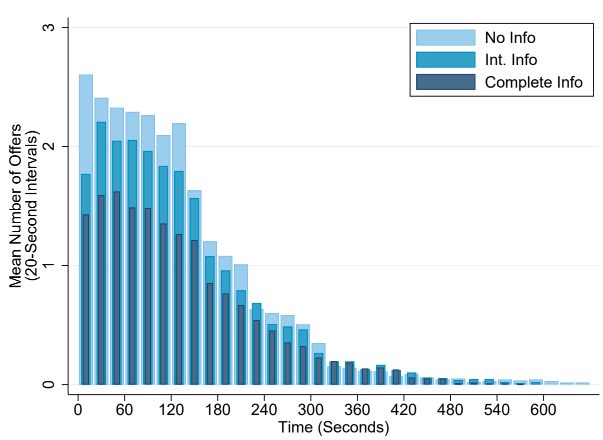
(iv) Figure 8 shows that offer sequences with a larger percentage of alternating offers are substantially more likely to result in agreement, and split-the-difference offers are particularly likely to be accepted.

Figure 5: Noisy Information: Efficiency

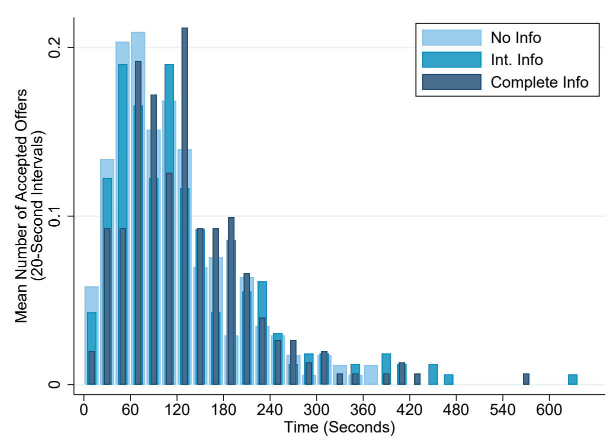


Notes: Efficiency is calculated as the sum of realized surplus divided by the sum of maximum surplus in a matching group and then averaged for each treatment. Predicted probabilities with 95% confidence intervals are from linear random effects regressions with dependent variable efficiency on the negotiation-level (realized surplus divided by maximum surplus available in a given negotiation) and standard errors clustered on matching groups.

Figure 6: Noisy Information: Timing of Proposed and Accepted Offers



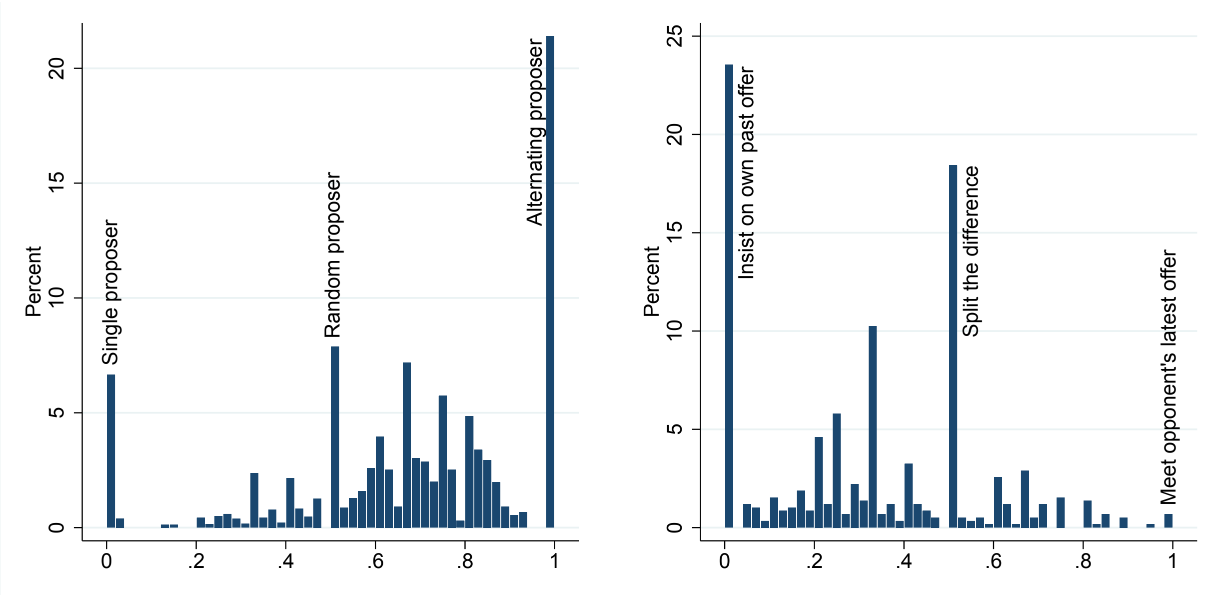
(a) Offers over Time



(b) Acceptances over Time

Notes: Figure ***(a)*** shows the mean number of proposed offers (single-item and bundles) per 20-second interval averaged by information structure. Figure ***(b)*** shows the mean number of accepted offers.

Figure 7: Noisy Information: Alternating Proposers and Split-the-Difference

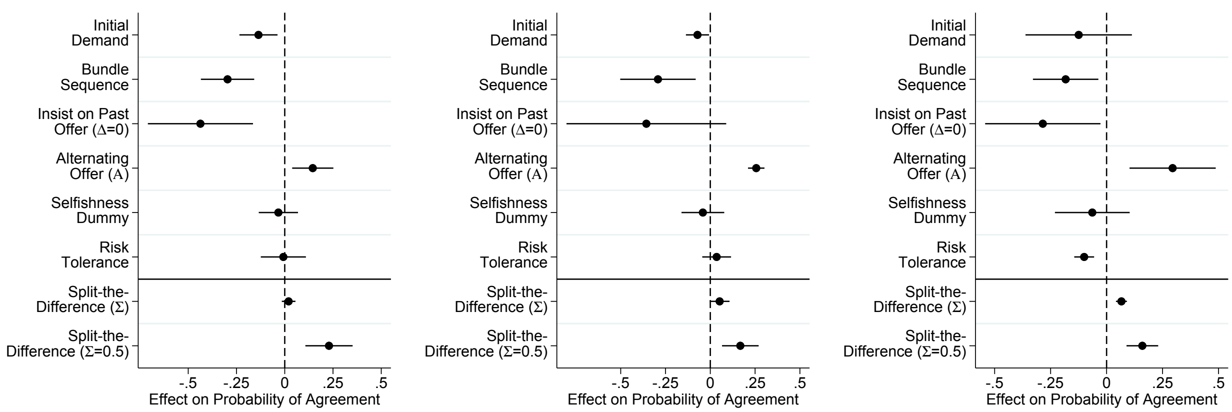


(a) Alternating Offers (A)

(b) Split-the-Difference (Σ)

Notes: Figure ***(a)*** shows a histogram for the percentage of alternating offers in a negotiation (A). Figure ***(b)*** shows a histogram of the split-the-difference measure (Σ).

