# Beyond Dividing the Pie: An Experimental Study on Bargaining over Multiple Issues*

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**Abstract**

We study bargaining under incomplete information when parties negotiate over multiple issues. The presence of multiple issues allows for richer information structures and a larger offer space (e.g., bundling) than with a single issue. An interesting case occurs when the maximum surplus of an agreement is known whereas valuations for individual items remain private information. As emphasized in the negotiation literature, this is akin to a situation in which parties engage in integrative bargaining focussing on the creation of value before distributive bargaining takes place. Informed by recent theoretical advances (Jackson et al., 2016), we present a comprehensive laboratory experiment investigating bargaining over multiple issues. Our main finding is that when players have information about the maximum surplus, outcomes are indistinguishable from the ones observed in a complete information version of the game. This equivalence only holds if the bargaining protocol allows bargainers to bundle issues. The finding also breaks down in a take-it-or-leave-it offer setting. We further document interesting interactions between the size of the surplus, information, and the aggressiveness of bargaining postures.

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# 1 Introduction

Bargaining and negotiations are at the core of the functioning of modern market economies. In the economic literature, the standard case studied is one where a buyer and a seller bargain over the terms of trade of a single object. If information is complete, these models are well-understood, ranging from the case of a take-it-or-leave-it offer—where the proposer, in theory, extracts all the surplus (e.g., Güth et al., 1982; Binmore et al., 1989)—to alternating offers bargaining—where more nuanced predictions apply, reflecting the patience of the bargaining parties while still generating immediate agreement (Stahl, 1972; Rubinstein, 1982). If information is incomplete, we know that inefficiency is often unavoidable (e.g., Chatterjee and Samuelson, 1983; Myerson and Satterthwaite, 1983; Abreu and Gul, 2000; Hörner and Vieille, 2009) but the extent to which bargaining is inefficient is difficult to predict, since there are typically a large number of equilibria (e.g., Cramton, 1992; Ausubel et al., 2002). Experiments have shown that such environments indeed lead to suboptimal outcomes (e.g., Ochs and Roth, 1989; Forsythe et al., 1991; Embrey et al., 2014; Bochet and Siegenthaler, 2018, 2019).

The benchmark case of how to split a pie can be extended in multiple directions. In this article, we are interested in situations where parties bargain over more than one issue or attribute, thereby enriching the standard bargaining setup. Indeed, when there are multiple dimensions, parties can *negotiate* on how to strike a deal rather than simply splitting a pie. There, in addition to determining the price, the scope of an agreement also needs to be determined, specifically both sides need to agree on which issues to include and which to exclude from an agreement (e.g., Fisher et al., 1981; Jackson et al., 2016). This is a common situation in daily life. To give some examples, labor contracts include multiple attributes such as wage, work hours and compensation packages. In procurement contracts, upstream and downstream firms need to agree on price, quantity, and quality of the service provided. Valuations and costs of each aspect tend to be private information. For instance, when signing a sponsorship agreement, parties may not know each other's preferences for individual attributes such as fees, performance bonuses, renewal rights and exclusivity clauses. Similarly, hiring an IT company may involve negotiations on all or only a subset of services ranging from software development and network maintenance to data mining and computer security, and for each item it may be unclear how costly it is for the seller and how valuable for the buyer.[1]

In the context of multidimensional negotiations an important observation is that bargaining parties often know whether or not there are gains from trade. The cost of time, forgone alternative meetings, travel expenses, and preparation all signal that there must be a joint surplus, and also the approximate size of said surplus. The negotiation literature, taking a slightly different angle but implying the same consequence, refers to the observation that negotiations often endogenously reveal information about the joint surplus as *value creation*. Specifically, before bargaining over who gets how much, there is a negotiation phase in which parties exchange views and preferences to

[1] It is easy to find additional examples. For instance when signing a lease parties may discuss several items such as lease term, monthly cost, specials, free parking, renewal options, pay for moving cost or a different unit in a complex. Another example is health care payer-provider bargaining. For the U.S. dental reimbursement system, many of the payments depend on bargaining between the insurer and physician. Dental services are typically a bundle consisting of different materials and whether the nurse or the doctor provides the service. For an illuminating reference on this, see "Evaluating bundled or episode-based contracts" published by the American Medical Association.

explore and pin down mutual interests, see Fisher et al. (1981) for a seminal reference and Frankel (1998) and Bac (2001) for different ways of employing this idea. In the present study, we adopt a simplified view of the process of value creation. Rather than studying how much information is revealed prior to distributive bargaining, we *assume* that bargaining parties reach a situation in which they have information about the maximum size of the joint surplus while valuations and costs for individual issues are still privately known.[2] Note that having information about the surplus is no contradiction with a model of incomplete information due to the private information regarding the valuations and costs for individual issues. The task of the negotiators is then to identify which issues are relevant and for whom and hence which issues should be included in a deal; the task is to simultaneously determine the price *and* the scope of a deal. This is why we refer to bargaining over several dimensions as negotiations.

Continuing this thought, it is clear that environments with multidimensional negotiations differ from those with a single issue. There is a new information stage in which the total surplus is known but valuations and costs for individual items remain private information. Let us call it the *intermediate stage*, as opposed to the interim stage in which parties only know their respective valuations over the multiple attributes. The notion of what an offer entails is also richer. The simplest extension of an offer for a single item to a multidimensional setting is one that states a separate price for each of the attributes a deal may include. However, in real world negotiations, it is often the case that parties engage in bundling of attributes, that is, they may agree on a single price for a set of issues while at the same time agreeing to leave aside some other issues over which agreements can't be reached or would be reached later. Because of this additional richness and possible complexity, one may expect that, even when the surplus is known, negotiations are actually harder than in the standard setup with a single attribute. More generally, one may expect inefficiencies to be prevalent when there is asymmetric information about valuations and costs, following a large body of theoretical work establishing generic inefficiencies due to incomplete information in similar trading environments, for instance the celebrated result of Myerson and Satterthwaite (1983).

Yet, in a recent theoretical article by Jackson et al. (2016), it is shown that when the total surplus is known and parties can offer bundles of issues, then in theory any bargaining structure reaches full efficiency in any (weak Perfect Bayesian) equilibrium. Hence, asymmetric information does not stand in the way of efficiency when offers can be bundled and coordinated across issues.[3] What is the intuition for this result? When parties negotiate over a single issue, they both try to capture value and to obtain a higher share of the surplus. This is true both under complete or asymmetric information. A new concern arises in multidimensional negotiations, one of creating

[2]We believe that this information structure captures the idea of value creation. In particular, in the absence of altruistic motives or naïve behavior, value creation should not result in a complete information environment. Such an approach would ignore bargainers' incentive to misrepresent their valuations. This is apparent in Susskind (2014) who introduces the concept of "the trading zone," which is the range of the terms of trade where deals are achieved that are "good for them but great for you." On the other hand, for value creation to have an impact, information on some dimension must be revealed. The maximum joint surplus seems to be an appropriate dimension as it emphasizes the value of agreement without revealing much about individual issues to be discussed.

[3]When only item-by-item bargaining is possible, the Myerson-Satterthwaite result applies once more. Depending on the specific trading environment, inefficiencies can take the form of trade failures or delay in agreement (e.g., Chatterjee et al., 1993; Ausubel et al., 2002; Deneckere and Liang, 2006). In both cases, the cause of inefficiency is the agents' incentives to exploit their private information.

value, i.e., to generate an agreement that maximizes the realized surplus by selecting the set of items for which the buyer's valuation exceeds the seller's cost (e.g., Sen, 2000). This alternative goal tends to weaken individuals' incentives to haggle; to an extent that efficiency is predicted to occur despite the asymmetric information. This intuition, together with the fact that a test of these predictions based on naturally occurring data seems difficult, provides the main motivation for our experiment.

We provide a comprehensive test of these predictions. We do this via a laboratory experiment, contributing to the long tradition of combining bargaining theory and experiments going back to Roth and Malouf (1979), Roth and Murnighan (1982) and Roth and Schoumaker (1983). In our experiment, each bargaining pair can trade up to three items by agreeing on a mutually acceptable price. Valuations (for the buyer) and reservation costs (for the seller) are drawn independently from the discrete uniform distribution on $\{0, 33\}$, implying that only 50% of the items contain positive gains from trade. We are interested in understanding how the participants in the experiment handle the richness of this multidimensional bargaining environment, identify which items should be traded, and make use of the information they are given. To that end, our experiment varies three treatment factors, which are explained next.

We look at two negotiation settings: *take-it-or-leave-it offers* and *free-form bargaining*. The former is a direct extension of the frequently studied ultimatum game to multiple items. The latter refers to a bargaining structure akin to the one popularized by Gächter and Riedl (2005), Karagözoğlu and Riedl (2014), Bolton and Karagözoğlu (2016) and Camerer et al. (2018). We also look at two offer protocols. One allows agents to make offers on combinations of items, i.e., *bundling* is possible (e.g., Inderst, 2000), and the other restricts agents by only allowing for offers on individual items, i.e., only *item-by-item* offers are permissible. The third factor we vary are the different information conditions. In the *no information* case, the buyer's valuations and the seller's production costs are private information and neither receives additional information about the total available surplus. In what refer to as the *intermediate information* case, apart from their private information, agents are given information about the total available surplus (i.e., the maximum gains they could jointly realize). Finally, in the *full information* case, agents know each other's valuations and reservation costs for each item.

Crossing the above treatment variations, we obtain a $2 \times 2 \times 3$ factorial design with 12 treatments and 480 subjects. Our main testable hypotheses are the following. In *Hypothesis 1*, we first state that efficiency is expected to be higher in treatments with full information than in treatments with no information. Given this benchmark, we are interested in whether treatments with intermediate information lead to behavior similar to the one observed under no information or full information. We hypothesize that when the offer protocol allows for bundling, bargaining behavior with intermediate information is identical to one observed under full information. In contrast, with item-by-item offers, bargaining behavior with intermediate stage is expected to be similar to the one without information. In other words, Hypothesis 1 puts forth the remarkable prediction that negotiations are efficient as long as the maximum surplus is commonly known and bundling is permissible. *Hypothesis 2* is about the different bargaining settings. Other things equal, we hypothesize that the efficiency-enhancing effect of information about the surplus is more likely to occur in the free-form bargaining setting than with take-it-or-leave-it offers. This hypothesis is based on the reasoning that free-form bargaining should naturally lead to equal sharing of the gains from trade and thus avoid complications due to fairness issues.

