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Fairness has less impact when agents are less informed

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Abstract

Research from the last four decades suggests that fairness plays an important role in economic transactions. However, the vast majority of this research investigates behavior in an environment where agents are fully informed. We develop a new experimental paradigm—nesting the widely used ultimatum game—and find that fairness has less impact on outcomes when agents are less informed. As we remove information, offers become less generous and unfair offers are more likely to be accepted.

Keywords Fairness · Ultimatum game · Information · Experiment

JEL Classification C91 · D91

1 Introduction

How important are fairness concerns in economic transactions? Research from the last 40 years suggests that fairness concerns meaningfully affect economic outcomes. Results from the ultimatum game, which models the last round of a

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negotiation between a buyer and seller, have found that behavior is far from the equilibrium prediction based on selfish agents, demonstrating the importance of fairness concerns in determining outcomes.[1] However, critiques about the extent to which fairness concerns should be incorporated into theoretical predictions started as early as the first results from the ultimatum game.[2]

In this paper, we find that the impact of fairness concerns on economic transactions depends fundamentally on the information available to negotiating parties. Outcomes are more unequal when one of the agents in the transaction is uninformed about the size of the pie, and it is even more unequal when both parties are uninformed. Put succinctly, fairness has less impact on outcomes when agents are less informed.

We introduce a new experimental paradigm, detailed in Sect. 3, which nests the ultimatum game, and allows us to systematically vary the information available to subjects across four treatments in a two-by-two design. Our design is inspired by the ultimatum game experiment in Kagel et al. (1996), which systematically varies the environment so that information about the size of the pie to split is known with certainty only by the proposer, only by the responder, or by both players.[3] We similarly vary who is fully informed about the size of the pie and introduce a treatment where neither player is fully informed. Subjects play 30 rounds of a take-it-or-leave-it offer game as either a buyer or a seller. In each round, each buyer offers a trading price to a seller who can either accept or reject the offer. In all treatments, the buyer knows the value they get if the seller accepts (the buyer earns this value minus the trading price) and the seller knows the cost of accepting (the seller earns the trading price minus this cost), so each party has partial information about the size of the pie. Our four information treatments vary whether or not the buyer is also informed of the seller's cost and whether or not the seller is also informed of the buyer's value. Depending on the information treatment, complete information about the size of the pie is known by neither party, only the buyer, only the seller, or both parties (as in the ultimatum game).

Consistent with prior work, we find strong evidence of fairness concerns affecting behavior and outcomes in the ultimatum game. As detailed in Sect. 4.1, the difference in the percentage of the pie received by the buyer and by the seller (i.e. a measure of inequality that is 1 when the buyer gets everything and is 0 for 50-50 splits or when offers are rejected) is only 10.22 percentage points in our ultimatum game. We also find a large impact of information structure on the extent of inequality in outcomes. That measure increases by almost 100%, to 20.14 and 20.60 percentage points, when either the buyer or the seller are uninformed about the size of the pie.

1 Early experimental evidence from the ultimatum game found that subjects deviated from equilibrium predictions based on self-interested agents (Selten, 1978; Roth et al., 1981; Güth et al., 1982).

2 See early discussions (Binmore et al., 1985; Ochs & Roth, 1989; Prasnikar & Roth, 1992) and more recent ones (Levitt & List, 2007; Carpenter, 2010).

3 That seminal work explores a setting where the pie is relatively more valuable to one of the two parties (i.e. the tokens that the subjects split are worth 3 times more for one subject than the other), allowing for self-serving definitions of fairness to arise. We explore a simpler setting where the pie being split is equally valuable to both parties.

It increases by nearly 150%, to 24.98 percentage points, when both the buyer and seller are uninformed as compared to when both are informed.[4]

Our two-by-two design allows us to identify the channels through which information structure affects inequality. As detailed in Sect. 4.2, when less information is available, (1) buyers make more unfair (i.e., more selfish) offers and (2) sellers are more willing to accept these offers. In particular, when sellers are uninformed about buyers' values, buyers with high values make systematically lower offers—effectively masquerading as buyers with low values—and report believing that uninformed sellers will accept these unfair offers. Sellers indeed accept them. In addition, when buyers are uninformed about sellers' costs, sellers with high costs are more likely to accept offers. This latter result suggests that sellers care about the intentions of buyers; sellers are more likely to accept an unfair split of the pie if the buyer who made it did not know that it was unfair.

Our results relate to prior work that has eliminated common knowledge of the size of the pie in the ultimatum game, either by giving the buyer full information and restricting the information of the seller (Mitzkewitz & Nagel, 1993; Straub & Murnighan, 1995; Croson, 1996; Kagel et al., 1996; Rapoport et al., 1996; Lee & Lau, 2013); giving the seller full information, and restricting the information of the buyer (Kagel et al., 1996; Harstad & Nagel, 2004); or by eliminating information from both parties (Schmitt, 2004). These papers have generally found evidence of lower offers and higher acceptance rates, consistent with what we find here. Because each paper has a different setting, however, looking at results from these papers alone cannot establish the effect on outcomes of informing each party or fully explore the mechanisms driving the relationship between information and fairness.

A key innovation of our two-by-two design is that we can systematically vary whether each of the transacting parties is informed while holding other features of the environment constant. This design also allows us to assess the value of information to each of the trading parties, which we do in Sect. 4.3. We find that benefits are asymmetric. Sellers earn more when they have information. Buyers, meanwhile, never gain from having information, and they do worse with information if the seller is also informed.

While fairness concerns still impact outcomes when agents are less informed, we find a heightened impact in environments with fully informed agents. This finding suggests that the workhorse ultimatum game—in which both agents have common knowledge about the size of the pie—is a special case at one end of a spectrum of how fairness concerns affect bargaining outcomes. The literature's focus on this experimental paradigm may give an outsized impression of the role fairness plays in economic transactions in practice, since transactions are typically made *without* common knowledge of the size of the pie. Sellers rarely (if ever) know a buyer's true willingness to pay for a good and buyers are unlikely to know a seller's cost of providing a good (as costs of production are rarely broadcast). We find that outcomes are less fair in the—arguably more realistic—environment with less information,

[4] These results focus on the last 10 rounds of the game, after subjects gain experience. However, results from all 30 rounds show consistent findings.

and we highlight that the information available to the negotiating parties impacts the extent to which fairness concerns will impact outcomes.