Figure 8: Noisy Information: Negotiation Process and Agreement Probability



(a) No Information

(b) Intermediate Information

(c) Complete Information

Notes: Marginal effects and 95% confidence intervals (cluster-robust standard errors) from linear random effects models on the probability of agreement of different bargaining process variables. The unit of observation is an offer sequence for the coefficients above the horizontal line and a single offer for coefficients below the horizontal line.

Table 3: Demanded Share of Total Surplus

	No Information			*Intermediate Information*			*Complete Information*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Total Surplus (TS)	0.545***	0.107**	0.0749	0.547***	0.243***	0.205***	0.430***	0.276***	0.277***
	(0.0163)	(0.0479)	(0.0461)	(0.0246)	(0.0435)	(0.0297)	(0.0465)	(0.0510)	(0.0413)
Two-Item Bundle ∗ TS	0.118***	0.246***	0.231***	0.0739***	0.148***	0.159***	0.0803	0.126***	0.134***
	(0.0221)	(0.0340)	(0.0273)	(0.0154)	(0.0235)	(0.0221)	(0.0418)	(0.0390)	(0.0388)
Three-Item Bundle ∗ TS	0.497***	0.653***	0.579***	0.255***	0.394***	0.385***	0.248**	0.301***	0.290***
	(0.0692)	(0.0525)	(0.0558)	(0.0338)	(0.0436)	(0.0469)	(0.0829)	(0.0683)	(0.0554)
Proposal Time (sec.)			-0.0255***			-0.0163***			-0.0129***
			(0.00314)			(0.00457)			(0.00171)
Risk Tolerance			-0.0522			-0.0553			-0.0935
			(0.246)			(0.312)			(0.248)
Selfishness			-0.657			1.704*			0.451
			(1.090)			(0.940)			(0.651)
Constant		6.458***	9.506***		4.887***	6.159***		3.022***	5.610***
		(0.722)	(1.017)		(0.536)	(1.277)		(0.470)	(1.186)
Offers (N)	3063	3063	3063	2536	2536	2536	2039	2039	2039
Matching Groups	6	6	6	6	6	6	6	6	17

Notes: * significant at 10%, ** significant at 5%, *** significant at 1%. OLS regressions for *No Info*, *Int. Info*, *Complete Info* with standard errors clustered on matching group level. Models (3), (6), (9) include period dummies.

Online Appendix D

Beyond Dividing the Pie:

Multi-Issue Bargaining in the Laboratory

By Olivier Bochet, Manshu Khanna and Simon Siegenthaler

This online appendix contains the experiment instructions for three of the twelve treatments discussed in the article. The instructions are representative as the instructions for the remaining nine treatments follow directly from them. Please contact the authors for the full set of instructions.

[Treatment: Free-form Bargaining & Bundling & Intermediate Information]

General Instructions

Welcome to the Laboratory for Research in Experimental Economics.

Your earnings from the experiment will largely depend on your decisions and the decisions of others. Therefore, it is important that you read the instructions carefully. The experiment consists of three parts that are independent of each other. The instructions for Part 1 can be found on the following pages. The instructions for Part 2 and Part 3 will be given on the computer screen.

In the experiment, we will not speak of EUR, but rather of ECU (Experimental Currency Units). At the end of the experiment the total amount of ECU you earned will be converted to EUR at the **exchange rate ECU 1 = EUR 0.25**. The final earnings will be rounded to the closest 10 cents. You will also receive a **show up fee** of **EUR 5**. You will be paid your earnings in cash, privately at the end of the session.

All interactions between you and other participants will occur through the computer terminals. Please do not talk directly to or attempt to communicate with other participants during the session. Please also do not ask questions aloud. If you have a question, raise your hand and a member of the experimenter team will come to you. All personal electronic devices should remain switched off until the end of the experiment.

Please now proceed to the instructions for Part 1.

Instructions Part 1

General Description of the Experiment

At the beginning of the experiment, all participants in the room will be divided into groups of 10. We will refer to this group as your “matching group”. In each matching group, the computer will randomly determine **5 buyers** and **5 sellers**. You will be either in the role of a buyer or a seller. If you are buyer (respectively, a seller), you will be a buyer (respectively, a seller) for the entire experiment. At the start of Part 1, everyone will receive 8 ECU to begin with.

You will play **10 rounds** of a decision situation. At the start of each round, you will be **randomly matched** with another participant in your matching group. In particular, if you are a buyer, you will be matched at random to one of the 5 sellers in your matching group. If you are a seller, you will be matched at random to one of the 5 buyers in your matching group. Hence, the person you are matched with will typically change between rounds. You will never know the identity of the person with whom you are matched in a given round or of the people in your matching group.

Decision Situation in each Round

We will now explain the decision situation you will face in each of the 10 rounds.

Objects

In each round, there are **3 objects**: **object A, object B and object C**. For each object, the buyer has a **valuation**. A valuation is the worth a buyer assigns to an object. Similarly, for each object, the seller has a **production cost**. The production cost is the cost the seller incurs if producing an object in order to sell it to the buyer.

At the beginning of each round, the buyer’s valuations and the seller’s production costs for the 3 objects will be randomly chosen to be **0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32 or 33 ECU.** Any value between 0 ECU and 33 ECU is **equally likely.** All valuations and production costs are randomly determined by the computer and are independent of each other, that is, the buyer’s values for the different objects will typically not be the same and neither will the seller’s production costs.

Information

The buyer’s valuations and the seller’s production costs are **private information**. In particular, the buyer will be told his or her valuations for the 3 objects and the seller will be told his or her production costs for the 3 objects. However, we will not tell the buyer what the seller’s production costs are and neither will we tell the seller the buyer’s valuations.