To discuss how our results fare with respect to these two hypotheses, we first make a preliminary observation: we find that efficiency is not responsive to the different information conditions (*Result 1, Result 3*), independent of the bargaining setting. In a strict sense, this evidence leads to a rejection of Hypothesis 1 and Hypotheses 2. However, the similar efficiency levels mask several key differences across treatments. In our setup, the maximum surplus varies across bargaining games, because valuations and costs are uniformly distributed over $\{0, 33\}$. We find that the realized rates of trade conditional on the size of the surplus (a local measure of efficiency) differ substantially across treatments. This means that even if overall efficiency is similar across treatments, there can still be large differences in bargaining outcomes depending on the size of the surplus. Indeed, we find that in the no information environment rates of trade are high in bargaining situations with high stakes (large surpluses) and low in bargaining situations with low stakes (low surpluses). The opposite holds in the presence of full information. That is, with full information, rates of trade are (relatively) higher in bargaining situations with low to medium-sized surpluses, while high surpluses lead to low rates of trade. The reason is that information has two countervailing effects. On the one hand, information facilitates agreement by helping bargainers find the price range that would lead to a positive profit for both sides. On the other hand, information complicates agreement because bargainers have a better estimate about their share of the gains from trade, introducing fairness considerations. The former effect dominates for low surplus sizes, the latter dominates for high surplus sizes.[4,5]

With this in mind, our results are stated in terms of rates of trade and how they change for different surplus sizes rather than focussing on overall efficiency. Our main result (*Result 3*) is as follows. Consider the free-form bargaining setting and assume bundling is possible. Then, the rates of trade observed in the intermediate information case are practically equivalent to the full information case, and significantly different from the no information case. In addition, removing the possibility of bundling brings rates of trade in the intermediate information environment back to the ones observed in the no information environment. This evidence is consistent with Hypothesis 1, although the equivalence of intermediate and full information under bundling is stated in terms of general bargaining behavior (rates of trade) rather than overall efficiency. In contrast, in the take-it-or-leave-it offer environment, information about the total available surplus doesn't change behavior compared to the no information case, neither with nor without bundling (*Result 1*). This is due to aggressive bargaining postures, in particular for bundled offers (*Result 2*). Interestingly, bargaining postures under free-form bargaining are initially aggressive as well, but this effect is

[4]This is in line with earlier findings on ultimatum games under incomplete information (e.g., Mitzkewitz and Nagel, 1994; Straub and Murnighan, 1995; Kagel et al., 1996; Croson, 1996) showing that negotiating parties show relative "prudence" when making offers compared to the observed behavior in a full information environment. Indeed concerns linked to social preferences are mitigated under incomplete information whereas they are salient otherwise.

[5]This interaction of information and surplus size underlines an advantage of experimental designs which include significant variation in the valuation and cost parameters. If we kept the parameters fixed in our study, depending on the size of the fixed surplus, we would have found that either (i) behavior in the intermediate information treatments resembles behavior observed with full information and differs from the one with no information, (ii) the opposite of (i), or (iii) there are no differences in behavior across the three information conditions. In contrast, our design allows us to detect how behavior changes depending on the surplus size.

weakened over time, allowing for more trades. These observations are in line with Hypothesis 2, emphasizing the importance of using natural bargaining settings (e.g., Karagözoğlu, 2018). Our final result (*Result 4*) is that for high surplus items, in all treatments where efficiency should theoretically prevail, bargainers exhibit a low willingness to compromise and trade failure is common relative to the environments where inefficiencies are theoretically expected. This haggling effect is the main driver for the lack of a difference in efficiency across the different bargaining environments.

To summarize, our data lends support to the insights of Jackson et al. (2016), but only when bargaining is unstructured and allows for multiple offers over time (as opposed to take-it-or-leave-it offers). On a general level, the results emphasize the value of information about the maximum surplus, indirectly highlighting the importance of integrative negotiations where bargaining parties focus on creating rather than claiming value. From an institutional design perspective, our results imply that moving from the interim information stage to the intermediate information stage (i.e. obtaining information about the surplus) is a promising way of promoting trade and facilitating complex negotiations. For example, information about the maximum surplus could be revealed through informal exchange (cheap-talk) or via a trusted third party. Given that we find low rates of trade for high surplus cases, however, a second step to reaching efficiency would be to alleviate fairness concerns.

An important issue not addressed in our design is how information about the surplus may become common knowledge between the two bargaining sides. A recent related paper addressing this issue is Jackson et al. (2018). By choosing parameters in a clever way, the authors create situations in which the players can infer information about the size of the surplus, but the surplus is never explicitly revealed. For instance, this allows studying the case when the surplus is approximately known. Their study also investigates the role of communication (via chat), confirming previous findings that communication is conducive to bringing behavior closer to theoretical expectations (e.g., Agranov and Tergiman, 2014) or to increasing efficiency (e.g., Valley et al., 2002). The present article and Jackson et al. (2018) employ complementary experimental designs: while we focus on the impact of a known surplus and its comparison with the interim and ex-post information stage and the role of bundling, Jackson et al. (2018) are concerned with testing the ability of subjects to infer the surplus from specific valuation and cost structures and the role of communication.[6]

The remainder of the paper is organized as follows. In Section 2 we discuss the theoretical motivation and background for our experiment. Section 3 presents the experimental design. Section 4 present the results from the take-it-or-leave-it offer setting, while Section 5 presents the results from the free-form bargaining setting. Finally, Section 6 concludes.

## 2 Theoretical Background

This section presents the theoretical ideas that motivated our experiment. It also serves to define the bargaining environments that we are going to examine experimentally.

[6]The experiments were designed and conducted independently.

## 2.1 Model

Consider a multi-issue bargaining problem that consists of a deal to be made among two agents, a buyer and a seller, over a finite number $n$ of items. Denote the set of items by $N$. The buyer has finite valuations $v_i$ for each item $i \in N$ drawn from a finite set $V \subset \mathbb{R}$ according to a probability distribution described by the density function $f$. Similarly, the seller has finite reservation costs $c_i$ for each item $i \in N$, which for simplicity are assumed to be drawn from the same probability distribution.

Time advances in discrete periods $t = 0, 1, \ldots$ where at the end of each period the bargaining process stops with known breakdown probability $1 - \delta$, where $\delta \in [0, 1)$. An offer $(K, p_K)$ consists of a set of items $K \subset N$, where $K \neq \emptyset$, and a corresponding price $p_K$ at which the set of items is traded if the offer is accepted. If $K$ contains more than one item, we will refer to it as a bundle of items. Further, we denote by $v_K = \sum_{i \in K} v_i$ and $c_K = \sum_{i \in K} c_i$, respectively, the sum of the buyer's valuations and the seller's reservation costs over the items in $K$. Let $\mathcal{K}$ be the set of offers that have been accepted when the bargaining process stops. Then, the buyer's payoff is

$$\Pi_B = \sum_{K \in \mathcal{K}} (v_K - p_K)$$

and the seller's payoff is

$$\Pi_S = \sum_{K \in \mathcal{K}} (p_K - c_K).$$

Thus, the payoff for the buyer is found by summing the difference between his valuations $v_K$ and the agreed transfer $p_K$ over all accepted offers $K \in \mathcal{K}$. The seller on the other hand receives the sum of transfers $p_K$ minus the reservation costs $c_K$ for all traded items.

The presence of multiple items allows for a large number of possible information structures. In particular, even with significant uncertainty over valuations for individual items, agents can be informed about the maximum gains from trade of the deal. A formal definition of this situation follows. The *available surplus* from trading item $i$ is $S_i = \max(v_i - c_i, 0)$. Correspondingly, the *total available surplus* over all items is $S \equiv \sum_{i \in N} S_i \geq 0$. We will say that the total available surplus is known if both agents are informed about the value of $S$ but not about valuations and costs for individual items, and this is common knowledge. Note that even if the total available surplus is known, bargainers still don't know which items need to be traded to realize the full surplus.

We next define the bargaining protocol. In each period, the proposer offers a finite number of offers. If bundling is possible, an offer can include all possible sets of items. This means that in addition to making offers for individual items, the proposer can also offer a single price for any bundle of items, including the bundle consisting of all items. If bundling is not possible, then each offer is for one item only, i.e., $K$ is a singleton for any offer $(K, p_K)$. The responder observes all offers and chooses which one(s) to accept. Two offers containing the same item cannot both be accepted. If at the end of a period some of the items have not been traded yet, the next period is entered with probability $\delta$ and new offers can be made on the items which haven't been traded yet.

The following theorem represents the main theoretical prediction. It first appeared in Jackson et al. (2016) and has been modified to fit our case.[7]

**Theorem 1.** *Consider a bargaining problem with known surplus $S > 0$ and an offer protocol that allows for bundling. Then in all weak perfect Bayesian equilibria*[8] *the agreement is reached immediately and the full surplus is realized. Moreover, the distribution of payoffs is the same as in complete information bargaining where all valuations and costs are known to both bargaining parties.*

*Proof.* See Jackson et al. (2016) Theorem 1. □

The theorem says that, if bundling is possible and the total available surplus is known, bargaining is efficient and outcome-equivalent to a situation with complete information. Notice that we did not specify whether the buyer or the seller is the proposer and how roles change over time. The theorem holds for all cases. For example, if the buyer is the proposer in all periods, then an immediate agreement is achieved in which all of the surplus goes to the buyer (and vice versa if the seller is the proposer). If players alternate in making offers, the initial proposer's payoff equals $\frac{S}{1+\delta}$ and the responder's payoff equals $\frac{\delta S}{1+\delta}$, equivalent to the outcome predicted in complete information alternating offers bargaining (Rubinstein, 1982).

