Coasian Bargaining in a Computerized Environment *

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Abstract

In this paper, we study Coasian bargaining in the experimental laboratory to better understand how modern negotiating environments affect bargaining outcomes. We first establish baseline findings by replicating bargaining protocols introduced by Hoffman and Spitzer (1982, 1985), and then extend them to a computerized environment. This leads to a 2x2x2, between-subjects design that varies the mechanism by which property rights are assigned (random or contest), if subjects engage in repeated bargaining (one-shot or two-shot), and whether the experiment is conducted in a face-to-face or a computerized environment. We replicate the findings in the seminal papers that randomly assigning property rights yields a higher incidence of equitable payoff distributions and that bargaining face-to-face yields a higher rate of efficient (i.e., total payoff maximizing) decision making than does bargaining in a computerized negotiation environment. In addition, subjects become significantly more self-regarding when bargaining digitally, with distributions strongly favoring the holder of property rights. Given that efficiency and other-regarding behavior are not invariant across negotiating environments, these results suggest that the predictions made in Coase (1960) may require additional behavioral considerations, particularly when negotiations occur with some degree of anonymity and social distance.

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1 Introduction

Economists have long focused on the allocative efficiency of markets, in that the prices of goods and services and their associated transactions reflect all information and all social costs and benefits generated by their production and consumption. When social and private costs of consuming that good or service do not equate, a market failure (i.e., an inefficient allocation of goods and services) transpires. One common type of market failure is an externality, which occurs when the production or consumption of a good or service imposes a cost or benefit to a third party that is not fully accounted for in its price, and leads to either too much or too little production and consumption. To correct externalities, Pigou (1920) posited that a government intervention was needed to restore market efficiency. Specifically, he proposed an approach wherein a governing authority levied taxes (or subsidies) that would change the price of the good or service to offset the externality.

Coase (1960) challenged this idea by showing that, as long as property rights are well defined, adversarial parties can bargain to obtain allocatively efficient outcomes. One example provided in the paper is that of solving a dispute between neighbors, which involved the cattle belonging to a rancher straying onto a neighboring farmer's property and destroying crops (i.e., a negative externality imposed on crop production caused by the production of cattle). The question is over which party should pay to prevent the cattle from destroying crops (e.g., by installing a fence), or receive compensation for the lost cattle production associated with keeping the cattle off of the property (presumably from less or lower quality feeding) or for the damage to crops that lowers yields. Instead of a centralized government intervening, such as by placing a tax on the rancher that would theoretically reduce the number of cattle on the property, or by providing a subsidy to the two parties for a fence or as compensation for crop damages, Coase posited that the two parties can negotiate together to achieve an efficient outcome as long as one party is assigned with property rights that are clearly defined and there are no transaction costs acting as impediments to negotiation.

Coase's work changed the way economists think about the externality problem, and has

served as a basis for countless court rulings and policy decisions (Hoffman and Spitzer, 1982; Medema and Zerbe 1999). For example, consider a similar case where a smoke-emitting factory causes health and other pollution-related damages to its district. Prior to the proposal by Coase, the two predominant solutions to the problem were the use of a per-unit emissions tax (Pigouvian tax) or a command-based approach.[1] Coase's paper added a third solution to the problem, which proposed that assigning one party a right to produce and generate emissions (or to prohibit production and therefore emissions), would lead agents to bargain (or negotiate) until they arrived at the socially efficient outcome. The premise of the idea is that bargaining would trigger lateral exchanges of money or other favors between the two parties until a mutually advantageous agreement on the amount of pollution and or compensation could be made, without costly government intervention.