2 Literature review

Research from the last 40 years suggests an important role of fairness in economic transactions, and the ultimatum game—which models the last round of a negotiation between a buyer (proposer) and seller (responder)—has been a workhorse of this literature. Early experimental evidence from ultimatum games demonstrate that actors do not follow equilibrium predictions of selfish agents, and instead seem to behave much more fairly (Selten, 1978; Roth et al., 1981; Güth et al., 1982). This research helped to spawn the literature on social preferences (Fehr & Schmidt, 1999; Bolton & Ockenfels, 2000) and the 50-50 norm (Andreoni & Douglas Bernheim, 2009; Charness & Rabin, 2002).

Simultaneously, there is also literature raising concerns that the role of fairness is overblown. Critiques of the validity of fairness concerns and the extent to which they should be incorporated into theoretical predictions arose as early as the first results from ultimatum games demonstrated that actors do not follow equilibrium predictions of selfish agents (Binmore et al., 1985; Neelin et al., 1988; Ochs & Roth, 1989; Prasnikar & Roth, 1992; Güth & van Damme, 1998). This debate persists to this day (Levitt & List, 2007; Carpenter, 2010); and the extent to which social preferences and fairness concerns impact the outcomes in economic environments of interest remains an open question.

Numerous variations of the ultimatum game have been studied to explore the role of fairness in bargaining. Early variations: allowed subjects to choose between set fair and unfair splits and introduced the possibility of punishment (Kahneman et al., 1986); involved two-stage games (Binmore et al., 1985); involved multi-stage games with various lengths (Neelin et al., 1988); varied proposer "property rights" (Hoffman & Spitzer, 1982); and allowed for random partners (Ochs & Roth, 1989). More recent lab studies using the ultimatum game have altered other contextual components in the game such as: varying intentions for given outcomes (Bereby-Meyer & Niederle, 2005); the perception of interdependence between players in the game (Declerck et al., 2009); the proposer's earned income (Lee & Shahriar, 2017); the addition of irrelevant offers on fairness perceptions (Voslinsky et al., 2021); the power to reject an offer (Mallucci et al., 2019); the ability to obtain information about the other players (Poulsen & Tan, 2007); the socioeconomic environment (Cochard et al., 2021); as well as wage assignment, principal intentions, and peer-induced fairness in 3-player games (Ho & Xuanming, 2009; Danková et al., 2022). Ultimatum games have also been used in the field, and in different countries, to understand how characteristics such as age, income, race and ethnicity, and political identity influence play (Bahry & Wilson, 2006; Brañas-Garza et al., 2006; Dhami et al., 2021; Griffin et al., 2012). Studies in the developing world have allowed researchers to explore the impact of increasing the stakes in the ultimatum game (Andersen et al., 2011).

However, with only a handful of exceptions of which we are aware, most explorations of the ultimatum game have kept one feature of the original design: agents have common knowledge about the size of the pie and thus the share of the pie that is going to each agent. This focus on a setting with complete information is surprising given that many transactions are made without common knowledge of the size of the pie at stake. For example, sellers rarely (if ever) know a buyer's true willingness to pay for a good and buyers are unlikely to know a seller's cost of providing a good as costs of production are rarely broadcast.

The few examples from the literature that eliminate common knowledge of the size of the pie have either given the buyer full information and restricted the information of the seller (Mitzkewitz & Nagel, 1993; Straub & Murnighan, 1995; Croson, 1996; Kagel et al., 1996; Rapoport et al., 1996; Lee & Lau, 2013); given the seller full information, and restricted the information of the buyer (Kagel et al., 1996; Harstad & Nagel, 2004); or eliminated information from both parties (Schmitt, 2004).[5] These papers have generally found evidence of lower offers and higher acceptance rates. However, each paper has a different setting, thus, looking at results from these papers alone cannot establish the effect on outcomes of informing each party or fully explore the mechanisms driving the relationship between information and fairness.[6]

How much impact do fairness concerns have on outcomes in environments with less information? What is the value of information to either bargaining party? Inspired by the ultimatum game experiment in Kagel et al. (1996), which systematically varies the environment so that information about the size of the pie is known with certainty only by the proposer, only by the responder, or by both players, we introduce a new experimental paradigm, which nests the ultimatum game, and allows us to systematically vary the information available to subjects across treatments. Depending on the information treatment, complete information about the size of the pie is known by neither party, only the buyer, only the seller, or both parties (as in the ultimatum game). This design also allows us to assess the value of information to each of the parties and determine who is harmed by having more information.

[5] In related work, Klempt et al. (2019) analyzes the effects of asymmetric information when either the proposer or the responder is better informed in the ultimatum and dictator game. See also Siegel and Fouraker (1960), which explored bilateral bargaining games in a different experimental paradigm but also considered the role of information on outcomes.

[6] Another related literature builds off of the "acquiring-a-company" game (Samuelson & Bazerman, 1984) and explores the impact of information available to buyers and sellers (Güth et al., 2017, 2019). Because that game was designed to explore the winner's curse, however, it typically involves additional uncertainty for one or both parties, such as parties not knowing their own payoff from transacting.

3 Experimental design

We introduce a new, simple experimental paradigm to investigate how information affects the fairness of economic transactions. Buyers and sellers meet in a given round with the opportunity to trade. It is common knowledge that the buyer's value for the good, V, is either 70 or 90 experimental units (each with 50% chance) and that the seller's cost to produce the good, C, is either 10 or 30 experimental units (each with 50% chance). In each round, the buyer makes a take-it-or-leave-it offer P to the seller to purchase the good. If the offer is accepted, the buyer receives $\pi_B = V - P$ and the seller receives $\pi_S = P - C$, where π_B and π_S are denoted in experimental units, which are traded for cash at the end of the study. If the offer is rejected, both players get 0 experimental units (i.e., $\pi_B = 0$ and $\pi_S = 0$). The buyer cannot make an offer for which $P > V$ and the seller cannot accept an offer for which $P < C$.