## 2.2 Is Bundling and Information on the Available Surplus Needed for Efficiency?

In this section, we discuss three examples. Example 1 shows why information about the total available surplus *and* the possibility of bundling lead to fully efficient bargaining, despite private information about valuations and reservation costs. Example 2 demonstrates that bargaining is generally inefficient if players do not have information about the total available surplus. Lastly, Example 3 shows that bundling is also necessary for efficiency.

**Example 1** (Known Surplus & Bundling)**.** *A buyer and a seller bargain over the price of three items $A$, $B$ and $C$, e.g., physical goods, services or aspects of a labor contract. The buyer's value and the seller's cost for each item are drawn from the continuous uniform distribution on the interval* $[0, 1]$*. Let $\delta = 0$ and assume that the buyer is the initial proposer, i.e., the buyer makes a set of take-it-or-leave-it offers to the seller. Suppose the buyer's realized valuations are* $(v_A, v_B, v_C) = (0.5, 0.5, 0.5)$*. He also knows that the total available surplus is $S = 0.2$. If bundling is possible, 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* $(\{A, B, C\}, 1.3)$*. These offers are constructed by summing the buyer's valuations over the items contained in an offer and subtracting the surplus $S$. The seller's payoff from accepting one of these offers is negative, unless she accepts the efficient offer (the one containing the items for which the buyer's valuation exceeds the seller's costs, and no other items). In this case, the seller's*

[7] The original theorem by Jackson et al. (2016) includes our bundling protocol (called combinatorial negotiations in their paper), but in addition applies to several other bargaining protocols that fall between combinatorial negotiations and item-by-item bargaining.

[8] 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).

*payoff is 0, or slightly higher if the buyer increases all prices by $\epsilon$. For example, suppose the seller's reservation costs are $(c_A, c_B, c_C) = (0.4, 0.9, 0.4)$. Then item A and C are the correct items to be traded. Indeed, accepting offer $(\{A, C\}, 0.8)$ gives the seller a payoff of 0. For all other offers, the sum of the seller's reservation costs exceeds the offered price. The seller's best response is thus to accept the efficient offer and the buyer receives the whole surplus.*

The observation that in Example 1 trade is efficient and the buyer receives the entire surplus is no coincidence. It holds for all distributions and for all realizations of valuations and reservation costs. If $\delta > 0$ and bargaining unfolds over several periods, equilibria follow a similar idea as with take-it-or-leave-it offers and efficiency is still guaranteed. The difference is that at equilibrium the proposer can only demand a fraction of the surplus rather than the full surplus, due to the possibility of counteroffers. For example, for alternating offer bargaining, the buyer's offers are constructed by summing the valuations over the items contained in an offer and subtracting $\frac{S}{1+\delta}$. Similarly, if the seller is the proposer, she sums her reservation costs over the items contained in an offer and adds $\frac{\delta S}{1+\delta}$.

We next examine what happens if we dispense with the assumption that the total available surplus is observable.

**Example 2** (Surplus Not Known & Bundling)**.** *Consider the same set-up as in Example 1. As before, the buyer knows his own valuations $(v_A, v_B, v_C) = (0.5, 0.5, 0.5)$ but this time he does not know the total available surplus. The buyer can still use the different bundles to ensure that at least one of his offer is for the efficient set of items. However, because he doesn't know the value of $S$, he maximizes for each offer his expected profit given by $Prob[\textit{offer accepted}] \times \textit{Profit} = Prob[c_K \leq p_K] \times (v_K - p_K)$. One can show that the optimal set of offers is $(\{A\}, 0.25)$, $(\{B\}, 0.25)$, $(\{C\}, 0.25)$, $(\{A, B\}, 0.67)$, $(\{A, C\}, 0.67)$, $(\{B, C\}, 0.67)$, and $(\{A, B, C\}, 1.12)$.[9] In general, these offers fail to yield the efficient outcome. To see this, suppose that, as in Example 1, the seller's reservation costs are $(c_A, c_B, c_C) = (0.4, 0.9, 0.4)$. Item A and C are the correct items to be traded, but the buyer's offer of 0.67 is too low for the seller to accept. In fact, in this example none of the items will be traded: The offer of 0.25 falls short of the reservation cost for each individual item, and the offer of 1.12 for the three-item bundle falls short of the sum of the reservation costs over the three items.*

Example 2 demonstrates the value of information about $S$. Without it, the proposer's offers are too demanding if the total available surplus is relatively small. The example also shows that an offer protocol that allows for bundling doesn't by itself guarantee efficiency. These observations shouldn't be surprising. In the interim information stage where players only know their own valuations and costs, it is well-known that bargaining is inefficient, as long as the support of the probability distributions of the buyer's valuation and the seller's cost overlap. The incentives of the buyer to understate valuations and of the seller to exaggerate costs prevents fully efficient trading (Chatterjee, 1982; Myerson and Satterthwaite, 1983). In the absence of bundling, these results directly apply to our

[9]The cumulative distribution function of a sum of $n$ continuous uniform random variables on the interval $[0, 1]$ is given by the Irwin–Hall distribution $\frac{1}{n!}\sum_{i=0}^{\lfloor p_K \rfloor}(-1)^i\binom{n}{i}(p_K - i)^n$. Maximizing $Prob[c_K \leq p_K] \times (v_K - p_K)$ recognizing that $c_K$ is distributed according to the Irwin-Hall distribution gives the optimal offers.

multi-issue setting since each item is bargained over independently. Example 2 shows that bundling alone doesn't resolve such inefficiencies.

We conclude with Example 3, showing that a known surplus by itself also doesn't guarantee efficiency.

**Example 3** (Known Surplus & No Bundling)**.** *Consider the same set-up as in Example 1, except that the buyer cannot offer bundles. The buyer observes his valuations* $(v_A, v_B, v_C) = (0.5, 0.5, 0.5)$ *as well as the total available surplus* $S = 0.2$*. Notice that in the absence of bundling the only set of offers that leads to an efficient outcome for all possible realizations of the seller's reservation costs is* $(\{A\}, 0.5)$, $(\{B\}, 0.5)$, $(\{C\}, 0.5)$*. Suppose the buyer does not make these offers, that is, for at least one item* $i$ *the offer is* $p_i < 0.5$*. Then, with strictly positive probability, the seller's reservation cost* $c_i$ *for item* $i$ *is such that* $0.5 > c_i > p_i$*. In this case, efficiency requires that item* $i$ *is traded but the seller rejects the offer. Now, it cannot be optimal for the buyer to offer a price of 0.5 on all items, as this will result in a payoff of 0. For instance, offering* $(\{A\}, 0.3)$, $(\{B\}, 0.3)$, $(\{C\}, 0.3)$ *is strictly better. To see this, note that with strictly positive probability, the seller has a reservation cost of 0.3 for one of the items and reservation costs above 0.5 for the other two items. In this case, she would accept the offer of 0.3 for the item with reservation cost 0.3 and the buyer receives a strictly positive expected profit. As already shown, offering* $(\{A\}, 0.3)$, $(\{B\}, 0.3)$, $(\{C\}, 0.3)$ *is generally inefficient, because these offers will be rejected if the gains from trade are distributed among more than one item. In such cases bundling is required for efficiency.*

Example 3 illustrates the importance of the offer protocol. Without bundling, information about the total available surplus doesn't lead to an efficient outcome. This is not to say that such information has no value. Indeed, in Example 3, the fact that the buyer knows $S = 0.2$ helps him formulate the optimal offer of 0.3 for a situation where the entire surplus is concentrated on one item. Without information on $S$ and without bundling, the offer on a single item that maximizes the buyer's expected payoff would be 0.25.[10] In our example, such an offer would not cover the reservation cost of the seller of 0.3. Notice that information about the total available surplus is particularly useful if the surplus is relatively small, because the proposer understands that he cannot ask for a higher profit than $S$. Nonetheless, the key conclusion from Example 3 is that efficiency cannot be obtained when bundling is not possible.

# 3 Experimental Design

In this section, we describe the experimental setting and treatments. The goal of our design is to draw a comprehensive picture of behavior in the lab when agents know the total available surplus of an agreement. To achieve this, we compare the intermediate information condition (bargainers know their own valuations or costs as well as the total available surplus) to the interim information stage (bargainers only know their own valuations or costs) and to the full information condition

[10]The buyer's maximization problem when making an offer for item $i$ in the absence of bundling, when reservation costs are drawn from the continuous uniform distribution on the interval $[0, 1]$, and without information about the surplus, is given by $\max_{p_i} Prob[\text{offer accepted}] \times \text{Profit} = \max_{p_i} Prob[c_i \leq p_i] \times (v_i - p_i) = \max_{p_i} p_i(v_i - p_i)$. The solution is $p_i^* = v_i/2$.

(bargainers are informed about each other's valuations and costs and thus also the total available surplus). We also manipulate the availability of bundling and investigate behavior in two polar bargaining settings.

### 3.1 General Setting

Two randomly matched players—one in the role of a buyer one in the role of a seller—engage in a negotiation to strike a deal on any or all of three items $A$, $B$ and $C$. For each item $i$ the buyer's valuations $v_i$ and the seller's reservation costs $c_i$ are drawn from the discrete uniform distribution $\mathcal{U}\{0, 33\}$. If an agreement to trade a set of items $K$ at price $p_K$ is reached, 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 $c_K = \sum_{i \in K} c_i$. Correspondingly, the maximum surplus that can be realized across the three items is $3 \times 33 = 99$. The minimum surplus is 0, which occurs if $v_i \leq c_i$ for each item.

### 3.2 Take-It-or-Leave-It Offer and Free-Form Bargaining

We study two general bargaining settings, *take-it-or-leave-it offer* and *free-form bargaining.* Though the settings are different, the idea that information about the total available surplus leads to efficient trade (see the Theorem 1 in the previous section) applies to both settings.