The proposal for a decentralized approach to externalities caused much debate, which often focused on the litany of assumptions underpinning his idea.[2] Hoffman and Spitzer (HS hereafter) waded into the debate by becoming the first to study the theorem experimentally. In their seminal work, HS developed a set of experimental protocols that both satisfied the assumptions underpinning Coase's proposed approach and allowed them test predictions over bargaining outcomes along various dimensions (HS 1982; 1985; 1986). They found that in a face-to-face and costless bargaining environment with well-defined property rights, subjects consistently achieved efficient (i.e., social welfare maximizing) outcomes in both one-shot and repeated-bargaining settings, under multiple methods of property rights allocation, and with drastic variations in the size of groups engaging in bargaining. Interestingly, HS found that randomly assigning property rights (as opposed to competing for property rights) led to subjects holding the property rights systematically agreeing to allocations that were not individually rational. This finding contradicts the prediction that an individually rational

[1] Under a command-based approach, a regulator sets a total allowable emissions threshold that the factory may emit, and forces it to abate at whatever cost until its emissions are below the threshold or face a large fine or other penalty.

[2] Coase did not actually state his own idea as a theorem. This formalization was first done by George Stigler (1966). For more examples of formalization, see Calabresi (1968), Regan (1972), Polinsky (1974), Frech (1979), Cooter and Ulen (1988), among others.

share of the socially efficient allocation would remain with the property rights holder.

HS's work made two things apparent. The efficiency prediction of Coase (1960) is robust to a variety of strategic regimes. However, these different regimes induce drastically different behavior among property rights holders, which has large implications for the distribution of welfare. These results also emphasize the importance of the role that human behavior plays more generally in negotiations, including those beyond just Coasian-esque disputes.[3] Specifically, influences such as social connection, cultural norms, guilt, and other considerations come into play when negotiating over a dispute or bargaining during a transaction that has immediate ramifications for personal well-being.

Since HS's seminal papers, rapid technological advancement has changed the way we communicate. One meaningful change has been the transition to digitally-mediated communication environments such as telecommunications or text-based messaging (text messages, email, etc.). This transition of the communication environment has brought about changes in how we negotiate with one another. For example, negotiations over privately-held mineral rights in the U.S. traditionally involved a landman visiting a mineral rights owner in person to inquire about leasing the minerals on the property. However, these negotiations now frequently occur over the phone, by email, or through a third party. It has also caused changes in the broader development of online markets such as Facebook Marketplace, Craigslist, eBay's "Best Offer" platform, Etsy, Letgo, OfferUp, Upwork and others, where communication and transactions occur in a drastically different fashion than under traditional face-to-face settings. For example, Backus et al. (2018) study online bargaining using a large data set of 25 million listings negotiated on eBay's Best Offer platform, and observe patterns of bargaining behavior consistent with theories in both economics and psychology.

Although digitized communication introduces many benefits (e.g., speed and convenience) it also introduces new behavioral considerations such as increased social distance

[3]Practical examples include negotiations over mineral or water rights, easements and other projects requiring access or right-of-way; in real estate markets, where the prices of homes are typically negotiable; re-sale markets such as garage sales, baseball card markets and ticket exchanges, and used cars; and service markets requiring labor or other expertise for which the wage rate is negotiable.

and anonymity. These factors affect the distribution of benefits acquired by negotiators in a transaction, but they also suggest some additional limitations of the predictive power of the Coasian bargaining approach. For example, social distance and anonymity may impose non-pecuniary transaction costs, such as increasing the level of communication breakdowns in negotiations or the depth and clarity of communication leading to socially inefficient bargaining outcomes (Backus et al. 2019). This implies such an environment may fail to satsify assumption of Coase theorem, which may suggest a need for intervention to restore efficiency. It is also straightforward to understand that increasing the level of anonymity and social distance in communications changes the way individuals behave, particularly in strategic decision-making, as it reduces the roles that external influences, such as self-image and morality, play. More simply, changing these communication dynamics directly enables humans to adjust their behavior when it benefits them or when they know it will not damage their image.[4][5]

In this paper, we study the effects of moving to a computerized bargaining platform on two behavioral outcomes documented in HS (1982; 1985). Namely, we are interested in how the ability of subjects to negotiate socially efficient outcomes and their level of self-regarding behavior change in a computerized relative to a face-to-face bargaining environment. We study these outcomes across a variety of property rights and entitlement schemes, and in sequential and non-sequential bargaining sessions. We first establish a baseline by implementing the procedures of HS in a face-to-face environment, and then conduct the same protocols using a computerized bargaining platform. Similar to HS (1982; 1985), we find that subjects frequently arrive at the efficient outcome (more than 80% of the time) when bargaining face to face. However, when bargaining in a computerized environment, subjects'

[4]A large collection of papers in the economics literature has studied the role of social distance and anonymity in a variety of settings. For example, Roth and Malouf, 1979; Hoffman et al., 1994; Laury et al., 1994; Eckel and Grossman, 1996; Bohnet and Frey, 1999; Valley et al., 2002; Naquin and Paulson, 2003; Dufwenberg and Muren, 2005; Charness and Gneezy, 2008.