The experimental design varies what information players have about the realization of the value V and cost C. As is reasonable to expect in practice, the buyer always knows her value V and the seller always knows his cost C. In the *Neither Knows* treatment, this is all the players know. In additional treatments, we provide additional information to: the buyer (who learns the seller's C), the seller (who learns the buyer's V), or both. In all treatments, the information structure is common knowledge. In total we have four information treatments shown in Table 1.

Our design embeds a version of the ultimatum game as the *Complete Information* treatment in which both players are informed of the buyer's value V and the seller's cost C, and thus both know the size of the pie. Our version differs from the standard ultimatum game in two ways. First, the size of the pie is determined by random draws of V and C that are associated with the buyer and seller. Second, framing the game as a market transaction may affect results; perhaps by increasing the inequality between the buyer and the seller, as in Liberman et al. (2004). These two factors are held constant across treatments, however, so any differences between our treatments can nevertheless be attributed to the information structure. In addition, as shown in Sect. 4.1, we replicate the standard ultimatum game results in our *Complete Information* treatment.

3.1 Experimental procedure

As shown in Table 1, a total of 374 subjects played in one of the four information treatments across 20 sessions (12 run at the Wharton Behavioral Lab and 8 run at the Stanford Economics Research Lab).[7] Treatment was varied at the session level so that instructions could be read aloud and the information structure would be common knowledge. In each session, subjects were randomly assigned to the role of buyer or seller and played 30 rounds of the bargaining game in that role. In each

[7] Three sessions of each treatment were run at Wharton and two sessions of each treatment were run at Stanford. As shown in Appendix Table B6, there were no substantial differences by location and so we pool the data in what follows.

round, subjects were assigned to a randomly selected trading partner of the opposite type.

Subjects receive feedback at the end of each round, but subjects are never told any additional information about the size of the pie that they do not already know at the start of the round. That is, buyers are told whether their offer was accepted, but are not told the seller's cost if they are in a treatment where they did not already know this information. Likewise, sellers are not told the buyer's value if they are in a treatment where this information was not already known.

Subjects were paid their earnings for a randomly selected round, and each experimental unit was worth $0.50. Average earnings were over $30, including a guaranteed payment for completing the study and bonus payments.

After playing all 30 rounds, subjects answered additional questions. For example, buyers in all information treatments were asked—in an incentive compatible way—the probability that offers made by other buyers in their session were accepted by sellers. Answers to these questions allow us to generate a distribution of beliefs for buyers, which we analyze in Sects. 4.2.2.

4 Results

In Sect. 4.1, we present results on how information affects inequality. In Sect. 4.2, we explore the mechanisms driving observed differences in inequality. In Sect. 4.3, we highlight how information structure affects the payoffs of buyers and sellers.

Before presenting the results, we note that Appendix A details what the rational model with selfish agents and a simple model of agents with inequity averse preferences, as in Fehr and Schmidt (1999), would predict in each of our treatments. The comparative statics generated by these models (i.e., what they predict will happen as we change the information structure) do a poor job of explaining the patterns in our data, an issue we return to in Sect. 5.

4.1 Eliminating information increases inequality

To assess how information impacts inequality in economic transactions, we need a way to measure inequality. Buyers almost always end up with more of the surplus than sellers, so an ideal measure of inequality should shrink as the seller's earnings get closer to the buyer's earnings and should be minimized when the seller's earnings and buyer's earnings are equal (either because an accepted offer split the pie equally or because an offer was rejected and both parties get nothing). This leaves open the question of what to do when an offer gives the majority of the surplus to the seller. Such offers could be thought of as increasing inequality at the transaction level (i.e., outcomes are less fair than an equal split for this particular buyer and seller) or it could be thought of as decreasing inequality at the market level (i.e.,

Table 1 Experimental treatments

		Buyer knows	
		Value	Value & cost
Seller Knows	Cost	*Neither knows (NK)* 5 Sessions 46 Buyers & 46 Sellers	*Buyer knows (BK)* 5 Sessions 49 Buyers & 49 Sellers
	Value & cost	*Seller knows (SK)* 5 Sessions 47 Buyers & 47 Sellers	*Complete information (CI)* 5 Sessions 45 Buyers & 45 Sellers

The experimental design involves four treatments varying in the information available to buyers and sellers. Table 1 shows the number of sessions of each treatment and the number of subjects that participated in each treatment

since buyers usually earn more than sellers, these generous offers help equalize average earnings).[8]

In what follows, we take as our primary measure a third path that treats these offers as neither increasing nor decreasing inequality relative to a fair split, and we explore the other two cases (see formal definitions in footnote 9) in Appendix B.2. We define *Inequality Share* $= \frac{max\{\pi_B - \pi_S, 0\}}{V-C}$. This measure increases as the difference between buyer and seller earnings increases from zero and treats all other outcomes as 0.[9] In addition, we define *Buyer Share* $= \frac{\pi_B}{V-C}$, *Seller Share* $= \frac{\pi_S}{V-C}$, and *Total Share* $= \frac{\pi_B + \pi_S}{V-C}$ as the percentage of the possible surplus of a transaction that went to the buyer, to the seller, and was captured by either party. *Total Share* is a measure of efficiency that is also the acceptance rate, since whenever an offer is accepted, $\pi_B + \pi_S = V - C$.[10]

Table 2 shows how these values differ by information treatment for the last 10 rounds. The stars in Table 2 test for treatment differences between the corresponding treatment and the *Complete Information* treatment (i.e., the ultimatum game), which we treat as a control for these tests, using regressions that cluster by both buyer and seller. The regressions that we use to assess significance are shown in Appendix Table B2. We see clear evidence that subjects learn with experience, so

[8] While rare, this type of overly generous offer is more likely to occur when buyers are uninformed of the seller's cost and so are unlikely to know that they have offered over half of the pie. When the buyer is informed, less than 2.5% of offers are overly generous.