In the *take-it-or-leave-it offer* setting each subject in a pair is randomly assigned to be a proposer or responder. The proposer makes take-it-or-leave-it offers on individual items and/or bundles of items. The responder observes the offers and chooses which offers to accept, if any. An item can be traded at most once. For example, if the proposer offers a price for item $A$ and a price for the bundle consisting of items $A$ and $B$, only one of these offers can be accepted by the responder as otherwise item A would be traded twice. On the other hand, if there is an offer for item $A$ and an offer for the bundle consisting of items $B$ and $C$, both offers can be accepted. After the responder's decision, the items contained in one of the accepted offers are traded at the offered price and the bargaining game ends.

With *free-form bargaining* the bargaining process is designed such that at any point in time both bargainers (1) can make offers on items which have not yet been traded (2) can cancel offers that have not yet been accepted and (3) can accept or reject the other party's standing offers. The game ends if all items have been traded or there is a bargaining breakdown. The breakdown cannot occur in the first minute. Then, after the first minute, there is a positive probability that bargaining stops, specifically, the breakdown occurs with a probability of 0.04 every 10 seconds.[11,12] Hence, the

[11]In the experimental instructions, participants were told that after the first minute the bargaining process will be stopped with a probability of 4% every 10 seconds. We also told the participants that this implies that 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%. Finally, we informed the participants that if bargaining has not ended after 12 minutes, we will stop at 12 minutes. The latter case never happened.

[12]Participants were also able to end the negotiation process by independently agreeing to do so. Notice that players didn't have the option to propose to end bargaining, but instead the bargaining process was stopped automatically if both *independently* clicked on a button saying that they agree to end negotiations.

free-form bargaining setting allows both sides to make and accept offers and no structure is imposed regarding the timing of offers. It does not, however, allow for verbal communication.

### 3.3 Offer Protocol

The protocol that governs offers is pivotal to the (predicted) outcomes in multi-item negotiation settings. In particular, the option to offer bundles of items is critical for the efficiency of bargaining. To investigate the impact of bundling in the lab, we consider *item-by-item* bargaining—where bargainers can only make offers on individual items—and a *bundling* offer protocol which allows bargainers to make offers on all possible combinations of items. In particular, players can make price offers on seven different sets of items: each individual item $\{A\}$, $\{B\}$, and $\{C\}$, as well as the bundles of items $\{A, B\}$, $\{A, C\}$, $\{B, C\}$, and $\{A, B, C\}$.

### 3.4 Information

Three levels of information are considered. In all cases, the buyer knows his own valuations and the seller knows her own reservation costs for each item. In *No Information*, bargainers only know the distribution (discrete uniform between 0 and 33) from which the valuations or reservation costs of the other party are drawn but do not receive any information about the realized values. In *Intermediate Information*, players learn as an additional piece of information the total available surplus in the current match, defined by $S = \sum_{i \in \{A,B,C\}} \max(v_i - c_i, 0)$. Finally, in *Full Information*, each player is fully informed about the other party's valuations or reservation costs for each item. With full information, bargainers can directly deduce the total available surplus $S$. In the experiment, we explicitly tell the participants the value of $S$ in the *Full Information* conditions. This way the only difference between the *Intermediate Information* and *Full Information* treatments is the additional information about the other's valuations or costs in the latter treatments.

### 3.5 Treatments

We implement a 2 x 2 x 3 factorial design. The first factor varies the bargaining setting between take-it-or-leave-it offers and free-form bargaining. The second factor varies the offer protocol between item-by-item and bundling. The third factor varies the information level between no information, intermediate information, and full information. There are thus twelve treatments in total. Each subject participated in one treatment only. For each treatment, we gathered data from 40 subjects, in 4 independent matching groups of size 10. The total number of participants is thus 480.

We note that we ran three additional treatments. These treatments were identical to the treatments with free-form bargaining and bundling over the three information levels, but with a larger breakdown probability. In particular, the probability of breakdown after the first minute was 20% every 10 seconds. The one minute threshold thus essentially functions as a deadline, given the large breakdown probability. The motivation for these treatments was to examine behavior in a setting that falls between the take-it-or-leave-it and free-form bargaining setting. Including these sessions, the total number of participants is 600.

## 3.6 Procedures

The experiment was conducted at the Laboratory for Research in Behavioural Experimental Economics (LINEEX) at the University of Valencia in June 2016 and May 2017. The software was programmed in z-Tree (Fischbacher, 2007). Written instructions (available in the Online Appendix) were distributed explaining to the subjects the relevant bargaining protocol, how valuations and costs are generated, and how their payoffs are computed. Subjects also had to complete a comprehension test. Before starting the bargaining experiment, one of the experimenters summarized the key points of the instructions. Sessions lasted always less than 120 minutes. At the beginning of each session, subjects were divided into matching groups of size 10 and randomly assigned the role of a buyer or a seller. Each session had ten periods. That is, subjects played ten different bargaining games. For each such game, subjects were randomly rematched into pairs within their matching group. At the end of each period, subjects were told which items were traded in this period and what their corresponding earnings were. Payments were made privately in cash at the end of the session. Average earnings were €27.4 per subject including a show-up fee of €5.

After the main experiment, subjects also participated in two additional tasks in which we collected information about their risk and fairness preferences. To elicit risk preferences, we used a task taken from Andreoni and Harbaugh (2016). Subjects are asked to choose one out of a set of six lotteries. The lotteries are: 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. The lotteries order subjects by risk aversion, with the first one revealing the greatest risk aversion, option 4 revealing risk neutrality (it maximizes expected value), and option 6 is the most risk loving choice. To elicit fairness preferences, we use an ultimatum game: Person $A$ has to distribute €5 between herself and person $B$. Person $B$ has to specify a minimum offer that she is willing to accept before knowing $A$'s proposed distribution. If $A$ allocates an amount to $B$ that covers $B$'s minimum acceptable offer, the proposed distribution is implemented. Otherwise both earn 0. Both subjects in a pair make decisions in both roles. The minimum acceptable offer is used as a proxy for a subject's inequality aversion.

## 3.7 Hypotheses

Based on the predictions of Theorem 1, we are interested in the following testable hypothesis.

**Hypothesis 1.** *Efficiency is higher in Full Information than No Information. If the bargaining protocol allows for bundling, efficiency in Intermediate Information is similar to Full Information; in contrast, for the item-by-item bargaining protocol, Intermediate Information is similar to No Information.*

The literature on ultimatum bargaining consistently demonstrates that inequality aversion complicates reaching an agreement when standard theory predicts that one party receives the lion's share of the surplus (see the discussion in the introduction). Our take-it-or-leave-it offer setting is such a case. We thus expect trade failures triggered by inequality aversion. On the other hand, in our free-form bargaining environment the predicted distribution is close to 50-50. In addition, the

Table 1: Summary of Outcomes

| | Efficiency | Rate of Trade | | | | Payoff | Duration | Number of Offers | |
|---|---|---|---|---|---|---|---|---|---|
| | | $S \in [1, 33]$ | $S \in [1, 11]$ | $S \in [12, 22]$ | $S \in [23, 33]$ | Prop.-Resp. | | One Item | Bundle |
| **Take-It-or-Leave-It Offer** | | | | | | | | | |
| Bundling | | | | | | | | | |
| No Info | 0.79 | 0.66 | 0.48 | 0.87 | 0.94 | 46-54 | | 2.40 | 2.97 |
| Int. Info | 0.79 | 0.66 | 0.51 | 0.85 | 0.96 | 59-41 | | 2.12 | 2.54 |
| Full Info | 0.81 | 0.77 | 0.74 | 0.79 | 0.91 | 74-26 | | 1.69 | 1.35 |
| Item-by-Item | | | | | | | | | |
| No Info | 0.85 | 0.67 | 0.43 | 0.94 | 0.97 | 49-51 | | 2.94 | |
| Int. Info | 0.80 | 0.65 | 0.45 | 0.89 | 0.97 | 53-47 | | 2.85 | |
| Full Info | 0.82 | 0.81 | 0.81 | 0.81 | 0.92 | 63-37 | | 1.82 | |
| **Free-Form Bargaining** | | | | | | | | | |
| Bundling | | | | | | | | | |
| No Info | 0.84 | 0.75 | 0.66 | 0.84 | 0.93 | 47-53 | 131 sec | 10.00 | 4.55 |
| Int. Info | 0.82 | 0.80 | 0.77 | 0.82 | 0.85 | 50-50 | 124 sec | 10.64 | 4.13 |
| Full Info | 0.80 | 0.79 | 0.77 | 0.82 | 0.86 | 52-48 | 137 sec | 8.49 | 2.97 |
| Item-by-Item | | | | | | | | | |
| No Info | 0.84 | 0.75 | 0.62 | 0.89 | 0.87 | 47-53 | 136 sec | 26.34 | |
| Int. Info | 0.74 | 0.65 | 0.54 | 0.71 | 0.97 | 51-49 | 149 sec | 22.28 | |
| Full Info | 0.82 | 0.85 | 0.89 | 0.80 | 0.79 | 53-47 | 110 sec | 16.05 | |

*Notes:* Efficiency is the sum of realized surplus divided by the sum of available surplus. Rate of trade is the proportion of items with $S_i = v_i - c_i > 0$ that are traded. Payoff split gives the share of realized surplus in proposer-responder format. Duration is calculated as the average time until the total available surplus is realized or a breakdown occurred or a pair agreed to stop bargaining. Number of offers is the average number of offers on one item/bundles of items in a bargaining game.

possibility of repeating and adjusting offers over time should make it easier for the subjects to agree on a price. These considerations lead to our second hypothesis.

**Hypothesis 2.** *The efficiency-enhancing effect of Intermediate Information & Bundling compared to the No Information conditions and the Intermediate Information & Item-by-Item condition is stronger in free-form bargaining than with take-it-or-leave-it offers.*

# 4 Results in the Take-It-or-Leave-It Offer Setting

We begin by discussing the results from the treatments in which proposers make take-it-or-leave-it offers. This bargaining setting is a direct extension of the large body of experimental research on ultimatum games with a single item to a situation with multiple items. Compared to the previous literature the multi-item setting allows us to examine a new information stage where individual valuations and costs are unknown but players are informed about the total available surplus. As discussed in the introduction, this information structure is akin to a situation where bargainers first engage in a stage of value creation; both agree that a deal is worth considering and have a good estimate about the gains from trade, but no private information has been revealed about the details of the valuations and costs of individual items.