There is an additional piece of information that both the buyer and the seller will know: each participant will be told the **maximal surplus** the buyer and the seller could realize in a given round. The maximal surplus corresponds to the maximal earnings the buyer and the seller can jointly realize in this round. In other words, the maximal surplus is the sum of the buyer's and the seller's earnings if they only trade the objects for which the buyer's valuation exceeds the seller's production cost. (An object generates a negative surplus if the buyer's valuation is smaller than the seller's production costs)

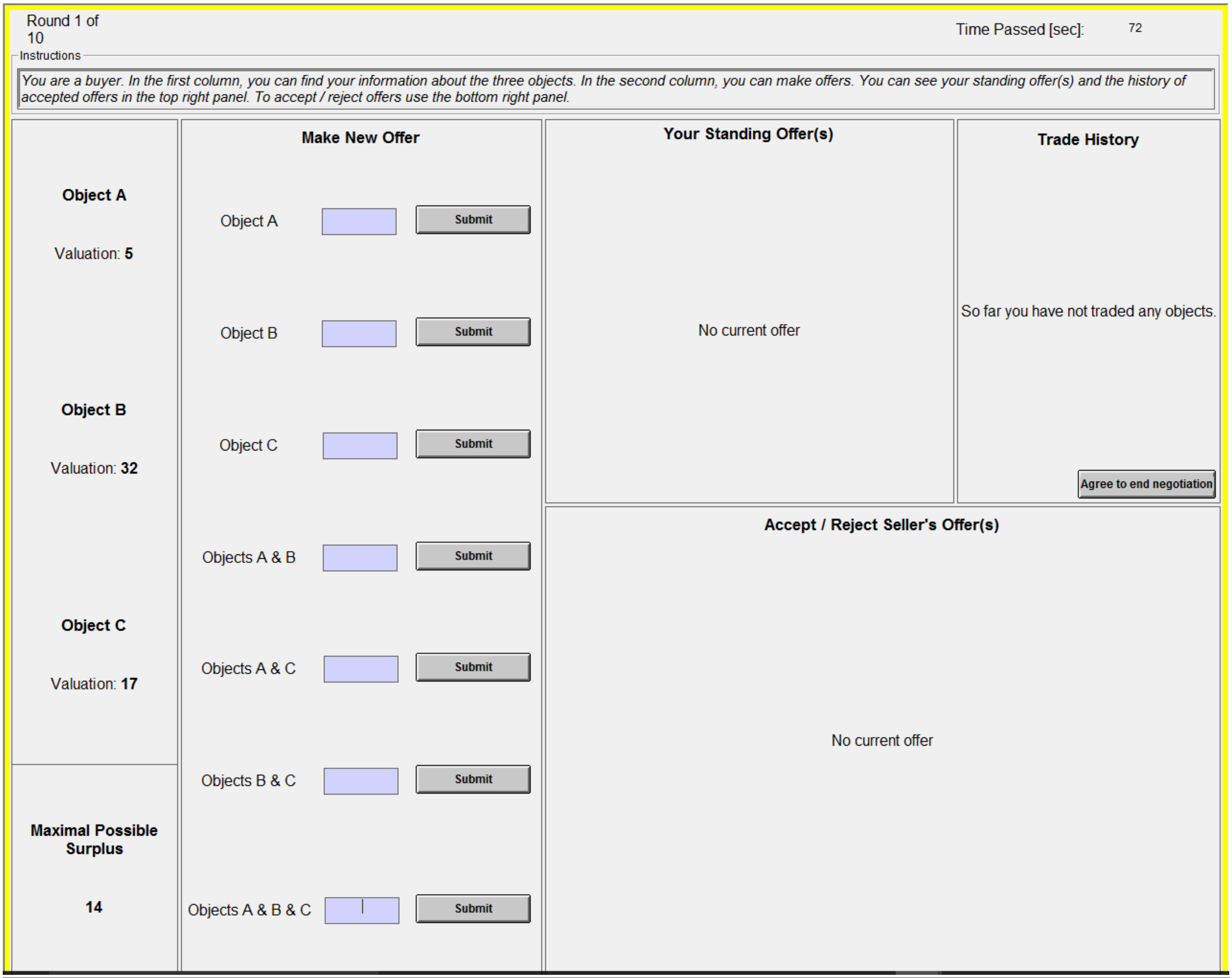
To understand what the maximal surplus is, it is easiest to look at an *example*:
Suppose the buyer's valuations are **15** for object A, **10** for object B and **5** for object C.
The seller's production cost is **7** for each of the objects.
The possible surplus for object A is therefore **15 – 7 = 8**.
The possible surplus for object B is **10 – 7 = 3**.
The possible surplus for object C is **0**, because if the object is traded the buyer receives a valuation of 5 and the seller pays a production cost of 7, and 5 – 7 = –2 is negative. Trading object C generates a negative surplus.
Thus, in this example, the maximal surplus is **8 + 3 + 0 = 11**. It is obtained if objects A and B are traded and object C is not traded.

We next describe the **bargaining process**. The bargaining process will determine which objects the buyer and the seller trade, and the price at which the objects are traded.

Making Offers
The buyer and seller will both be able to make offers. **An offer includes a selection of objects and a price.** Thus, when you are buyer, an offer will specify which objects you would like to buy and the price for these objects. When you are a seller, an offer will specify which objects you would like to sell and the price of these objects.

Since there are 3 objects, there are **7 possible selections of objects: {A}**, **{B}**, **{C}**, **{A, B}**, **{A, C}**, **{B, C}** and **{A, B, C}**. An offer will be a selection of objects and a price at which you would like to trade the selected objects. **The price has to be a whole number between 0 and 33 ECU for a single object, between 0 and 66 ECU for a selection of two objects and between 0 and 99 ECU for an offer that includes all three objects.** The price is for the whole selection of objects, for instance, if a seller accepts to sell objects A and B at a price of 29 ECU, s/he receives 29 ECU for both objects together, and not 29 ECU per object.

Below you can see a screen shot of the experiment. The screen shows the situation of a buyer. Notice that the buyer can **see his/her valuations for each object on the left-hand side of the screen, but s/he does not know the production costs of the seller. You can see the maximal possible surplus in the bottom left corner of the screen**. You can further see the 7 possible selections of objects. To make an offer, you can enter a price in the box next to the selection of objects you wish to buy / sell and click on "Submit". You can make up to 7 simultaneous offers, one for each selection of objects. You can revise an offer by making a new offer for the same selection of objects. You can also cancel an offer, in which case this offer will be removed from your standing offers.


Round 1 of
10
Time Passed [sec]:
72
Instructions
You are a buyer. In the first column, you can find your information about the three objects. In the second column, you can make offers. You can see your standing offer(s) and the history of accepted offers in the top right panel. To accept / reject offers use the bottom right panel.
Object A
Valuation: 5
Object B
Valuation: 32
Object C
Valuation: 17
Maximal Possible Surplus
14
Make New Offer
Object A
Object B
Object C
Objects A & B
Objects A & C
Objects B & C
Objects A & B & C
Submit
Your Standing Offer(s)
No current offer
Trade History
So far you have not traded any objects.
Agree to end negotiation
Accept / Reject Seller's Offer(s)
No current offer

<u>Accepting and Rejecting Offers</u>

You will also decide whether you would like to accept or reject the offers made by the other party. If an offer is accepted, the corresponding selection of objects is traded at the specified price. If an offer is rejected, the offer is removed from the list of offers. In a given round, **it is possible that the buyer and the seller agree to trade several different selections of objects.** For example, it is possible that objects {A, C} are traded first and then, later on, object B is traded as well. Of course, offers cannot include objects which have already been traded.