[9] We define two alternative definitions of inequality share that differently handle the small number of cases where buyers are overly generous and offer the seller a larger share of the pie than they keep. These offers can be seen as increasing inequality at the transactional level or reducing inequality at the market level. *Absolute Inequality Share* $= \frac{|\pi_B - \pi_S|}{V-C}$ is the absolute difference between the buyer and seller's earnings divided by the total surplus and treats offers that give the majority of the surplus to the seller as increasing inequality. *Difference Inequality Share* $= \frac{\pi_B - \pi_S}{V-C}$ is the difference in earnings between buyers and sellers divided by the total surplus, which is allowed to be negative and thus treats offers that give the majority of the surplus to the seller as decreasing inequality.

[10] Note that since the surplus available for a given transaction, $V - C$, differs across rounds, we report all outcomes in terms of the fraction of surplus that was available in a given round.

we pay particular attention to the last 10 rounds of the game.[11] These last 10 rounds allow us to explore behavior of experienced agents, which may be particularly relevant when considering bargaining environments outside of the laboratory.

Focusing on *Inequality Share* in Table 2, we see that environments with less information have more inequality. Inequality share is 10.22 percentage points in the *Complete Information* treatment. Less information for either party—the buyer or seller—leads to statistically significantly more inequality; *Inequality Share* in these treatments is about 20 percentage points. The environment where neither party is informed has even more inequality; *Inequality Share* is 24.98 percentage points in the *Neither Knows* treatment. This 14.76 percentage point increase over the *Complete Information* treatment reflects a 144% increase in our measure of inequality.[12] Furthermore, the total share is constant across treatments in these last 10 rounds, suggesting that information does not impact the likelihood of trade, even though it dramatically changes how gains from trade are split.

4.2 Why does less information increase inequality?

Our experimental design allows us to answer this question by looking at offers and acceptance rates across our four treatments. In this section, we report on two factors driving this pattern. First, as discussed in Sects. 4.2.1 and 4.2.2, buyers—particularly high-value buyers—make lower offers when sellers are uninformed. Second, as discussed in Sects. 4.2.3 and 4.2.4, sellers are more likely to accept offers when either buyers or sellers are uninformed.

In particular, we find that either: (1) removing buyers' information when the seller is informed (i.e., going from *Complete Information* to *Seller Knows*) or (2) removing sellers' information, regardless of whether or not the buyer is informed (i.e., going from *Complete Information* to *Buyer Knows* or going from *Seller Knows* to *Neither Knows*) significantly lowers buyers' offers and directionally increases sellers' likelihood of acceptance for a given offer. Combining these two patterns, inequality rises. In contrast, removing buyers' information when sellers are uninformed (i.e., going from *Buyer Knows* to *Neither Knows*) only directionally decreases offers but significantly increases the acceptance rate for a given offer. Combining these two patterns, inequality increases.[13]

[11] Appendix Table B1 shows corresponding results for all 30 rounds, the first 10 rounds, and the last 10 rounds (replicating the results in Table 2). The regressions that we use to assess significance in Appendix Table B1 are shown in Appendix Tables B2–B4. We find differences in play between the first 10 and last 10 rounds: across all treatments, *Buyer Share, Seller Share*, and *Total Share* increase as subjects play more rounds while *Rejection Rate*, which is equal to 1−*Total Share*, falls. We confirm there are significant differences in a regression framework, shown in Appendix Table B5, which compares outcomes in the first 10 rounds and the last 10 rounds.

[12] Appendix Table B6 presents results for participants at Wharton and Stanford separately and shows that differences between participants at the two schools are not statistically significant. Appendix Table B7 shows that results are consistent and significant using session clusters. Appendix Table B8 shows that our results on inequality from Table 2 are robust to using the two alternative measures of inequality.

[13] Appendix Figure B1 summarizes these results and points to where these results are documented.

Table 2 Last 10 rounds: inequality share, buyer share, seller share, total share, and rejection rate

	Last 10 rounds				
Treatment	Inequality share	Buyer share	Seller share	Total share	Rejection rate
Complete information	10.22	49.22	39.00	88.22	11.78
Seller knows	20.14***	53.83*	35.11*	88.94	11.06
Buyer knows	20.60***	54.89**	34.50**	89.39	10.61
Neither knows	24.98***	54.19*	31.90***	86.09	13.91

Table 2 reports on data from all subjects for the last 10 rounds (see Appendix Table B1 for data on all 30 rounds and on the first 10 rounds). *Inequality Share* = $\frac{max\{\pi_B-\pi_S,0\}}{V-C}$. *Buyer Share* = $\frac{\pi_B}{V-C}$. *Seller Share* = $\frac{\pi_S}{V-C}$. *Total Share* = $\frac{\pi_B+\pi_S}{V-C}$ is the sum of *Buyer Share* and *Seller Share*. *Total Share* is less than 100% since some offers are rejected by the seller and lead to both players getting 0. *Rejection Rate* is the percentage of offers that are rejected, reported in percentage points, and is equal to 1−*Total Share*. The stars test whether we observe treatment differences between the corresponding treatment and the *Complete Information* treatment (i.e., the ultimatum game), which we treat as a control for these tests. The estimates come from a regression framework in which we include each transaction once and cluster by buyer and seller (of which there are 187 in each role). For the last 10 rounds, we have 1870 observations. See Appendix Table B2 for corresponding regression tables for the last 10 rounds.

Significance: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

4.2.1 How do buyer offers respond to the absence of information?

Figure 1 shows the average offer by treatment across the last 10 rounds for low-value buyers ($V = 70$) in panel (a) and high-value buyers ($V = 90$) in panel (b). Buyers make lower offers when sellers are uninformed (in *Neither Knows* and *Buyer Knows*) than when they are informed (in *Seller Knows* and *Complete Information*).