[5]The psychology literature has also studied this phenomenon extensively, including in regular, day-to-day activities such as driving (Ellison et al. 1995), theft opportunities (Diener et al. 1976), levels of aggression amongst anonymous vs. non-anonymous communicators (Zimmerman 2012), and others.

ability to arrive at the efficient outcome drops by approximately 22%. In addition, we observe that property right holders behave in a more rational (i.e. self-regarding) way in the computerized environment. Following HS' use of an Average Greed Index (AGI) as an indicator of the level of self-regarding behavior of the property rights holder, we observe that the AGI increases from 0.73 to 2.96 when switching from the face-to-face to the computerized bargaining environment. Collectively these results indicate that moving to a computerized platform does change bargaining behavior among subjects, and they provide evidence that outcomes (both individual and aggregate) are sensitive to the negotiation environment, and indicating that Coase's hypothesis may not be applicable in a computerized setting, highlighting some noteworthy considerations to make as we transition into an increasingly computerized world.

2 Literature Review

2.1 Overview of Hoffman and Spitzer (1982 & 1985)

HS began their study of bargaining with their 1982 experiment, which yielded strong support for the efficiency prediction of Coase (1960) but also showed that bargainers randomly endowed with property rights agreed to non-core allocations that were efficient but not individually rational whenever they knew they would engage in repeated bargaining.[6] This antithetical result prompted HS to investigate the roles of entitlement and fairness in determining payoff distributions. HS hypothesised that subjects chose allocations according to some sense of distributional fairness and that randomly-assigned property rights failed to create a moral basis for self-regarding behavior. They argued that such moral equivalence led Controllers to accept disadvantageous bargains. Thus, HS (1985) tested whether competing for property rights or priming Controllers with a sense of entitlement would impact payoff distributions. HS again observed high rates of efficiency and also that efficiency was robust to both competition and entitlement priming. However, their results also showed that

[6] Most bargaining outcomes in the repeated interaction setting involved an equal splitting of money.

competing for property rights and entitlement priming both yield more rational bargaining outcomes.

2.2 Other Literature

Many bargaining experiments extending this work soon emerged. Hoffman and Spitzer (1986) showed that efficiency in full- and limited-information settings does not deteriorate as the size of bargaining groups increases. Harrison and McKee (1985) argued that the irrational payoff distributions in HS 1982 resulted from subjects' misunderstanding of property rights. In contrast, they showed that two-person, full-information bargaining experiments yield rational payoff distributions whenever subjects first bargain first with joint property rights and then with unilateral property rights. This inspired many other works that explored entitlement and fairness in bargaining and in markets (Kahneman et al. 1986, 1990; Thaler 1988; Guth and Tietz 1990).

Hoffman et al. (1994) show that coupling entitlement priming with competing for the role of first-mover in a set of dictator and ultimatum games induces self-regarding behavior; these results contradicted the 'fairness' exhibited in previous experiments using canonical games by Guth et al. (1982). Cherry et al. (2002) show that dictators act in an exceptionally self-regarding manner whenever splitting earned rather than unearned wealth. Shogren (1992) examined bargaining behavior when subjects bargained over uncertain payoff streams (an ex ante lottery and the ex post payoff) and found that 87-percent of all agreements were PE. Shogren and Cherry (2005) studied how transaction costs affect bargaining in settings with secure and insecure property rights, and find that bargaining efficiency is inversely related to property right security. They estimate that less secure property rights increased economic efficiency twofold, in contrast to the case of property owners with secure rights opting for their lower cost option and not engaging in what would be social welfare-improving bargaining.