We will refer to a situation in which the total available surplus is known to the bargainers as the intermediate information stage. Our key question is whether behavior in the intermediate information stage is closer to the one observed with full information or to the one observed in the no information environment. Recall that the theoretical prediction is that treatment *Intermediate Information* should be similar to *Full Information* if bundling is possible. In the absence of bundling, *Intermediate Information* should be similar to *No Information.* Table 1 summarizes some of the outcomes of our experiment. The upper part of the table displays the outcomes of the take-it-or-leave-it setting.

The last column in Table 1 shows that if bundling is possible proposers frequently offered bundles. Notice that a proposer can make an offer on at most four bundles, namely $\{A, B\}$, $\{A, C\}$, $\{B, C\}$, and $\{A, B, C\}$. In the *No Information* treatment on average 2.97 bundles were offered. In the *Intermediate Information* treatment, the average number of bundled offers was 2.54. In the *Full Information* treatment, the number of offered bundles is lower (1.35), because proposers know which items contain positive gains from trade and which items don't. The second to last column shows that in the treatments with incomplete information, proposers typically also made offers for single items: on average 2.40 in *No Information* and 2.12 in *Intermediate Information* out of a maximum of 3 offers. Also in line with expectations, column 6 of Table 1 shows that the distribution of payoffs is skewed toward the proposer in the *Full Information* treatment. The proposer advantage is weaker in *Intermediate Information* and disappears in *No Information.*

The remaining columns in Table 1 show the achieved efficiency levels (column 1) and the rates of trade (columns 2 to 5). Efficiency is computed as the sum of realized surpluses divided by the sum of total available surplus over all bargaining games in a treatment. The rate of trade is the proportion of items with $S_i = v_i - c_i > 0$ that are traded. Column 2 shows the overall rates of trade, while columns 3 to 5 separate the rate of trade by the size of the surplus contained in an item. For example, if the buyer's valuation is 20 and the seller's reservation cost is 5, the size of the surplus is 15, implying that this item would be part of the fourth column for which $S \in [12, 22]$. We next state our first main result.

**Result 1—Information in the Take-It-or-Leave-It Offer Setting.** *Consider the take-it-or-leave-it offer setting when bundling is possible. There are no significant differences in efficiency between the different information conditions. However, for items with a low surplus, trade failures are more common in No Information than Full Information, while for items with a high surplus the opposite holds. In contradiction to the theoretical prediction, rates of trade failures in Intermediate Information follow the same pattern as in No Information and are significantly different from Full Information.*

Result 1 follows from a close inspection of Table 1. While the result is stated for the case when bundling is possible, the same patterns are observed in the item-by-item setting as well. To confirm that there are no significant differences in efficiency between treatments we ran a multilevel regression with random effects on the matching group and subject level. The regression is reported in column 1 of Table 2. The dependent variable is the realized surplus. Controlling for the surplus contained in an item, efficiency is not significantly different between the *No Information* (reference group), *Intermediate Information* and *Full Information* treatments. Notice that for the item-by-item setting, information about the total available surplus even seems to lead to slightly worse efficiency

Table 2: Does Efficiency Change with Information?

| | *Take-It-or-Leave-It Offer* | | *Free-Form Bargaining* | |
|---|---|---|---|---|
| | Bundling | Item-by-Item | Bundling | Item-by-Item |
| *Dep. Var.* Realized Surplus | (1) | (2) | (3) | (4) |
| Surplus | 0.950*** | 0.857*** | 0.875*** | 0.837*** |
| | (0.0367) | (0.0342) | (0.0272) | (0.0496) |
| Int. Information | 0.334 | -0.984* | -0.419 | -2.114*** |
| | (0.496) | (0.506) | (1.034) | (0.760) |
| Full Information | 0.374 | -0.662 | -0.767 | -0.444 |
| | (0.863) | (0.710) | (1.026) | (0.729) |
| Constant | -5.372*** | 0.588 | -0.490 | 2.201 |
| | (1.631) | (0.789) | (1.306) | (1.344) |
| Observations | 491 | 498 | 471 | 483 |

*Notes:* Multilevel regressions with random effects on matching group and subject level. Standard errors clustered on matching group reported in parentheses: * sign. 10%, ** sign. 5%, *** sign. 1%. Period dummies included. Reference treatment is *No Information*.

levels than in *No Information*. The effect is only significant at the 10% level but we will return to it when discussing the free-form bargaining environment.

The absence of a difference in efficiency does not mean that behavior is the same across the treatments. This is apparent when looking at rates of trade. In Figure 1 we present the predicted probability of trade failure based on logistic regressions with the dependent variable being trade failure (i.e., a dummy which is equal to 1 if an item contains positive gains from trade but is not traded) and the independent variable surplus (i.e., the size of the gains from trade contained in an item). We can see that with bundling (as well as in the absence of bundling), the predicted trade failures for the different surplus sizes are similar in *Intermediate Information* and *No Information*. In Appendix A, Table A.1 we provide the results of the regressions in table form, confirming that *Intermediate Information* and *No Information* are not significantly different but that both are significantly different from *Full Information*, at the 1% significance level. Importantly, treatments *No Information* and *Intermediate Information* perform best for items with large surpluses. Relative to the these treatments, *Full Information* performs best for items with low surpluses.

There is a simple explanation for some of these effects. In treatment *No Information*, it is difficult to achieve trade on items with small gains from trade, as players have to find a trading price in a relatively small interval $[c_i, v_i]$. The problem is much simpler if the gains from trade a large. In treatment *Full Information* beneficial trades are in principle easy to achieve, even if the surplus generated by such a trade is small. Then, other considerations that may hinder trade become relevant, for instance the exact distribution of the gains from trade. The results show that this leads to trade failures, in particular for items with large surpluses. On the other hand, we also find that information about the total available surplus (treatment *Intermediate Information*) leads to a behavior similar to the case of no information rather than complete information. This is not in line with the key predictions of the theory on multi-issue bargaining and there is no obvious explanation.

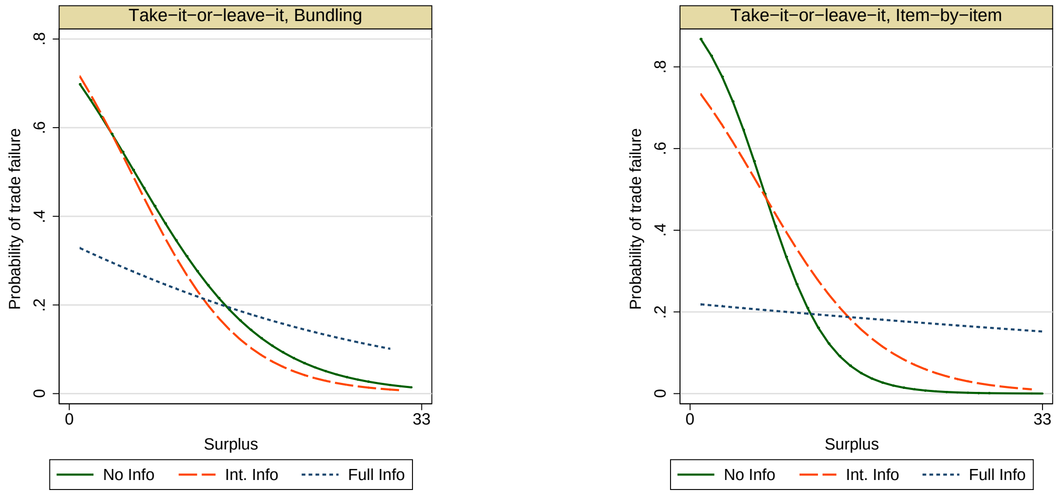



Figure 1: Take-It-or-Leave-It Offer—Trade Failure

*Notes:* Predicted probability of trade failure for different levels of surplus per item. Based on logistic regressions with dependent variable trade failure and independent variable surplus; standard errors clustered on subject-level.

Note that the finding is stark: Behavior in *Intermediate Information* is almost indistinguishable from behavior in *No Information* and clearly different from *Full Information*.

To explore this discrepancy between theory and the experimental data, we look at the predicted trade failures when assuming that responders always accept the set of offers that maximizes their payoff, regardless of the induced payoff distribution. That is, we are interested in the counterfactual world where responders behave optimally in the sense that they maximize their monetary payoff. This allows us to eliminate trade failures due to mistakes or inequality aversion on the responder's side. Figure 2 shows the counterfactual predicted probability of trade failure. Trade failures in *Full Information* are fully eliminated for high surplus sizes. This confirms that the effects of inequality aversion are strongest when information is complete and the size of surplus is large. Most importantly, however, the finding that *Intermediate Information* behaves as *No Information* persists, which implies that proposers' offers in *Intermediate Information* often don't allow for efficient trade.

To conclude the discussion of the take-it-or-leave-it offer setting, we take a closer look at the effect of bundling within the *Intermediate Information* setting. Remember that, theoretically, bundling is predicted to improve efficiency relative to item-by-item bargaining. In the first column of Table 1, we can see that efficiency in the *Intermediate Information* treatment is 0.79 when bundling is possible and 0.80 for item-by-item offers. However, this average across all bargaining games hides an important observation; we describe it in Result 2.