Pooling across the two panels, buyers offer 3.257 fewer experimental units in *Buyer Knows* than in *Complete Information* ($p = 0.003$, see column (4) of BK vs. CI in Appendix Table B12); similarly, buyers offer 2.703 fewer experimental units in *Neither Knows* than *Seller Knows* ($p = 0.029$, see column (4) of NK vs. SK in Appendix Table B12). While there are small, directional decreases in offers when $V = 70$, these decreases are substantially larger (and statistically significant) when $V = 90$, so it is the high-value buyers (i.e., in panel (b) of Fig. 1) who are driving this pattern. For example, buyers with $V = 90$ offer 6.770 fewer experimental units in *Buyer Knows* than *Complete Information* ($p < 0.001$ see column (6) of BK vs. CI in Appendix Table B12); similarly, buyers with $V = 90$ offer 4.459 fewer experimental units in *Neither Knows* than *Seller Knows* ($p = 0.006$, see column (6) of NK vs. SK in Appendix Table B12).[14]

In these last 10 rounds, buyers are also making lower offers in *Seller Knows* than in *Complete Information* ($\beta = -1.941$, $p = 0.051$ for all buyers), particularly when $V = 90$ ($\beta = -4.077$, $p = 0.001$, see columns (4) and (6) of SK vs. CI in Appendix Table B12). We show this graphically in Appendix Figure B3; the offers in *Seller*

[14] These differences are consistent and statistically significant when examining all 30 rounds of the game (see Appendix Figure B2 and the left panel of Appendix Table B12).

Knows are more similar to offers in *Complete Information* when sellers have a cost of 10 than when sellers have a cost of 30. This pattern suggests that uninformed buyers may act as if they are facing a seller with a cost of 10—perhaps suspecting that sellers will be more willing to accept low offers when the buyer could plausibly believe the seller had a cost of 10.

Finally, comparing across panels (a) and (b) of Fig. 1, we see that when sellers are not informed (in *Neither Knows* and *Buyer Knows*), the average offers of high-value buyers are similar to the offers of low-value buyers. This pattern suggests that high-value buyers are aiming to masquerade as low-value buyers when sellers are not informed.[15]

4.2.2 How do buyer beliefs respond to the absence of information?

After subjects completed all 30 rounds of the bargaining game, we asked buyers—in an incentive compatible way—to report the probability that the seller would accept a given offer. In particular, each buyer was randomly assigned one of the last 10 rounds and asked about the probability an offer was accepted for each of the buyer-seller pairs in that round. For each buyer-seller pair, the buyer was shown the buyer's value, any other information the buyer had in that round (i.e., the seller's cost in the *Buyer Knows* and *Complete Information* treatments), and the offer the buyer made in that round. The buyer then reported their best guess of the probability the offer was accepted (on a scale of 0–100%).[16]

Consistent with making lower offers when sellers are uninformed, buyers report believing that uninformed sellers are more likely to accept low offers.[17] This is easiest to observe in Fig. 2, which compares buyer beliefs in the *Complete Information* and *Buyer Knows* treatments in panels (a) and (b), and compares buyer beliefs in the *Seller Knows* and *Neither Knows* treatments in panel (c). Looking at panels (a) and (b), we see that buyers recognize that seller acceptance probabilities cannot be conditioned on buyer value in the *Buyer Knows* treatment—the gray and black solid lines practically overlap in panels (a) and (b). In addition, for both panels, the reported acceptance beliefs in *Buyer Knows* are close to beliefs from the *Complete Information* treatment when $V = 70$. This latter result suggests that buyers believe

[15] This is consistent with work by Ockenfels and Werner (2012) in which dictators "hide behind the small cake" when the size of the pie is unknown. While our setting does not have a reputational component because identities are not known, this result may also be consistent with a model of reputation formation (Camerer & Weigelt, 1988; Jung et al., 1994; Embrey et al., 2014).

[16] We used a Becker–DeGroot–Marschak (BDM) method for binary outcomes. To supplement the BDM instructions, we also explicitly emphasized for subjects that the method incentivized honest reporting of beliefs (see instructions in Appendix Section C).

[17] In this section, we focus on buyer beliefs conditional on offers between 20 and 60 experimental units, where most of our data is concentrated. Figure B4 in the appendix presents the cumulative distribution functions of offers used to elicit beliefs and shows that more than 99% of offers are between 20 and 60 experimental units.