<u>Timing</u>

The buyer and the seller can make, accept or reject offers at any time they wish to do so. In the top right corner of the screen, you will see how long the bargaining process has already lasted.

<u>When Does Bargaining End?</u>

There are three ways the bargaining process can end.

- The bargaining process will be stopped if all **3 objects have been traded**.
- The bargaining process may also end at a random point in time before all objects have been traded. We will refer to this as a **bargaining breakdown**. This will not happen during the **first minute.** After the first minute, bargaining will be stopped with a probability of **4% every 10 seconds**. This means that bargaining breaks down at exactly 1 minute with a probability of 4%. With a probability of 96% bargaining continues beyond 1 minute. The next point in time at which bargaining could break down is 1 minute and 10 seconds, and so on. You do not need to calculate the breakdown probabilities. It is sufficient to know that this implies that bargaining never breaks down before 1 minute, bargaining does not break down before 2 minutes with a probability of 78%, before 3 minutes with 61%, before 4 minutes with 48%, before 5 minutes with 38%, before 6 minutes with 29%, before 7 minutes with 23%, before 8 minutes with 18%, before 9 minutes with 14%, before 10 minutes with 11%, before 11 minutes with 9%, and before 12 minutes with 7%. If bargaining has not ended after 12 minutes, we will stop at 12 minutes.
- The third way through which the bargaining process can end is if the buyer and the seller **agree to end negotiations**. In particular, there will be a button “agree to end negotiation”, and the bargaining process ends if both bargaining parties click the button. You will not observe if the other bargaining party has clicked the button, that is, to end bargaining both parties need to click the button independently.

<u>Earnings</u>

As a buyer, your earnings will depend on your valuations and on the prices you agree to pay. For each object you buy, you will earn your valuation minus the agreed price.

Buyer's Earnings = Sum of valuations of traded objects – Sum of prices for traded objects

As a seller, your earnings will depend on your production costs and on the prices at which you agree to sell objects. For each object you sell, you will earn the agreed price minus your production cost.

Seller's Earnings = Sum of prices for traded objects – Sum of production costs of traded objects

Untraded objects do not affect your earnings. In other words, if the bargaining process ends before all three objects are traded, **the earnings for the untraded objects are zero**.

Below you can find five examples of how earnings are calculated. All examples are to help you understand better the experiment. They should not be considered as guides on how to behave in the experiment.

Example 1: You are a buyer and your valuation for object A is 26. You made an offer to buy object A at a price of 20 and the offer was accepted. No other offers were accepted. Then you will earn 26 ECU – 20 ECU = 6 ECU.

Example 2: You are a seller and your production costs are 8 for object A and 17 for object B. You offer to sell object A at a price of 13 and the buyer accepts the offer. You also accept an offer by the buyer to buy object B at a price of 19. Then you will earn 13 ECU + 19 ECU – 8 ECU – 17 ECU = 7 ECU.

Example 3: You are a buyer with valuations 33 for object B and 15 for object C. You buy objects B and C jointly at a price of 32. Then you will earn 33 ECU + 15 ECU – 32 ECU = 16 ECU.

Example 4: You are a seller and your production costs are 17 for each object A and B and 28 for object C. You sell objects A, B and C jointly for a price of 57. Then you will earn 57 ECU – 17 ECU – 17 ECU – 28 ECU = – 5 ECU. That is, you will lose 5 ECU.

Example 5: The buyer's valuations are 10 for object A, 20 for object B and 30 for object C. The seller's production costs are 24 for object A, 18 for object B and 12 for object C. If the buyer and the seller trade object A, the generated surplus is 10 ECU – 24 ECU= –14 ECU. The generated surplus if object B is traded is 20 ECU – 18 ECU= 2 ECU. The generated surplus if object C is traded is 30 ECU – 12 ECU= 18 ECU. In this example, the maximal possible surplus of 2 ECU + 18 ECU = 20 ECU is thus achieved if objects B and C are traded and object A is not traded.

Your earnings from each of the 10 rounds will be summed up and paid to you at the end of the session. If your earnings in a given round are below 0 ECU, the amount will be subtracted from your previous earnings. If your earnings at the end of the experiment are below 5 EUR, you will receive the minimum of 5 EUR. As a buyer, you should thus be careful to not accept or make offers for which you pay more for an object than your valuation. As a seller, you should be careful to not accept or make offers for which your production cost for an object exceed the selling price.

All 10 rounds of this part of the experiment will be the same, except that your valuations (as a buyer) or productions costs (as a seller) for the objects are randomly determined at the beginning of each round, and the participant you are matched with will change between rounds.

This completes the description of the instructions. If you have any questions, please raise your hand. Otherwise, please proceed to answer the questions that will be shown on your computer. The purpose of the questions is to make sure that you understand the different elements of the experiment. Any unclear points will be explained by the experimenter.

[Treatment: Free-form Bargaining & Item-by-item & Full Information]

General Instructions

Welcome to the Laboratory for Research in Experimental Economics.

Your earnings from the experiment will largely depend on your decisions and the decisions of others. Therefore, it is important that you read the instructions carefully. The experiment consists of three parts that are independent of each other. The instructions for Part 1 can be found on the following pages. The instructions for Part 2 and Part 3 will be given on the computer screen.

In the experiment, we will not speak of EUR, but rather of ECU (Experimental Currency Units). At the end of the experiment the total amount of ECU you earned will be converted to EUR at the **exchange rate ECU 1 = EUR 0.25**. The final earnings will be rounded to the closest 10 cents. You will also receive a **show up fee** of **EUR 5**. You will be paid your earnings in cash, privately at the end of the session.

All interactions between you and other participants will occur through the computer terminals. Please do not talk directly to or attempt to communicate with other participants during the session. Please also do not ask questions aloud. If you have a question, raise your hand and a member of the experimenter team will come to you. All personal electronic devices should remain switched off until the end of the experiment.

Please now proceed to the instructions for Part 1.

Instructions Part 1

General Description of the Experiment

At the beginning of the experiment, all participants in the room will be divided into groups of 10. We will refer to this group as your "matching group". In each matching group, the computer will randomly determine **5 buyers** and **5 sellers**. You will be either in the role of a buyer or a seller. If you are buyer (respectively, a seller), you will be a buyer (respectively, a seller) for the entire experiment. At the start of Part 1, everyone will receive 8 ECU to begin with.