**Result 2—Bundling in the Take-It-or-Leave-It Offer Setting.** *Consider the take-it-or-leave-it offer setting when bargainers know the total available surplus (intermediate information). In bargaining games in which one item contains the entire available surplus, the possibility of bundling lowers the probability of trading the correct set of items compared to item-by-item offers. In contrast,*

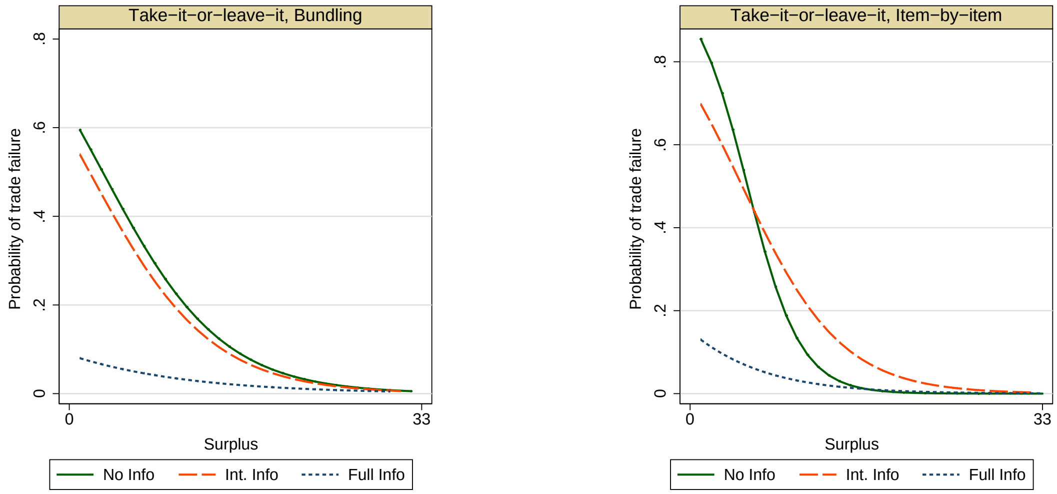


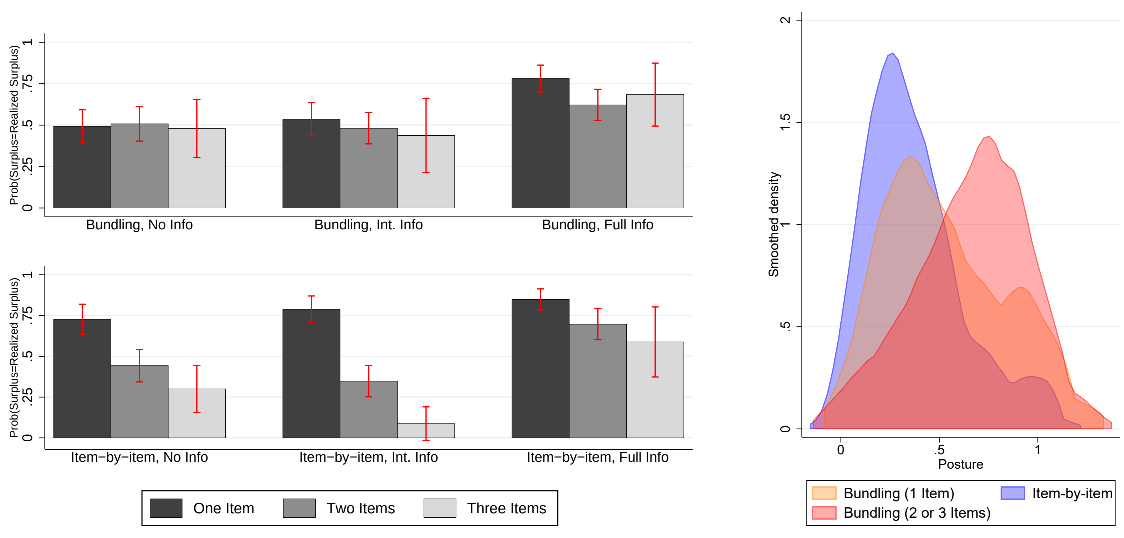

Figure 2: Take-It-or-Leave-It Offer—Counterfactual Trade Failure

*Notes:* Predicted probability of counterfactual trade failure—i.e. assuming responders accept the payoff-maximizing offer—for different levels of surplus per item. Based on logistic regressions with dependent variable counterfactual trade failure and independent variable surplus; standard errors clustered on subject-level.

*if the total available surplus is distributed between two or three items, bundling increases the probability of trading the correct set of items. Overall, bargainers demand a larger share of the surplus when bundling is possible.*

Result 2 is illustrated in Figure 3 (a). The figure shows for all take-it-or-leave-it offer treatments the fraction of bargaining games in which the full surplus was realized. It also separates between cases where the entire surplus was concentrated on one item or distributed between two items or three items. Notice that the *Full Information* treatment generally performs best based on this metric. This is in line with our previous observations: With complete information, trade failures are relatively rare, but if they happen they typically involve items that would have generated large gains from trade. More importantly, the figure shows that in *Intermediate Information* and *No Information* the possibility of bundling significantly increases the probability that the efficient set of items is traded when it contains more than one item. In contrast, the possibility of bundling lowers the probability that the full surplus is realized when only one item should be traded. These effects are significant at the 1% level (see Table A.2 in Appendix A.)

Why did the possibility of bundling fail to increase efficiency relative to the item-by-item setting? For treatment *Intermediate Information*, we define *posture* as the share of available surplus demanded in a given offer. Figure 3 (b) depicts the distribution of posture for bargaining with bundling as well as item-by-item bargaining. For the former, we separate posture by whether an offer was made on a single item or on a bundle of two or three items. We find that in the setting with bundling, the posture for offers that include only one item is significantly larger than in the item-by-item setting (significant at the 5% level, see Table A.3 in Appendix A). Moreover, the average posture for bundled offers (including more than one item) is significantly larger than the average posture




(a) Is the Efficient Set of Items Traded?

(b) Posture in *Intermediate Info*.

Figure 3: Take-It-or-Leave-It Offer—Comparing Bundling to Item-by-Item

*Notes:* Figure (a): Fraction of cases in which the realized surplus is equal to the total available surplus, i.e. items are traded if and only if the buyer's valuation exceeds the seller's cost. Figure (b): Distribution of posture for *Intermediate Information & Bundling* and *Intermediate Information & Item-by-item*. Posture is defined as the share of available surplus demanded in an offer.

for offers that only include a single item (significant at the 1% level, see Table A.3 in Appendix A). Thus, bargaining postures are generally more aggressive when bundling is possible and are particularly aggressive for bundled offers. The latter is not in line with theory where the demanded share of the surplus should be constant across offers (see Example 1).

The findings in the take-it-or-leave-it offer environment can be summarized as follows. First, while there are no significant differences in efficiency across the different information conditions, there are big differences in the rates of trade for different surplus sizes. We can use the latter measure to test whether the intermediate information condition leads to behavior similar to the no information or the full information condition. In contradiction with theory, we find that when bundling is possible, bargaining in intermediate information looks similar to no information. Second, when looking at bargaining behavior within the intermediate information condition, the possibility of bundling is detrimental to efficiency when only one item contains positive gains from trade. Bundling does improve performance when multiple items should be traded, but the improvement is limited due to aggressive bargaining postures for bundled offers. These findings reject Hypothesis 1 for the take-it-or-leave-it setting.

## 5 Results in the Free-Form Bargaining Setting

The main advantages of the take-it-or-leave-it offer setting are its simplicity and its comparability to the literature on ultimatum games. However, one may argue that a free-form bargaining environment where both sides on the bargaining table can make multiple offers constitutes a more natural setting to look at. An obvious reason why this may be true is that such a setting potentially leads to more equal payoff distributions, thus eliminating an important source of disagreements. Free-form bargaining may be necessary to unleash the positive effect of information about the available surplus and bundling.

We begin the discussion with a look at Table 1. The second to last and last column show the average number of offers made for individual items and bundles of items. Bargainers were active. In the incomplete information environments, when bundling is possible, a bargaining game had on average more than ten offers on single items and more than four offers on bundles. In the item-by-item setting, the average number of offers on individual items even reaches 26.34 in *No Information*. The third column from the right shows the average length of a bargaining game, calculated as the average time until the total available surplus is realized or a breakdown occurred or a pair agreed to stop bargaining. We can see that bargaining typically lasted a bit longer than 2 minutes. Finally, in line with our expectation, column 6 of Table 1 shows that the distribution of payoffs is approximately equal. That is, the proposer of an accepted offer on average wasn't able to obtain a larger share of the gains from trade than the responder.

We next state the main result of this article.

**Result 3—Information and Bundling in Free-Form Bargaining.** *Consider the free-form bargaining setting when bundling is possible. There are no differences in efficiency between the different information conditions. However, for items with a low surplus, trade failures are more common in No Information than Full Information, while for items with a high surplus the opposite holds. In contrast to the take-it-or-leave-it offer setting, rates of trade failures in Intermediate Information follow the same pattern as in Full Information and are significantly different from No Information. Furthermore, when bundling is not possible, this result breaks down, that is, rates of trade failures in Intermediate Information follow the same pattern as in No Information.*

Like in the take-it-or-leave-it offer setting, efficiency levels are similar across the information conditions, see column 3 in Table 2. Thus, the measure that allows us to detect differences across information conditions is again the rate of trade for the different surplus sizes. This time, however, in line with Hypothesis 1, behavior in the *Intermediate Information* treatment when bundling is possible is similar to the behavior in the *Full Information* treatment. This is an important result, because it provides evidence in support of the theoretical idea that in a natural bargaining environment, information about the total available surplus is sufficient to render behavior practically equivalent to behavior under complete information. In line with Hypothesis 2, the free-form bargaining environment seems to be a more appropriate test bed for the theory of multi-issue bargaining.