Valley et al. (2002) explored how modes of communication can affect outcomes in a double auction. They found that written communication led to higher rates of deception

and higher efficiency than did no communication. They also found that face-to-face communication increased efficient outcomes by increasing coordination. Naquin and Paulson (2003) compared outcomes between online and face-to-face bargaining and found that online negotiators reported feeling less satisfied with their outcomes, less trusting of their partner, and had less desire for future interaction with the same partner. However, they also found that face-to-face and online bargaining produced similar outcomes.

Many papers have examined the role of anonymity in various bargaining designs. Roth and Malouf (1979) test bargaining theory developed by Nash (1950) using a binary lottery system and found that subjects split tickets equally between themselves whenever they had equal payoffs, and either split tickets equally or to equate expected payoff values when they had unequal payoffs. However, Roth and Malouf do not assign property rights, subjects bargained for non-exclusive payoffs (they could both win the positive prize), and both subjects faced the threat of receiving a zero payoff with certainty if they failed to reach a deal. Hoffman et al. (1994) explored the effect of anonymity in double-blind dictator games and found that anonymity caused dictators to act in a self-regarding manner, suggesting offers are due to strategic and expectant considerations.

Laury et al. (1994) examined whether anonymity would reduce the provision of public goods but found no significant effects. However, this finding is possibly confounded by the fact that subjects in their control group (they sat together in the same room) did not know exactly who was in their group. Thus, control subjects also made decisions under anonymous conditions. Eckel and Grossman (1996) tested the role of anonymity in dictator games and saw a significant increase in donations when subjects regarded recipients as deserving of donation. Bohnet and Frey (1999) explored the role of social distance in dictator games and found that the dictators were more other-regarding when they knew more personal information about recipients. Dufwenberg and Muren (2005) tested how a person's generosity depended on the degree of anonymity in dictator games by paying people publicly or privately and found that subjects gave less when paid publicly.

Charness and Gneezy (2008) examined how behavior changes in dictator games with varying degrees of anonymity and social distance. They found that revealing some information of recipients, such as family name, to dictators caused more generosity. Conversely, results in the full anonymity treatment and family-name treatment produced no difference in ultimatum games, suggesting strategic concerns can crowd out generosity. Thunströma et al. (2016) use a one-shot dictator game and show that dictators often choose to reduce social distance by finding out the deservingness level of recipients, and they act on that frame by giving more to deserving recipients.

Considered together, the existing literature suggests that anonymity induces more self-regarding behavior but that closing social distance can, in some contexts, counteract this effect. Thus, allowing unrestricted communication might mitigate the impact of anonymity on bargaining outcomes.

3 Experimental Design & Lab Procedures

We use a 2x2x2, between-subjects design with three factors: property rights assignment, repeated bargaining, and bargaining environment. First, we define two types of property rights: strong property rights (competing for rights and entitlement priming) and weak property rights (randomizing rights and no entitlement priming). Second, subjects engage in either one-shot or two-shot bargaining. These two factors allow us to replicate the treatments from Hoffman and Spitzer (1985) that produced the two extremes of self-regarding behavior.Third, we use either face-to-face bargaining or computerized bargaining. Additionally, subjects made a total of ten bargaining decisions each. Subjects in two-shot sessions bargained with a total of 5 partners and subjects in one-shot sessions with a total of ten partners. We implemented all research protocols from Hoffman and Spitzer (1982, 1985), described above.

We recruited undergraduate students from Texas A&M University, conducted 2 sessions for each treatment, and used 12 subjects in each session. We used complete stranger matching

to form new bargaining pairs after each bargaining period in one-shot bargaining sessions and after every two bargaining periods in two-shot bargaining sessions. We randomly selected two bargaining decisions for payment. For two-shot bargaining, we paid subjects for both bargaining decisions made with a single partner. For one-shot bargaining, we paid subjects for two bargaining decisions made with two different partners. We paid subjects in the nine sessions that took place between December 2016 and May 2017 a $5 show up fee. We paid subjects in the seven sessions that took place in fall 2017 a $10 show-up fee.