You will play **10 rounds** of a decision situation. At the start of each round, you will be **randomly matched** with another participant in your matching group. In particular, if you are a buyer, you will be matched at random to one of the 5 sellers in your matching group. If you are a seller, you will be matched at random to one of the 5 buyers in your matching group. Hence, the person you are matched with will typically change between rounds. You will never know the identity of the person with whom you are matched in a given round or of the people in your matching group.

Decision Situation in each Round

We will now explain the decision situation you will face in each of the 10 rounds.

Objects

In each round, there are **3 objects**: **object A, object B and object C**. For each object, the buyer has a **valuation**. A valuation is the worth a buyer assigns to an object. Similarly, for each object, the seller has a **production cost**. The production cost is the cost the seller incurs if producing an object in order to sell it to the buyer.

At the beginning of each round, the buyer's valuations and the seller's production costs for the 3 objects will be randomly chosen to be **0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32 or 33 ECU.** Any value between 0 ECU and 33 ECU is **equally likely.** All valuations and production costs are randomly determined by the computer and are independent of each other, that is, the buyer's values for the different objects will typically not be the same and neither will the seller's production costs.

Information

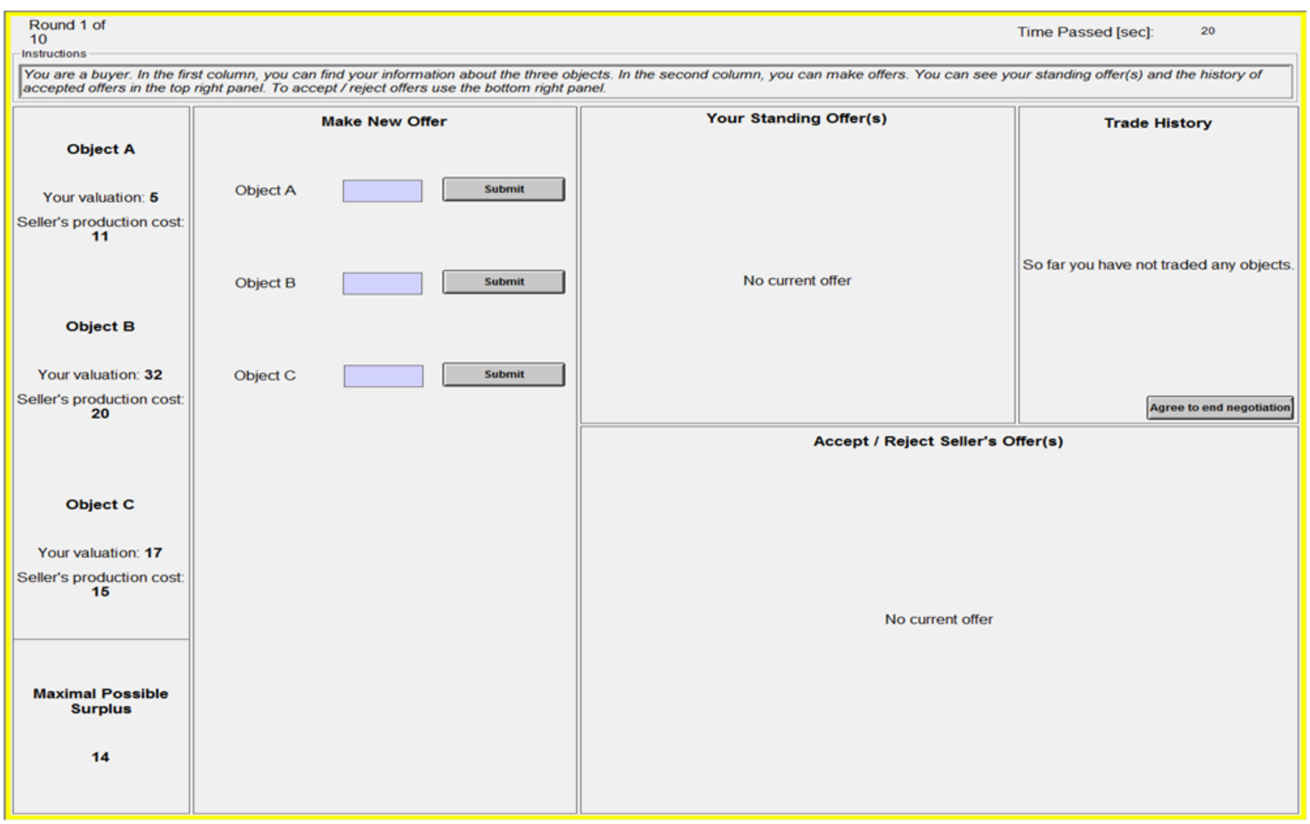
The buyer and the seller will be informed about all valuations and production costs. In particular, at the beginning of a round, the buyer will be told his/her valuations as well as the seller's production costs for each of the 3 objects. The same applies to the seller.

We next describe the **bargaining process**. The bargaining process will determine which objects the buyer and the seller trade, and the price at which the objects are traded.

Making Offers

The buyer and seller will both be able to make offers. **An offer includes an object and a corresponding price.** Thus, when you are buyer, an offer will specify the object you would like to buy and the price for this object. When you are a seller, an offer will specify which object you would like to sell and the price of the objects. **The price has to lie between 0 and 33 ECU and has to be a whole number.** For instance, a seller could offer to sell object A at a price of 29 ECU, or a buyer could offer to buy object B at a price of 4 ECU.

Below you can see a screen shot of the experiment. The screen shows the situation of a buyer. Notice that **the buyer can see his or her valuations as well as the seller's production costs on the left-hand side of the screen.** You can also see the **maximal possible surplus,** which is given by the sum of the buyer's and the seller's earnings when trading all objects for which the buyer's valuation exceeds the seller's production cost. The screen will be the same for the seller, except that s/he will see his/her production costs instead of the valuations (s/he will also see the buyer's valuations). As you can see, there are 3 objects. To make an offer, you can enter a price in the box next to the object you wish to buy / sell and click on "Submit". You can make up to 3 simultaneous offers, one for each object. You can revise an offer by making a new offer for the same object. You can also cancel an offer, in which case this offer will be removed from your standing offers.



Accepting and Rejecting Offers

You will also decide whether you would like to accept or reject the offers made by the other party. If an offer is accepted, the corresponding object is traded at the specified price. If an offer is rejected, the offer is removed from the list of offers. In a given round, **it is possible that the buyer and the seller agree to trade several objects.** For example, it is possible that object A is traded first and then, later on, object B is traded as well. Of course, offers cannot include objects which have already been traded.