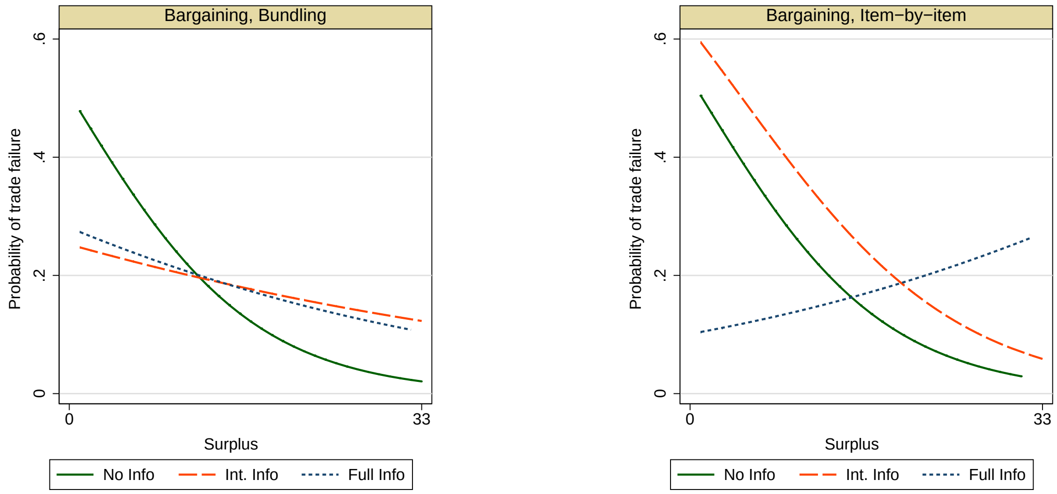



Figure 4: Free-Form Bargaining—Trade Failure

*Notes:* Predicted probability of trade failure for different levels of surplus per item. Based on logistic regressions with dependent variable trade failure and independent variable surplus (standard errors clustered on subject-level).

Result 3 thus confirms both of our main hypotheses.[13,14]

In Figure 4 we present the predicted probability of trade failure over the different surplus sizes based on logistic regressions. The left figure is for the case when bundling is possible. The predicted trade failures are similar for *Intermediate Information* and *Full Information*. In Table A.2 in Appendix A we provide the results of the regressions in table form, confirming that both are significantly different from *No Information*, at the 1% significance level. Also note that, as in the take-it-or-leave-it offer setting, *No Information* performs better than *Full Information* for items with a large surplus. Hence, even with repeated offers, bargainers have difficulties agreeing on how to share a large surplus when information is complete.

Based on the discussion so far the free-form bargaining setting could be the exclusive reason why we see similar behavior in *Intermediate Information* and *Full Information*. That is, bundling may not be essential. Next, we therefore compare treatments *Intermediate Information & Bundling* and *Intermediate Information & Item-by-item*. A look at the right part of Figure 4 shows that bundling is in fact essential: In the item-by-item setting, behavior in *Intermediate Information* is again similar to the *No Information* treatment. In line with this, the middle column of Figure 5 shows that, if the total available surplus is distributed between two or three items, the possibility of

[13]It is worth noting that some real-world bargaining settings may not allow for repeated back-and-forth offers; in such cases the results from the take-it-or-leave-it offer setting are more informative.

[14]We ran an additional set of treatments, identical to the free-form bargaining setting except that the breakdown probability was much higher. In particular, after the first minute has passed, bargaining stops with a probability of 20% every 10 seconds. This implies that in 75% of the cases bargaining lasts less than two minutes. The one minute mark essentially works as a fuzzy deadline. As such, this setting falls between the take-it-or-leave-it and free-form bargaining setting. Bargaining outcomes in these treatments are similar to the ones for the take-it-or-leave-it offer setting. This shows that the initial minute of bargaining where there is no risk of a bargaining breakdown is not sufficient to induce an equivalence of the *Intermediate Information & Bundling* and *Full Information & Bundling* environment.

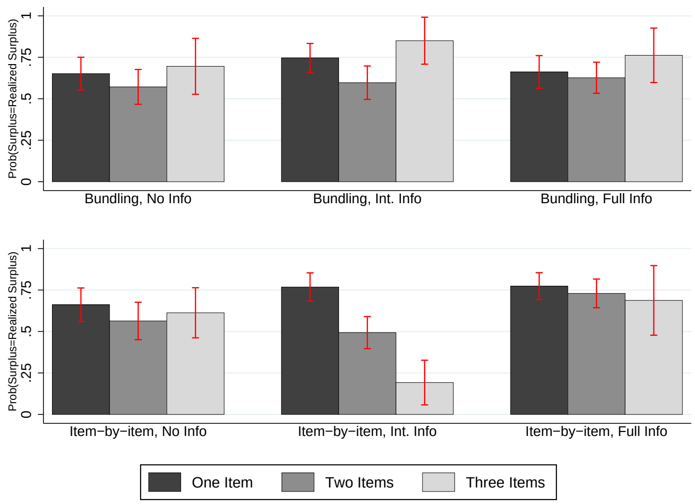



Figure 5: Free-Form Bargaining—Is the Efficient Set of Items Traded?

*Notes:* Fraction of cases in which the realized surplus is equal to the total available surplus, i.e. items are traded if and only if the buyer's valuation exceeds the seller's cost.

bundling significantly improves the probability that the full surplus is realized relative to item-by-item bargaining. Table A.2 in Appendix A confirms that the effect is significant at the 5% level. If the entire surplus is concentrated on a single item, the percentage of bargaining games in which the correct item is traded is around 75%, independently of whether bundling is possible or not.

An interesting secondary observation from Figure 4 is that in the item-by-item setting, the probability of trade failure is larger for *Intermediate Information* than *No Information* for all surplus sizes. Table A.1 in Appendix A shows that the difference is significant at the 1% level. The different rates of trade failure also lead to a significantly lower efficiency level in *Intermediate Information*, see the last column in Table 2. Thus, when bundling is not possible, giving bargainers access to information about the total available surplus lowers efficiency. Knowing the total available surplus opens the door for disagreements about how to share the gains from trade, and without the possibility of bundling there is nothing to counteract this effect.

The main limitation of Result 3 is that while rates of trade in *Intermediate Information & Bundling* are equivalent to bargaining with complete information, there is no efficiency increase over the *No Information* environment. This is due to relatively low rates of trade for items with a high surplus. Figure 6 depicts bargaining posture over time in treatment *Intermediate Information*. The first figure shows the distribution of posture up to and including the twentieth second over all bargaining games. The second figure shows the distribution of posture between second 20 and 40. For each time interval, we include postures from offers which were on the table at some point during the interval. We find that, as in the take-it-or-leave-it setting, bargainers demand the highest share of the total available surplus when they make offers for bundles of items. This effect is weakened over time—which explains why bundling is effective in free-form bargaining but not in the take-it-or-

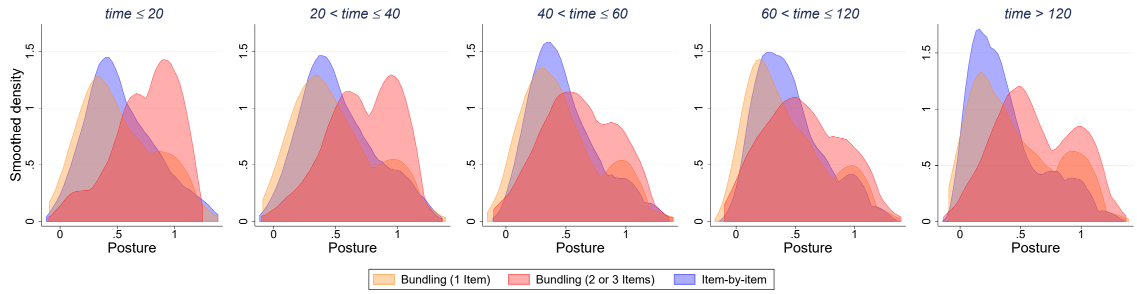



Figure 6: Free-Form Bargaining—Posture over Time in *Intermediate Information*

*Notes:* Distribution of posture over time for *Intermediate Information & Bundling* and *Intermediate Information & Item-by-item*. Posture is defined as the share of available surplus demanded in an offer. To compute the posture for a specific time interval we include all offers which were on the table at some point during this interval.

leave-it offer setting—but never fully disappears, and is again stronger for offers that occur after 120 seconds. Table A.3 in Appendix A confirms that the differences in posture for bundles and single items are significant.

A similar point can be made when looking at the median acceptance times. In the free-form bargaining treatments with bundling, the median acceptance time of an offer on a single item was 81 seconds in *No Information* and *Intermediate Information* and 94 seconds in *Full Information*. For offers on more than one item (i.e., two or three items), the median acceptance time was 58 seconds in *No Information*, 97 seconds in *Intermediate Information* and 133 seconds in *Full Information*. This demonstrates once more that, in particular for bundled offers, bargainers need more time to agree on a price the more information they have. This observation leads to the following result.

**Result 4—Haggling in Free-Form Bargaining.** *In the bargaining environments which in theory allow for fully efficient trade—specifically, treatments Full Information & Bundling, Full Information & Item-by-Item, and Intermediate Information & Bundling—bargaining is characterized by a low willingness to compromise relative to environments where inefficiencies are theoretically expected—specifically, treatments No Information & Bundling, No Information & Item-by-item, and Intermediate Information & Item-by-item.*

The lower willingness to compromise in the bargaining environments which in theory should lead to efficient trade comes in two forms. First, the profit demanded by bargainers decreases over time, but it decreases less fast in the theoretically efficient treatments *Full Information & Bundling*, *Full Information & Item-by-Item*, and *Intermediate Information & Bundling*. Second, bargainers revise their offers more slowly and wait longer before accepting an offer in these treatments. That is, more information also leads to a lower bargaining activity. Given that behavior is similar across the theoretically efficient treatments, we will pool them in the following to simplify the exposition.