3.1 Lab Procedures for Face-to-Face Sessions

We enforce complete stranger matching for both one- and two-shot bargaining sessions. For one-shot sessions, subjects bargained with each partner only once. For two-shot sessions, subjects bargained with each partner twice.

We arranged the laboratory to allow maximal distance between bargaining stations to allow privacy between bargaining pairs.[7] The same moderator read instructions aloud for each session, and we also provided paper instructions for reference. We concluded instructions with a comprehension quiz that we checked individually before proceeding. Note that instructions for strong property rights treatments included entitlement priming language and instructions for weak property rights treatments included neutral language.

We always provided a bargaining pair's contract to the Controller and provided each subject with a payoff sheet to ensure payoffs were common knowledge. Once a pair finished bargaining and completed the contract, they signaled an experimenter who collected payoff tables and the contract. We instructed subjects to wait quietly until all pairs finished bargaining.

Face-to-Face Property Rights:

We allocated weak property rights at the pair level with a coin flip. If the result of the

[7] Hoffman and Spitzer made subjects bargain publicly and receive payments publicly in their experiments. Thus, our only goal was to prevent subjects from overhearing other bargaining strategies and not to provide bargaining subjects privacy from experimenter scrutiny.

coin flip was heads, we designated the subject with the lower identification number[8] as the Controller. We allocated strong property rights by having subjects play a deterministic hash mark game.[9] The hash mark game worked as follows: subjects were presented with N hash marks arranged in a row. During her turn, a subject could cross out from 1 to Y hash marks. Whichever subject crossed out the last hash mark lost the hash mark game. We give an example of this game below, where we suppose that N = 5 and Y = 3.

In odd-numbered periods, the player with the lower identity number moved first, and in even-numbered periods, the player with the higher identity number moved first. At the start of the game, before either player has moved, subjects see a certain number of hash marks:

/ / / / /

Now, suppose that whoever plays first marks out three hash marks:

~~/ / /~~ / /

And then the second player now marks out one hash mark:

~~/ / / /~~ /

The player who moved first must now cross out the last hash mark. Thus, the first mover loses.

3.2 Lab Procedures for Computer Bargaining Sessions

We conducted all computerized bargaining sessions with a computerized interface programmed using Ztree (Urs Fischbacher, 2007). This program used generated complete stranger matches each period for one-shot sessions and every two periods for two-shot sessions.

[8] All subjects used randomly-assigned numbers between 1 and 12 as identifiers during experiments.

[9] We asked subjects to record a strategy for this game. There is no evidence that any subject solved the game.

A period of bargaining in the computerized environment always had the same flow as in face-to-face bargaining. After Controllers selected a unilateral decision for implementation in cases of bargaining failures, Bargainers learned of this decision. Next, subjects used a chat box to bargain with one another. If subjects agreed to a mutual decision, both players could indicate this with a button provided on the chat screen. If both subjects clicked this button, then the Bargainer completed a contract and forwarded it to the Controller for approval. Controllers could refuse a contract for any reason.

If a Controller refused a contract, the program implemented the Controller's unilateral decision and the period ended. If the Controller approved the contract, then the program implemented payoffs according to the terms of the contract and the period ended. If subjects were unable to reach an agreement then the program implemented the Controller's unilateral decision and bargaining ended.

Computerized Property Rights:

We allocated weak property rights at the pair level using a random number generation. We allocated strong property rights by having subjects compete a simple addition task for time. Though this competition task is different than the one employed during face-to-face bargaining, we saw little difference in the frequency of role switching as a result. We chose a programmable task that we thought best replicated the deterministic, competitive properties of the hash mark game described above. We further discuss in the results section why we believe that this difference had no impact on behaviors across environments.

4 Results

4.1 Replication Results

We consider our replication successful if we obtain a significant result in the same direction as the result of interest in the original study, since this measure is the most rigorous applied

(as measured by relative replication rates) in Camerer et al. (2016).

HS (1982) focused on two things: testing the predictive power of Coase's bargaining theorem and understanding how the strategic considerations implicit in repeated bargaining might alter bargaining outcomes in terms of efficiency and in terms of payoff distributions.