Timing

The buyer and the seller can make, accept or reject offers at any time they wish to do so. In the top right corner of the screen, you will see how long the bargaining process has already lasted.

When Does Bargaining End?

There are three ways the bargaining process can end.

- The bargaining process will be stopped if all **3 objects have been traded**.
- The bargaining process may also end at a random point in time before all objects have been traded. We will refer to this as a **bargaining breakdown**. This will not happen during the **first minute.** After the first minute, bargaining will be stopped with a probability of **4% every 10 seconds**. This means that bargaining breaks down at exactly 1 minute with a probability of 4%. With a probability of 96% bargaining continues beyond 1 minute. The next point in time at which bargaining could break down is 1 minute and 10 seconds, and so on. You do not need to calculate the breakdown probabilities. It is sufficient to know that this implies that bargaining never breaks down before 1 minute, bargaining does not break down before 2 minutes with a probability of 78%, before 3 minutes with 61%, before 4 minutes with 48%, before 5 minutes with 38%, before 6 minutes with 29%, before 7 minutes with 23%, before 8 minutes with 18%, before 9 minutes with 14%, before 10 minutes with 11%, before 11 minutes with 9%, and before 12 minutes with 7%. If bargaining has not ended after 12 minutes, we will stop at 12 minutes.
- The third way through which the bargaining process can end is if the buyer and the seller **agree to end negotiations**. In particular, there will be a button "agree to end negotiation", and the bargaining process ends if both bargaining parties click the button. You will not observe if the other bargaining party has clicked the button, that is, to end bargaining both parties need to click the button independently.

Earnings

As a buyer, your earnings will depend on your valuations and on the prices you agree to pay. For each object you buy, you will earn your valuation minus the agreed price.

Buyer's Earnings = Sum of valuations of traded objects – Sum of prices for traded objects

As a seller, your earnings will depend on your production costs and on the prices at which you agree to sell objects. For each object you sell, you will earn the agreed price minus your production cost.

Seller's Earnings = Sum of prices for traded objects – Sum of production costs of traded objects

Untraded objects do not affect your earnings. In other words, if the bargaining process ends before all three objects are traded, **the earnings for the untraded objects are zero**.

Below you can find five examples of how earnings are calculated. All examples are to help you understand better the experiment. They should not be considered as guides on how to behave in the experiment.

Example 1: You are a buyer and your valuation for object A is 26. You made an offer to buy object A at a price of 20 and the offer was accepted. No other offers were accepted. Then you will earn 26 ECU – 20 ECU = 6 ECU.

Example 2: You are a seller and your production costs are 8 for object A and 17 for object B. You offer to sell object A at a price of 13 and the buyer accepts the offer. You also accept an offer by the buyer to buy object B at a price of 19. Then you will earn 13 ECU + 19 ECU – 8 ECU – 17 ECU = 7 ECU.

Example 3: You are a buyer with valuations 33 for object B and 15 for object C. You buy object B at a price of 20 and object C at a price of 12. Then you will earn 33 ECU + 15 ECU – 20 ECU – 12 ECU = 16 ECU.

Example 4: You are a seller and your production costs are 17 for each object A and B and 28 for object C. You sell object A at a price of 20, object B at a price of 20 and object C at a price of 17. Then you will earn 57 ECU – 17 ECU – 17 ECU – 28 ECU = – 5 ECU. That is, you will lose 5 ECU.

Example 5: The buyer's valuations are 10 for object A, 20 for object B and 30 for object C. The seller's production costs are 24 for object A, 18 for object B and 12 for object C. If the buyer and the seller trade object A, the generated surplus is 10 ECU – 24 ECU = –14 ECU. The generated surplus if object B is traded is 20 ECU – 18 ECU = 2 ECU. The generated surplus if object C is traded is 30 ECU – 12 ECU = 18 ECU.

Your earnings from each of the 10 rounds will be summed up and paid to you at the end of the session. If your earnings in a given round are below 0 ECU, the amount will be subtracted from your previous earnings. If your earnings at the end of the experiment are below 5 EUR, you will receive the minimum of 5 EUR. As a buyer, you should thus be careful to not accept or make offers for which you pay more for an object than your valuation. As a seller, you should be careful to not accept or make offers for which your production cost for an object exceed the selling price.

All 10 rounds of this part of the experiment will be the same, except that your valuations (as a buyer) or productions costs (as a seller) for the objects are randomly determined at the beginning of each round, and the participant you are matched with will change between rounds.

This completes the description of the instructions. If you have any questions, please raise your hand. Otherwise, please proceed to answer the questions that will be shown on your computer. The purpose of the questions is to make sure that you understand the different elements of the experiment. Any unclear points will be explained by the experimenter.

[Treatment: Take-it-or-leave-it Offer & Bundling & No Information]

General Instructions

Welcome to the Laboratory for Research in Experimental Economics.

Your earnings from the experiment will largely depend on your decisions and the decisions of others. Therefore, it is important that you read the instructions carefully. The experiment consists of three parts that are independent of each other. The instructions for Part 1 can be found on the following pages. The instructions for Part 2 and Part 3 will be given on the computer screen.

In the experiment, we will not speak of EUR, but rather of ECU (Experimental Currency Units). At the end of the experiment the total amount of ECU you earned will be converted to EUR at the **exchange rate ECU 1 = EUR 0.25**. The final earnings will be rounded to the closest 10 cents. You will also receive a **show up fee** of **EUR 5**. You will be paid your earnings in cash, privately at the end of the session.

All interactions between you and other participants will occur through the computer terminals. Please do not talk directly to or attempt to communicate with other participants during the session. Please also do not ask questions aloud. If you have a question, raise your hand and a member of the experimenter team will come to you. All personal electronic devices should remain switched off until the end of the experiment.

Please now proceed to the instructions for Part 1.

Instructions Part 1

General Description of the Experiment

At the beginning of the experiment, all participants in the room will be divided into groups of 10. We will refer to this group as your "matching group". In each matching group, the computer will randomly determine **5 buyers** and **5 sellers**. You will be either in the role of a buyer or a seller. If you are buyer (respectively, a seller), you will be a buyer (respectively, a seller) for the entire experiment. At the start of Part 1, everyone will receive 8 ECU to begin with.

You will play **10 rounds** of a decision situation. At the start of each round, you will be **randomly matched** with another participant in your matching group. In particular, if you are a buyer, you will be matched at random to one of the 5 sellers in your matching group. If you are a seller, you will be matched at random to one of the 5 buyers in your matching group. Hence, the person you are matched with will typically change between rounds. You will never know the identity of the person with whom you are matched in a given round or of the people in your matching group.