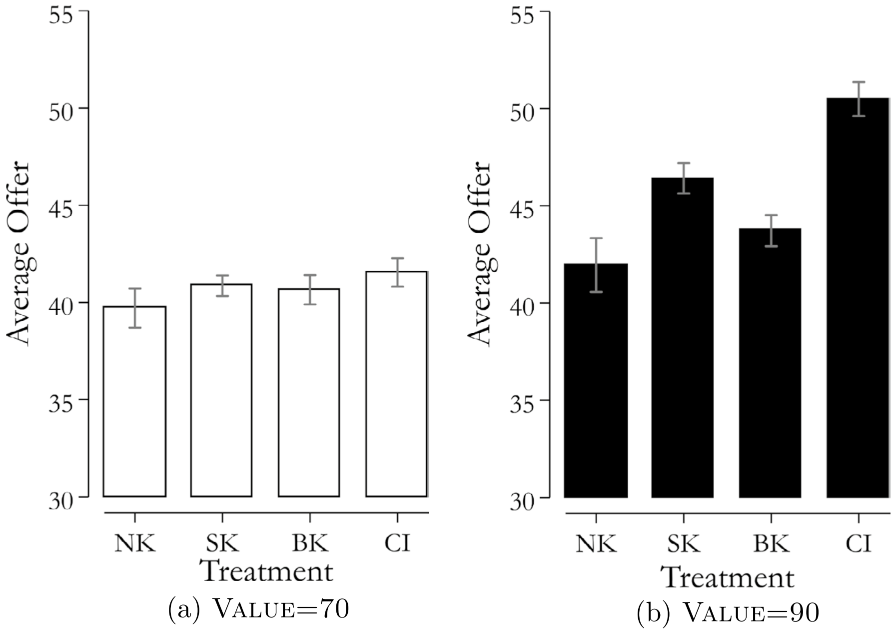


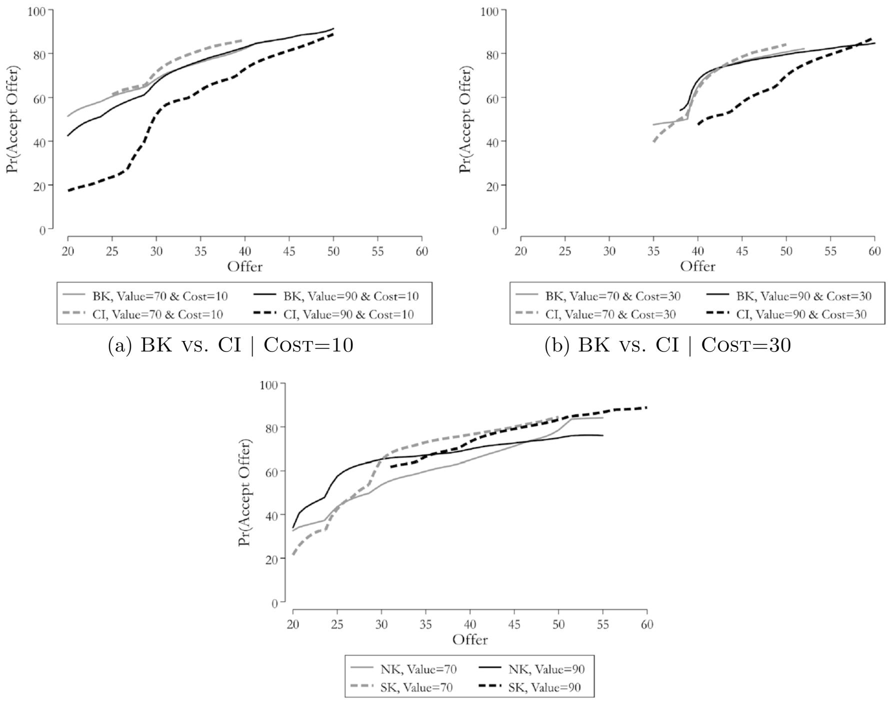
Fig. 1 Buyers' offers by treatment and value (last 10 rounds). Figure 1 shows the average offer for the last 10 rounds. Panel (**a**) shows the average offer by treatment for buyers with a value of 70, while Panel (**b**) shows the average offer by treatment for buyers with a value of 90. Buyers do not have information on sellers' costs in NK and SK but know sellers' costs in BK and CI. Buyers, particularly high-value buyers, make lower offers when sellers are uninformed. This amounts to high-value buyers masquerading as low-value buyers when sellers are uninformed. Robust standard error bars clustered at the buyer level are shown around each mean

uninformed sellers will make acceptance decisions as if they believe they are facing a low-value buyer.[18]

This buyer belief data allows us to demonstrate two key facts: (1) buyers understand that sellers cannot condition on information they do not have (e.g., the buyer's value in the *Buyer Knows* condition) and (2) buyers understand that sellers cannot use their offer as a perfect signal of the information they do not have.[19] This allows buyers to make lower offers when the sellers are uninformed and buyers believe that sellers will accept these lower offers. In the next section, we show that buyers' beliefs that sellers will accept these lower offers are (somewhat) accurate but that sellers' acceptance decisions also depend on the sellers' beliefs about buyer intentions.

[18] The data in panel (c) is slightly noisier, but beliefs in the *Neither Knows* treatment do not vary much by value and are slightly above acceptance probability beliefs in the *Seller Knows* treatment when low offers are made.

[19] If each offer corresponded to a certain buyer's value (i.e., no pooling) then we would not have seen differences by treatment.



(a) BK vs. CI | Cost=10

(b) BK vs. CI | Cost=30

(c) NK vs. SK

Fig. 2 Buyers' beliefs that offers were accepted. Figure 2 shows buyers' beliefs across treatments. Panel (**a**) reports the buyer's belief probability that an offer is accepted when the seller's cost is 10 for the *Complete Information* and *Buyer Knows* treatments. Buyers in the BK treatment correctly recognize that uninformed sellers cannot condition acceptance on the buyer's value (the solid lines are on top of each other). In addition, the reported probability of acceptance is nearly identical to beliefs in CI when $V = 70$. This latter result suggests buyers believe uninformed sellers will make acceptance decisions as if they believe they are facing a low-value buyer. Similarly, panel (**b**) compares *Complete Information* and *Buyer Knows* treatments conditional on the seller's cost being 30. Buyers in BK correctly realize that uninformed sellers cannot condition acceptance on the buyer's value (the solid lines are on top of each other). In addition, the reported probability of acceptance is nearly identical to beliefs in CI for $V = 70$. Panel (**c**) compares *Seller Knows* and *Neither Knows* treatments. Buyers' beliefs in the *Neither Knows* treatment do not vary much by value and are very similar to beliefs in the *Seller Knows* treatment

4.2.3 How do seller acceptance rates respond to the absence of information?

In this section, we explore how sellers with a given cost respond to the same offer in different information environments. Generally, there are no differences in sellers' acceptance rates across treatment conditions.[20] One exception is among uninformed sellers comparing cases where the buyer is uninformed (i.e., in *Neither Knows*) to cases where the buyer is informed (i.e., in *Buyer Knows*). Figure B6 shows this comparison graphically. When buyers are uninformed, sellers are 7.2 percentage

[20] See Appendix Table B13 for regression results across all 30 rounds and the last 10 rounds.

points more likely to accept a given offer compared to when buyers are informed ($p = 0.024$, see column (3) of NK vs. BK in Appendix Table B13). This is effect is driven by high-cost sellers (i.e., $C = 30$) who are 14.2 percentage points more likely to accept a given offer when buyers are uninformed ($p = 0.034$, see column (3) of NK vs. BK in Appendix Table B13).[21]

The increase in acceptance rates when the buyer is uninformed could arise due to concerns about buyer intentions. For example, sellers with $C = 30$ in *Neither Knows* may believe that buyers are responding to the expected seller cost (i.e., $E[C] = 20$) or that buyers think they are facing a seller with $C = 10$. These—perhaps motivated—beliefs will lead sellers to think a given offer is more generous in *Neither Knows* than in *Buyer Knows*, when the seller knows that the buyer knows that $C = 30$.