We replicate the research protocols employed in the two-person, full-information bargaining treatments from Hoffman and Spitzer (1982) in Table 1,[10] which reports percentages of efficient and 'sharing' allocations for both one- and two-shot bargaining. Following HS, we define sharing as any allocation where Controller and Bargainer payoffs are within \$1 of equality. We observe an equivalently high proportion of efficient decisions as did HS ($p > .01$)[11] and find no statistically significant difference in levels of efficiency achieved with one- and two-shot bargaining. Thus, we replicate HS's efficiency results. Regarding payoff distributions, we replicate the finding that Controllers in two-shot bargaining are other-regarding.[12]

Table 1: Replicating Results for Repeated Bargaining.

	Efficiency		**Sharing**	
	HS Data	**Our Data**	**HS Data**	**Our Data**
2-Shot Bargaining	94%	80%	100%	80%
1-Shot Bargaining	91%	83%	21%	75%

We have a total of 34, two-shot bargaining decision and 12 one-shot bargaining decisions in respective the 'HS Data' columns. We have 24 one- and two-shot bargaining decisions, in the respective 'Our Data' columns. 'Sharing' allocations are allocations where money is split within one dollar of an even split.

However, we observe no statistical difference in the proportion of sharing allocations obtained in one- and two-shot bargaining treatments. Thus, we fail to replicate HS's finding that repeated interaction increases other-regarding behavior. We observe less sharing in our

[10] Results reported in the 'Our Data' column in Table 1 include data from only the first two periods of the face-to-face, weak property rights sessions. Results in the 'HS Data' column include data from their 1982 paper and also from the random assignment, no entitlement treatments of their 1985 paper.

[11] We use a proportions test with the null hypothesis that the proportion of efficient decisions obtained in our experiment is the same as the proportion of efficient decisions obtained by HS.

[12] We test whether the proportion of sharers in our data is different from the proportion of sharers in HS's data and find no statistically significant difference. Note that a 'sharing' allocation is any allocation where a bargaining pair splits money within \$1 of an equal split. For example, if the joint payoff of an allocation is \$14, then (\$7,\$7) and (\$8,\$6) are sharing allocations but (\$9,\$5) is not.

two-shot sessions ($p < .01$) and much more sharing in our one-shot sessions ($p < .0001$) than did HS.

We now turn to Hoffman and Spitzer (1985), which tests the role of entitlement to property rights on bargaining behavior. We provide results from Hoffman and Spitzer (1985) alongside our own in Table 2, which reports an Average Greed Index (AGI), a measure of self-regarding behavior introduced by HS.[13] The AGI measure how much more a Controller earns for a given bargaining outcome than what she would have earned from an equal-split payoff. Thus, an $AGI > 0$ indicates an unequal payoff favoring the Controller, an $AGI = 0$ indicates an equal split, and an $AGI < 0$ indicates an unequal payoff favoring the Bargainer. Table 2 shows that, similar to HS (1985), we find that strong property rights produce more self-regarding behavior than do weak property rights. (testing $AGI_{strong} > AGI_{weak}$ yields $p = .094$). Thus, we replicate the finding of HS that strong property rights induces more self-regarding behavior than do weak property rights.

Table 2: Impact of Entitlement and Fairness on Payoff Distributions

	Strong Property Rights		**Weak Property Rights**	
	HS Data	**Our Data**	**HS Data**	**Our Data**
Average Greed Index	\$4.52	\$1.10	\$1.00	\$0.23

To summarize, we replicate the finding that subjects are good at choosing efficient allocations, that efficiency is equivalently high in one-shot and repeated bargaining, and that efficiency is invariant to the strength of property rights. Additionally, we replicate the finding that weak property rights produce equitable allocations and that strong property rights produce self-regarding behavior. However, unlike HS, we do not find that one-shot bargaining produces more self-regarding behavior than does two-shot bargaining.

[13] We use the two-shot bargaining data from the first two periods of our face-to-face, weak-property-rights sessions and from our face-to-face, strong property rights sessions to replicate Hoffman and Spitzer (1985).