Table 3 presents random effects regressions corroborating Result 4. In columns 1 and 2 the dependent variable is the demanded profit. For instance, if the sum of the buyer's valuations over all items included in an offer equals 30 and the buyer offers a price of 20, the demanded profit is

Table 3: Free-Form Bargaining—Random Effect Regressions on Haggling

| *Dep. Var.:* | Demanded Profit | | Time Between Offer | | Time to Accept | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Efficient in Theory | -1.205** | -3.714*** | 1.543*** | 0.964 | 3.224*** | 1.508 |
| | (0.477) | (1.095) | (0.343) | (1.052) | (1.189) | (3.622) |
| Time | -0.0302*** | -0.0302*** | | | | |
| | (0.00195) | (0.00195) | | | | |
| Efficient in Theory ∗ Time | 0.0156*** | 0.0155*** | | | | |
| | (0.00315) | (0.00315) | | | | |
| Risk-Accepting | | -0.0691 | | 0.106 | | -0.0714 |
| | | (0.212) | | (0.159) | | (0.656) |
| Efficient in Theory ∗ Risk-Accepting | | 0.794*** | | 0.195 | | 0.339 |
| | | (0.306) | | (0.312) | | (0.983) |
| 50-50 Norm | | 0.649 | | 0.766** | | 3.180** |
| | | (0.481) | | (0.389) | | (1.477) |
| Efficient in Theory ∗ 50-50 Norm | | -0.299 | | -0.246 | | 0.353 |
| | | (0.799) | | (0.610) | | (2.272) |
| Constant | 9.913*** | 9.707*** | 10.09*** | 9.258*** | 17.71*** | 16.07*** |
| | (0.576) | (0.942) | (0.589) | (0.789) | (2.659) | (3.619) |
| Observations | 15292 | 15292 | 14532 | 14532 | 1027 | 1027 |

Regressions include random effects for each subject. Standard errors are clustered on the subject-level, reported in parentheses: * significant at 10%, ** significant at 5%, *** significant at 1%. Period dummies included. Time is in seconds. The dummy *Efficient in Theory* equals 1 for treatments *Full Information & Bundling*, *Full Information & Item-by-Item*, and *Intermediate Information & Bundling* and 0 otherwise.

10.[15] We find that the demanded profit is lower in the treatments which are efficient in theory at the beginning of a bargaining game (coefficient *Efficient in Theory*). This is natural because in these treatments proposers cannot reasonably ask for more than the total available surplus. The coefficient *Time* shows that demanded profits decrease over time in all treatments. However, the interaction shows that this decrease is significantly weaker in the theoretically efficient treatments, indicating a lower willingness to compromise.

Column 2 presents a similar regression including two additional regressors *Risk-Accepting* and *50-50 Norm*. Both are constructed using the elicitation tasks describes in Section 3.6. In particular, *Risk-Accepting* is a dummy equal to 1 if a subject chose a lottery that indicates risk-neutral or risk-seeking behavior. The regressor *50-50 Norm* is also a dummy, equal to 1 if a subject in the fairness preferences elicitation task asked for at least 50% of the gains from trade. We find that in the theoretically efficient treatments, less risk-averse proposers were more likely to start with a high demanded profit; presumably they are less concerned about the breakdown probability.

In columns 3 and 4 of Table 3, the dependent variable is *Time Between Offers*, that is, how long it took in a given bargaining game until one of the two bargainers made another offer. In columns 5 and 6, the dependent variable is *Time to Accept*, that is, how long an offer that was eventually accepted

[15] The variable *demanded Profit* is similar to the previously defined variable *posture*, except that the latter is normalized by the total available surplus. However, posture makes sense only for the intermediate information treatments. In *No Information*, proposers don't know the total available surplus and hence we would often see postures above 1. In *Full Information*, a better measure for posture would be the share of the surplus demanded for the items included in a given offer. Thus, demanded profit is a more natural measure to use when comparing information conditions.

remained on the bargaining table. We find that offers were made and revised less frequently in the theoretically efficient treatments, and they also remained on the table for a longer time before being accepted. Interestingly, bargaining activity was particularly low for individuals for which the *50-50 Norm* dummy equals 1. Thus, the presence of individuals who care about distributional aspects of the bargaining game seem to almost fully explain the lower bargaining activity in the theoretically efficient treatments.

# 6 Concluding Remarks

This article presents a laboratory experiment in which participant bargaining over multiple issues. We find that if bargainers know the size of the maximum available surplus and they interact through a rich bargaining setting (in particular, bundling of issues is possible), then bargaining outcomes can be expected to be close to what we would observe under complete information. This finding is in line with theory, thus underlying the predictive power of bargaining models. A caveat is that this result only holds in a free-form bargaining environment where repeated offers can be made; take-it-or-leave-it offers are not sufficient. The finding nonetheless emphasizes the role of value creation, a negotiation phase where parties establish the potential value of an agreement, taking place before distributive bargaining starts. The creation of value creation is akin to a situation where parties have successfully exchanged information about the total available surplus.

Further, in spite of the first point above, efficiency is not higher in the environment where the total available surplus is known (or in the complete information environment) than in the environment without such information. Overall, agreements are reached more frequently when agents have more information about each other's valuations and costs. But we find clear evidence that when the stakes are high, environments with less information outperform environments with more information. In other words, information has two countervailing effects. It facilitates agreement because it makes it easier to find a price that falls between the buyer's valuation and the seller's reservation cost. It complicates agreement because bargainers have a better estimate about their share of the gains from trade, opening the door for fairness considerations. The former effect dominates for low surplus cases, the latter dominates for high surplus cases.

There are several interesting extensions of our study. For example, in real-world bargaining situations, approximate knowledge of the maximum possible gains from trade is much more likely to occur than precise knowledge. It would thus be of interest to know whether approximate knowledge of the total surplus would suffice to generate bargaining outcomes which are equivalent to the ones observed under complete information. Further, we exogenously changed the existence of information about the total available surplus. A key question is whether bargainers would find ways to endogenously reveal and aggregate information about the total available surplus, for example through cheap-talk. It appears that bargainers could have an interest in at least partially revealing their private information, given that (at least in theory) a common understanding of the total available surplus leads to fully efficient outcomes while inefficiencies are unavoidable in the absence of such an understanding. Further theoretical and empirical work is needed to answer this question.

Table A.1: Logistic Regressions—Trade Failure

| | *Take-it-or-leave it* | | *Take-it-or-leave it Counterfactual* | | *Free-form Bargaining* | |
|---|---|---|---|---|---|---|
| | Bundling | Item-by-item | Bundling | Item-by-item | Bundling | Item-by-item |
| *Dep. Var.* Trade failure | (1) | (2) | (3) | (4) | (5) | (6) |
| Surplus | -0.164*** | -0.321*** | -0.180*** | -0.404*** | -0.118*** | -0.117*** |
| | (0.0270) | (0.0615) | (0.0319) | (0.0579) | (0.0322) | (0.0200) |
| Int. Info | 0.114 | -1.015** | -0.229 | -1.126*** | -1.115*** | 0.346 |
| | (0.457) | (0.475) | (0.438) | (0.422) | (0.409) | (0.345) |
| Full Info | -1.666*** | -3.466*** | -2.909*** | -3.910*** | -0.970*** | -2.321*** |
| | (0.413) | (0.545) | (0.564) | (0.628) | (0.344) | (0.405) |
| Int. Info ∗ Surplus | -0.0291 | 0.142** | 0.00290 | 0.189*** | 0.0912** | 0.0186 |
| | (0.0440) | (0.0666) | (0.0419) | (0.0700) | (0.0359) | (0.0275) |
| Full Info ∗ Surplus | 0.113*** | 0.307*** | 0.0808 | 0.236*** | 0.0812** | 0.154*** |
| | (0.0307) | (0.0648) | (0.0667) | (0.0827) | (0.0362) | (0.0291) |
| Constant | 1.001*** | 2.206*** | 0.563* | 2.177*** | 0.0289 | 0.134 |
| | (0.300) | (0.422) | (0.305) | (0.329) | (0.265) | (0.250) |
| Observations | 829 | 843 | 829 | 843 | 804 | 833 |

Logistic regressions with standard errors clustered on subjects are reported in parentheses: * significant at 10%, ** significant at 5%, *** significant at 1%. Period dummies included.

# A Additional Regressions

In the main text, we have used figures to illustrate our results. This appendix provides the corresponding regression outputs. Table A.1 gives the regressions used for Figures 1, 2, and 4. Table A.2 corroborates Figures 3 and 5. Table A.3 shows the regressions for Figure 6.

Table A.2: Logit Regressions—Is the Efficient Set of Items Traded?

| | *Take-it-or-leave-it Offer* | *Free-form Bargaining* |
|---|---|---|
| *Dep. Var.* Right item(s) traded | (1) | (2) |
| Item-by-item treatment | 1.172*** | 0.118 |
| | (0.373) | (0.403) |
| Bundle | -0.251 | -0.438 |
| | (0.281) | (0.332) |
| Item-by-item × Bundle | -1.998*** | -1.100** |
| | (0.474) | (0.518) |
| Constant | 0.145 | 1.080*** |
| | (0.254) | (0.264) |
| Observations | 327 | 328 |

Logit regressions with standard errors clustered on subjects are reported in parentheses: * significant at 10%, ** significant at 5%, *** significant at 1%. Period dummies included. The *Bundle* dummy is 0 when there is only one item with positive surplus and 1 when there are two or three items with positive surplus. Only treatment with *Intermediate Information* are included. The reference treatment allows for bundling.

Table A.3: Random Effects Regressions—Posture in *Intermediate Information* Treatments

| | *Take-it-or-leave it* | *Free-form Bargaining* | | | | |
|---|---|---|---|---|---|---|
| | | $time \leq 20$ | $20 \leq time \leq 40$ | $40 \leq time \leq 60$ | $60 \leq time \leq 120$ | $time \geq 120$ |
| *Dep. Var.* Posture | (1) | (2) | (3) | (4) | (5) | (6) |
| Bundle | 0.229*** | 0.880* | 0.970** | 0.573 | 0.238 | 0.999* |
| | (0.0370) | (0.478) | (0.461) | (0.399) | (0.344) | (0.575) |
| Item-by-item | -0.131** | 0.0813 | 0.0225 | -0.128 | -0.351 | -0.927 |
| | (0.0500) | (0.157) | (0.121) | (0.117) | (0.233) | (0.679) |
| Constant | 0.543*** | 0.812*** | 0.749*** | 0.771*** | 0.882*** | 1.371** |
| | (0.0342) | (0.139) | (0.106) | (0.110) | (0.232) | (0.678) |
| Observations | 1190 | 825 | 1195 | 1204 | 2163 | 1941 |

Regressions with subject-level random effect and standard errors clustered on subjects reported in parentheses: * significant at 10%, ** significant at 5%, *** significant at 1%. Period dummies included.

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