Decision Situation in each Round

We will now explain the decision situation you will face in each of the 10 rounds.

Objects

In each round, there are **3 objects**: **object A, object B and object C**. For each object, the buyer has a **valuation**. A valuation is the worth a buyer assigns to an object. Similarly, for each object, the seller has a **production cost**. The production cost is the cost the seller incurs if producing an object in order to sell it to the buyer.

At the beginning of each round, the buyer's valuations and the seller's production costs for the 3 objects will be randomly chosen to be **0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32 or 33 ECU.** Any value between 0 ECU and 33 ECU is **equally likely.** All valuations and production costs are randomly determined by the computer and are independent of each other, that is, the buyer's values for the different objects will typically not be the same and neither will the seller's production costs.

Information

The buyer's valuations and the seller's production costs are **private information**. In particular, the buyer will be told his or her valuations for the 3 objects and the seller will be told his or her production costs for the 3 objects. However, we will not tell the buyer what the seller's production costs are and neither will we tell the seller the buyer's valuations.

We next describe the **bargaining process**. The bargaining process will determine which objects the buyer and the seller trade, and the price at which the objects are traded.

Proposer or Responder

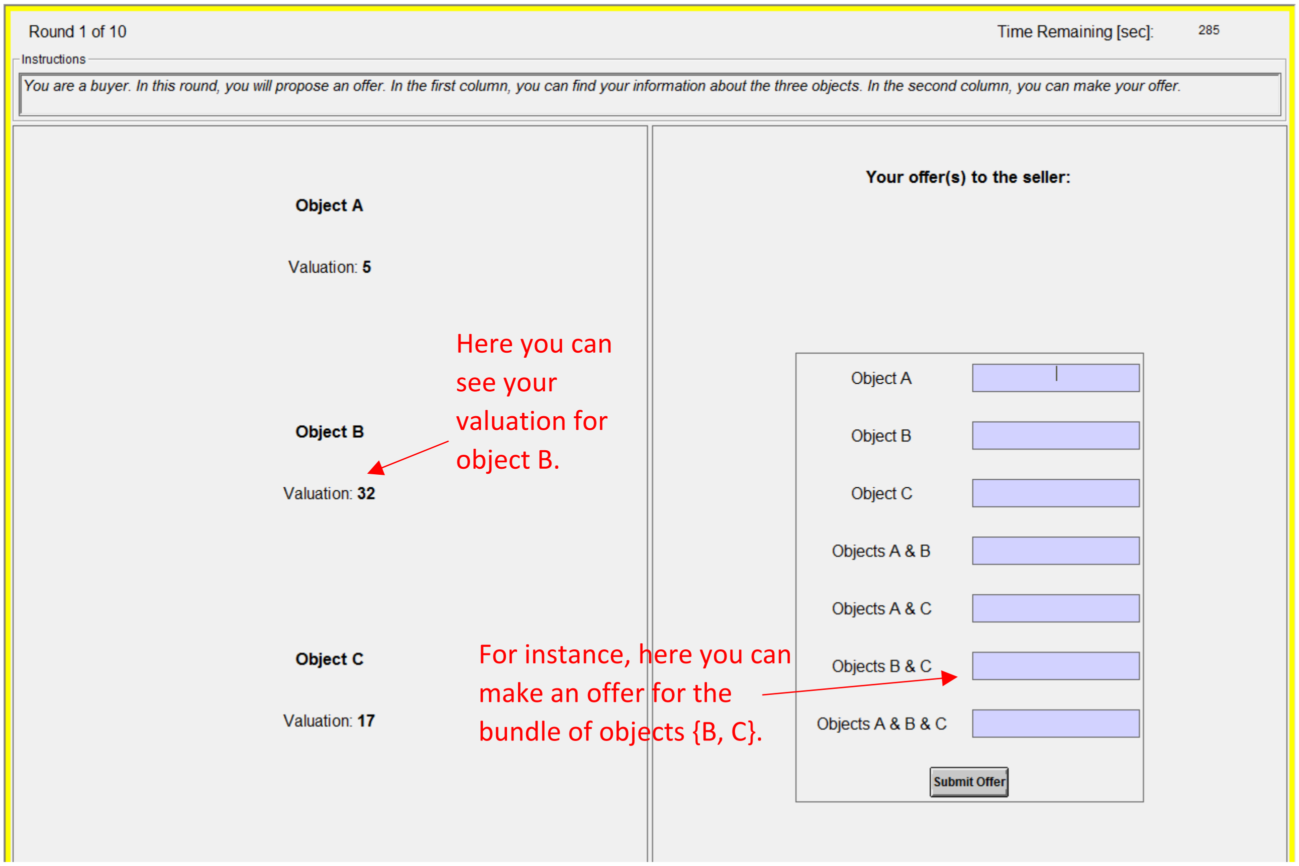
In each round, you will be a **proposer** or a **responder**. This will be determined randomly. That is, either the buyer will be the proposer and the seller the responder or vice versa, both with probability 50%.

Making Offers

The proposer will make offers. **An offer includes a selection of objects and a price.** Thus, when you are buyer, an offer will specify which objects you would like to buy and the price for these objects. When you are a seller, an offer will specify which objects you would like to sell and the price of these objects.

Since there are 3 objects, there are **7 possible selections of objects: {A}**, **{B}**, **{C}**, **{A, B}**, **{A, C}**, **{B, C}** and **{A, B, C}**. An offer will be a selection of objects and a price at which you would like to trade the selected objects. The price has to be a whole number between 0 and 33 ECU for a single object, between 0 and 66 ECU for a selection of two objects and between 0 and 99 ECU for an offer that includes all three objects. The price is for the whole selection of objects, for instance, if a buyer offers objects A and B at a price of 29 ECU and the seller accepts, the buyer will pay 29 ECU for both objects together, and not 29 ECU per object.