4.2 Main Results: Face-to-Face vs. Computerized Environment

4.2.1 Efficiency

We begin our analysis of the computerized bargaining environment by discussing efficiency. Figure 1 reports the aggregate proportion of efficient allocations achieved in each of our 4 treatment types in both face-to-face and computerized environments. First, we note that environment itself impacts efficiency. Proportions testing shows that efficiency for each of our four treatment types is significantly lower in the computerized environment than in the face-to-face environment ($p < .01$ for all).

Proportions testing also confirms that there is no interaction between environment and property rights; varying the strength of property rights does not cause different rates of efficiency in either the face-to-face or computer mediated environment. However, we reject the null hypothesis ($p = .066$) that subjects bargain to PE outcomes at the same rate in the one-shot and two-shot settings in the computerized environment. Subjects are significantly less likely[14] ($p < .01$ using two-sided t-test) to achieve an efficient outcome whenever engaging in one-shot bargaining in the computerized environment. This difference in efficiency does not appear in the strong property rights sessions ($p = .58$).

Figure 2 aggregates data by period and environment and shows that rates of efficiency in the two environments converge over time but that learning subsides about halfway through sessions and a clear difference in efficiency persists. Though subjects participating in computerized bargaining are able to learn through experience to achieve a higher rate of efficient outcomes, they are unable to converge to complete efficiency as are subjects participating in face-to-face bargaining.

A by-round proportions test reveals that, aside from round seven, the difference in the proportion of efficient decisions between the two environments is significant ($p < 0.05$).[15]

[14] There is a 17.5% difference in the percentage of PE allocations obtained with weak property rights in the one-shot, computerized sessions relative to the analogous two-shot sessions. Thus, this result is driven mostly by differences in efficiency that obtain in one-shot relative to two-shot bargaining in the weak property rights, computerized sessions.

[15] Aside from rounds seven, five and two, the difference is significant at $p < .01$.

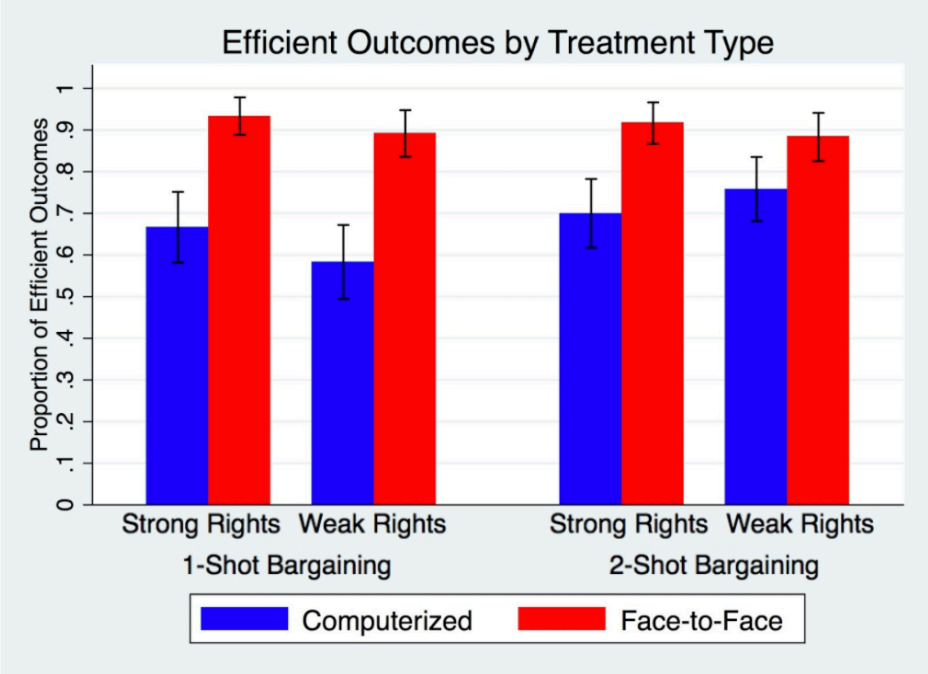

Figure 1: Each of the eight treatments described here consist of 120 decision made by 24 subjects across ten bargaining periods. The difference in the proportion of PE decisions between the computerized and face-to-face settings is highly significant ($p < .01$) according to both a proportions test and Fisher's exact test.