4.2.4 How do seller beliefs respond to the absence of information?

After subjects played all 30 rounds of the bargaining game, we incentivized sellers in the *Neither Knows* and *Buyer Knows* conditions (i.e., in each treatment where they did not know the buyer's value) to report the probability that the buyer had $V = 70$ (i.e., was a low-value buyer), one by one for each offer they received in the last 10 rounds of the game.[22] We use sellers' beliefs to explore why sellers are directionally more likely to accept an offer when uninformed.

Evidence from our belief elicitation suggests that when sellers are uninformed, they give buyers the benefit of the doubt by assuming that relatively low offers disproportionately come from low-value buyers. Figure 3 Panel (a) reports the true probability that an offer from the last 10 rounds of *Neither Knows* came from a low-value buyer (dashed line) as well as sellers' beliefs that the offer came from a low-value buyer (solid line). We can see that when offers are in the range of 25–45 experimental units, sellers report a much higher probability that the offer came from a low-value buyer than it actually did. Similarly, Fig. 3 Panel (b) shows that in *Buyer Knows*, high-cost sellers report that low offers (between 35 and 40 experimental units) were more likely to come from a low-value buyer than they did in practice. Both of these differences are statistically significant ($p < 0.000$), as shown in Appendix Table B14.

Giving buyers the "benefit of the doubt" makes sense if sellers get disutility from inequality (Fehr & Schmidt, 1999; Bolton & Ockenfels, 2000) and are capable of holding motivated beliefs (Möbius et al., 2022; Bénabou & Tirole, 2016). That is, sellers may want to believe that they are being treated fairly since giving buyers the benefit of the doubt makes inequity averse sellers less likely to reject an offer, which

[21] Appendix Figure B5 replicates this graph for all 30 rounds and the left panel of Appendix Table B13 shows the corresponding regression results.

[22] We used a Becker–DeGroot–Marschak (BDM) method for binary outcomes. To supplement the BDM instructions, we also explicitly emphasized for subjects that the method incentivized honest reporting of beliefs (see instructions in Appendix Section C).

leads them to earn more and gives them more utility when they accept an offer. We return to this hypothesis in Sect. 5.

4.3 Who benefits from information?

In this section, we analyze the effect of information on the surplus earned by buyers and sellers. Looking back at Table 2, we see that sellers always earn more when they have information about the buyer's value when they respond to the buyer's offer. For example, seller earnings increase from 32 to 35% of the pie, a roughly 10% increase, comparing uninformed sellers in the *Neither Knows* treatment to informed sellers in *Seller Knows*. In contrast, information is not valuable to buyers, and it can even harm buyers if sellers are already informed. Buyers earn less in *Complete Information* than in any of the other three treatments, and their earnings are basically identical across the other three treatments.

The asymmetrical value of information for buyers and sellers suggests that, in a setting like ours where there is common knowledge of which parties are informed, the seller has an incentive to get information but the buyer has an incentive to remain uninformed.[23] This pattern makes the setting in which the seller is informed and the buyer is not informed an absorbing state that might be likely to arise in environments in which sellers and buyers have the opportunity to get additional information.

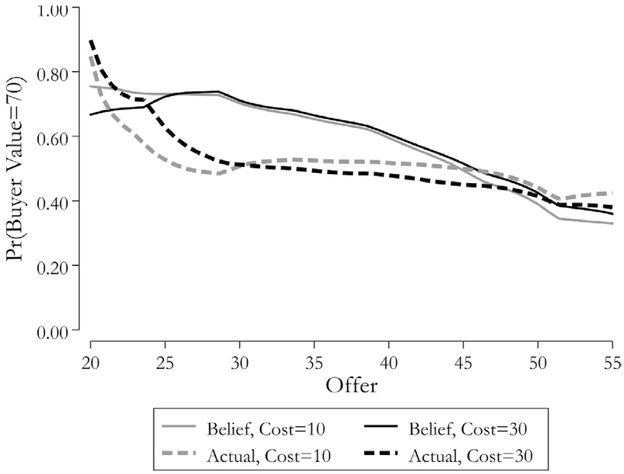
5 Conclusion

In this paper, we find that inequality in economic transactions rises dramatically when parties are less informed. Inspired by the experimental design in Kagel et al. (1996), a seminal work on information in bargaining games, our new experimental paradigm allows us to systematically vary the information available to each party. We show that the ultimatum game—the workhorse that has attracted significant attention in the literature and has highlighted the importance of fairness concerns in economic transactions—is a special case at one end of the spectrum of the impact of fairness on outcomes.

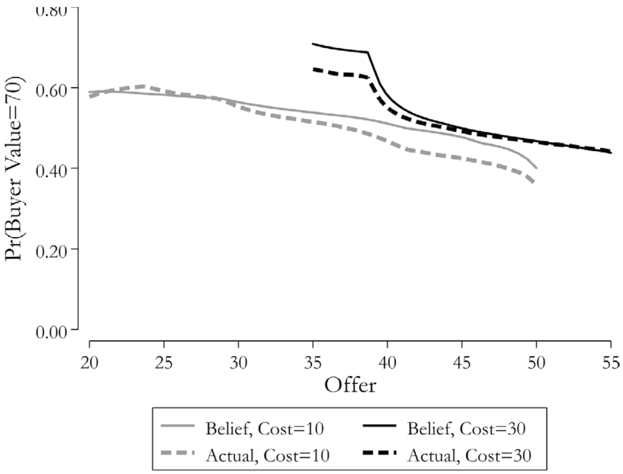
The large increases in inequality when one or both parties are uninformed arise from two sources. First, buyers make more selfish offers when parties are less informed. For example, buyers facing uninformed sellers make offers that are similar to the offers that low-value buyers make to informed sellers. Put simply, high-value buyers masquerade as low-value buyers when sellers are uninformed. This behavior is consistent with buyer beliefs that sellers will accept lower offers when sellers are uninformed.