Below you can see a screen shot of the experiment. The screen shows the situation of a buyer who is also a proposer. Notice that the buyer can **see his/her valuations for each object on the left-hand side of the screen, but s/he does not know the production costs of the seller.**

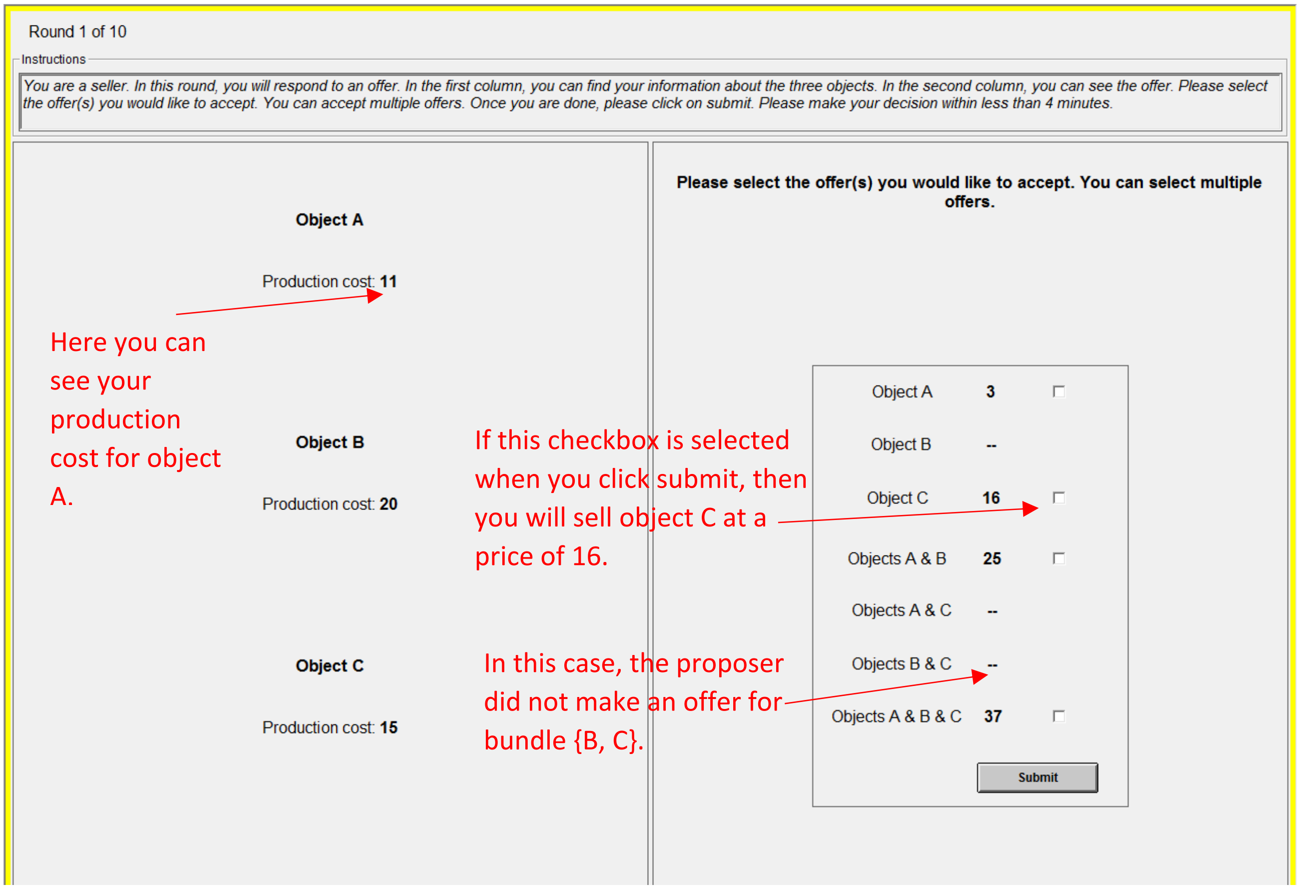


The screen will be the same for the seller, except that s/he will see his/her production costs instead of the valuations. As you can see, there are 7 possible selections of objects. To make an offer, you can enter a price in the box next to the selection of objects you wish to buy / sell. You can make up to 7 offers, one for each possible selection of objects. If you do not enter a price for a selection of objects, no offer will be made for this combination of objects. Once you are done entering offers, you need to click on "Submit Offer". The responder will then receive the offers and choose which ones s/he would like to accept. **Notice that once you click on submit, you cannot revise your offers in this round anymore.**

Accepting and Rejecting Offers

As a responder, you will decide whether you would like to accept or reject the offers made by the other party. To do so, you will **select the offers you would like to accept by clicking the respective checkbox** (see the screen shot below). Once you have selected all offers you would like to accept, confirm your choice by clicking on "Submit". **A responder can accept several offers, as long as no two accepted offers contain the same object.** For instance, you can accept the offer for {A} and {C}, or the offer for {C} and {A, B}. But you cannot accept the offer for {A} as well as the offer for {A, B}, because object A cannot be traded more than once.

Once the responder clicks on "Submit", all selected offers are traded at the specified prices.



Earnings

As a buyer, your earnings will depend on your valuations and on the prices you agree to pay. For each object you buy, you will earn your valuation minus the agreed price.

Buyer's Earnings = Sum of valuations of traded objects – Sum of prices for traded objects

As a seller, your earnings will depend on your production costs and on the prices at which you agree to sell objects. For each object you sell, you will earn the agreed price minus your production cost.

Seller's Earnings = Sum of prices for traded objects – Sum of production costs of traded objects

Untraded objects do not affect your earnings.

Below you can find four examples of how earnings are calculated. All examples are to help you understand better the experiment. They should not be considered as guides on how to behave in the experiment.

Example 1: You are a buyer and your valuation for object A is 26. You made an offer to buy object A at a price of 20 and the offer was accepted. No other offers were accepted. Then you will earn 26 ECU – 20 ECU = 6 ECU.

Example 2: You are a seller and your production costs are 8 for object A and 17 for object B. Your offers to sell object A at a price of 13 and object B at a price of 19 are accepted. Then you will earn 13 ECU + 19 ECU – 8 ECU – 17 ECU = 7 ECU.

Example 3: You are a buyer with valuations 33 for object B and 15 for object C. You accept an offer of the seller and buy objects B and C jointly at a price of 32. Then you will earn 33 ECU + 15 ECU – 32 ECU = 16 ECU.

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Your earnings from each of the 10 rounds will be summed up and paid to you at the end of the session. If your earnings in a given round are below 0 ECU, the amount will be subtracted from your previous earnings. If your earnings at the end of the experiment are below 5 EUR, you will receive the minimum of 5 EUR. As a buyer, you should thus be careful to not accept or make offers for which you pay more for an object than your valuation. As a seller, you should be careful to not accept or make offers for which your production cost for an object exceed the selling price.

All 10 rounds of this part of the experiment will be the same, except that your valuations (as a buyer) or productions costs (as a seller) for the objects are randomly determined at the beginning of each round, the participant you are matched with will change between rounds, and in some rounds you will be a proposer while in others you will be a responder.

This completes the description of the instructions. If you have any questions, please raise your hand. Otherwise, please proceed to answer the questions that will be shown on your computer. The purpose of the questions is to make sure that you understand the different elements of the experiment. Any unclear points will be explained by the experimenter.