Second, sellers directionally increase acceptance rates when less information is available. In addition, uninformed, high-cost sellers are statistically significantly

[23] While not our focus here, exploring cases where information acquisition is private information is an exciting avenue for future work. For example, Roth and Keith Murnighan (1982) shows more disagreement in a lottery game when the information setting itself is not common knowledge.



(a) Neither Knows (NK)



(b) Buyer Knows (BK)

Fig. 3 Seller' beliefs vs. reality. Fig. 3 shows the probability an offer came from a low-value buyers and a seller's incentive compatible belief that it came from a low-value buyer. Panel (**a**) reports the probability that an offer from the last 10 rounds of the NK treatment came from a low-value buyer (dashed lines) as well as sellers' incentive-compatible beliefs that the offer came from a low-value buyer (solid lines). We can see that when offers are in the range 25–45, sellers report a much higher probability that the offer came from a low-value buyer than it did in practice. Similarly, panel (**b**) reports the probability that an offer from the last 10 rounds of the BK treatment came from a low-value buyer (dashed lines) as well as sellers' incentive-compatible beliefs that the offer came from a low-value buyer (solid lines). We can see that when offers are in the range 35–40, sellers report a much higher probability that the offer came from a low-value buyer than it did in practice. Kernel: Epanechnikov; Degree=0; Bandwidth=5 more likely to accept offers when buyers are uninformed. This latter result suggests that sellers care about the intentions of buyers—sellers are willing to accept unfair offers if they can imagine buyers thought the offer was fair.

As shown in Appendix A, neither the standard model with selfish agents nor a model with inequity concerns, as in Fehr and Schmidt (1999), yield comparative statics that match the patterns in our data. What type of model can explain our findings?

Part of the pattern of results we observe could theoretically be driven by a form of inequity aversion with a non-linear "motivation" function. Bolton and Ockenfels (2000) defines a motivation function and proposes that it is non-linear. A non-linear motivation function could help explain our results if the (expected) utility from accepting an offer is higher when it is equally likely to be fair or unfair than when it is certainly fair half of the time and certainly unfair half of the time. Such a pattern could theoretically explain sellers being more likely to accept an offer in *Buyer Knows*—where it may or may not be fair, depending on the buyer's value—than in *Complete Information* where it is obviously fair or unfair. Buyers anticipating this response might then strategically lower their offers in *Buyer Knows* given the potentially higher likelihood of acceptance.

While such a motivation function could explain some of our results, it leaves others unexplained, such as why high-value buyers in *Buyer Knows* give offers as low as those made by low-value buyers in *Complete Information* or why seller acceptance rates in *Buyer Knows* are as high—or nearly as high—as acceptance rates for offers from low-value buyers in *Complete Information*.

To explain these patterns requires a signaling model where sellers infer the size of the pie from the offer made by the buyer. In this type of model, high-value buyers in *Buyer Knows* or *Neither Knows* might try to pool with low-value buyers by making offers that a low-value buyer might make. In a model like this, uninformed sellers who receive a low offer would know that it might have come from a high-value buyer, but they might still accept the offer at high enough rates that high-value buyers still find it desirable to pool.

This type of model can explain more of the findings, but it still cannot explain some of our findings. For example, sellers systematically overreport the probability that they have faced low-value buyers, which we would not expect if sellers fully understood that high-value buyers were pooling with low-value buyers. The signaling story also cannot explain why sellers accept more often when *buyers* are uninformed.

A final possibility is that sellers have fairness concerns but *want to believe that buyers are treating them fairly*. Such a desire is sensible. If sellers have fairness preferences, as in Fehr and Schmidt (1999) or Bolton and Ockenfels (2000), and are capable of holding motivated beliefs, as in Möbius et al. (2022) or Bénabou and Tirole (2016), they will want to believe that low offers come from buyers with $V = 70$. Believing offers come from low-value buyers makes it easier for them to accept unfair offers and decreases the disutility that they receive when they accept offers. In addition, if sellers care about buyers' intentions as in Rabin (1993) or Charness and Rabin (2002), sellers will want to believe that uninformed buyers believe they are making fair offers (i.e., that low offers are going to sellers with

$C = 10$). Similarly, buyers who care about fairness may also want to believe that they are facing low-cost sellers.

If the absence of information allows parties to hold such motivated beliefs, this could help to rationalize our results. Keniston et al. (2021) offer a related theoretical explanation: when agents have incomplete information about opponents' values (e.g., in *Neither Knows*), they may favor outcomes that yield an equal split of the "most optimistic" inference about their opponents. They find evidence consistent with this notion in rich field data from alternating-offer negotiations. Stüber (2020) finds something similar in a dictator game with punishment, in which a third party can choose whether to learn whether a dictator treated a recipient unfairly. Third party punishers give the dictator the "benefit of the doubt," choosing not to learn and thus not to punish. This pattern is similar to the pattern observed in the classing "moral wiggle room" paradigm (Dana et al., 2007). In our setting, however, the absence of information is exogenous rather than endogenous.

While other explanations could also drive the pattern of results we observe—such as subjects simply caring less about fairness when less information is available or norms developing differently in different information structures—we see the exploration of how fairness preferences might induce motivated beliefs as an exciting avenue for future work. Such future work might follow the lead of Dana et al. (2007) and Stüber (2020) by offering parties the opportunity to learn information about the other party. In addition, one might consider providing information about cost and value after the transaction has been made. Perhaps knowing that the size of the pie will eventually be revealed will change offers and acceptance decisions.

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