Marginal effects from a probit regression indicate that moving from the face-to-face to the computerized environment yields an approximately 22% decrease in the probability of subjects bargaining to an efficient allocation. Aside from rounds seven, five and two, the difference is significant at $p < .01$.

One possible explanation for the difference in efficiency observed between environments (as shown in the general case of Figure 2) is the fact that Controllers in the computerized setting selected a unilateral action before beginning bargaining. This selection might have caused Controllers to more forcefully demand that they receive at least the individual maximum whenever bargaining. However, we would expect to observe the effect of such anchoring to appear in all treatments as a level difference in efficiency between environments. However, this is not the case. Comparing efficiency between environments by period and treatment type reveals that rates of efficiency converge to a similar level in the weak property rights, two-shot bargaining treatments (Figure 3). This result indicates that changing/adding the

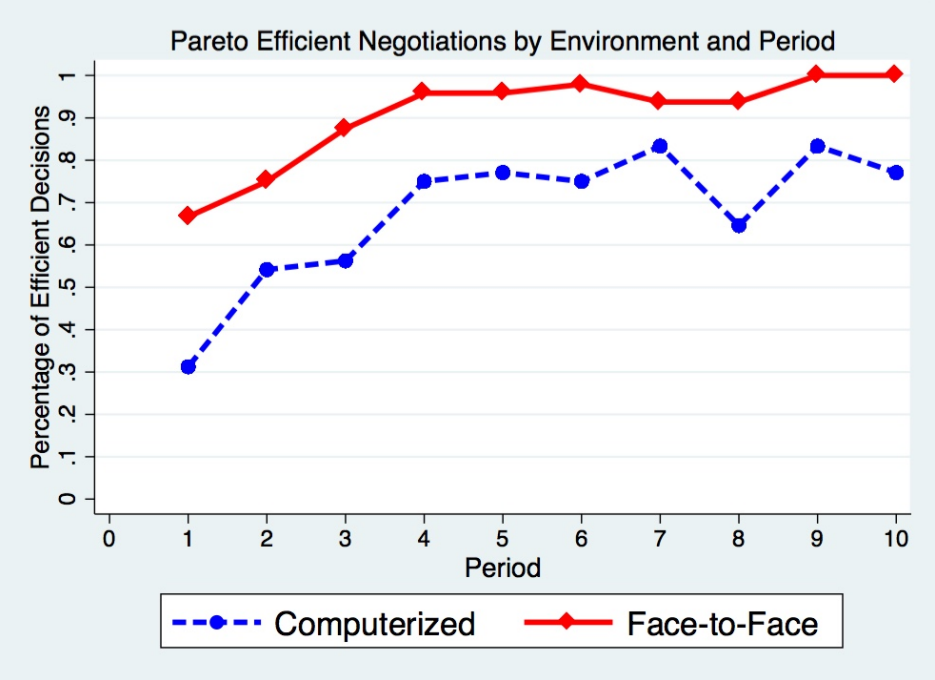

Figure 2: 96 subjects made a total of 48 decision in each environment for each period. Subjects make significant improvements as they gain experience in early periods but learning levels out around period four. Subjects learned at about the same rate in each environment but subjects in the computerized environment failed to converge to complete efficiency as did subjects bargaining in the face-to-face environment.

protocols necessary to implement our experiment did not themselves induce behavioral differences relative to Hoffman and Spitzer (1982, 1985).

Additionally, there is no reason to expect ex-ante that allowing Controllers to select a unilateral outcome before beginning the bargaining stage of a period would systematically affect negotiations in one environment but not the other. Controllers in both environments are equally capable of quickly discerning the individual maximum payoff and anchoring onto that amount whenever bargaining since payoffs are common knowledge in both environments and presented in a format that subjects can parse quite easily. Note also that the impact of learning on efficiency tapers out at about the same time in each environment and that only in the weak property rights, 2-shot setting do we see subjects in both environments converge to an equivalently-high rate of efficiency.

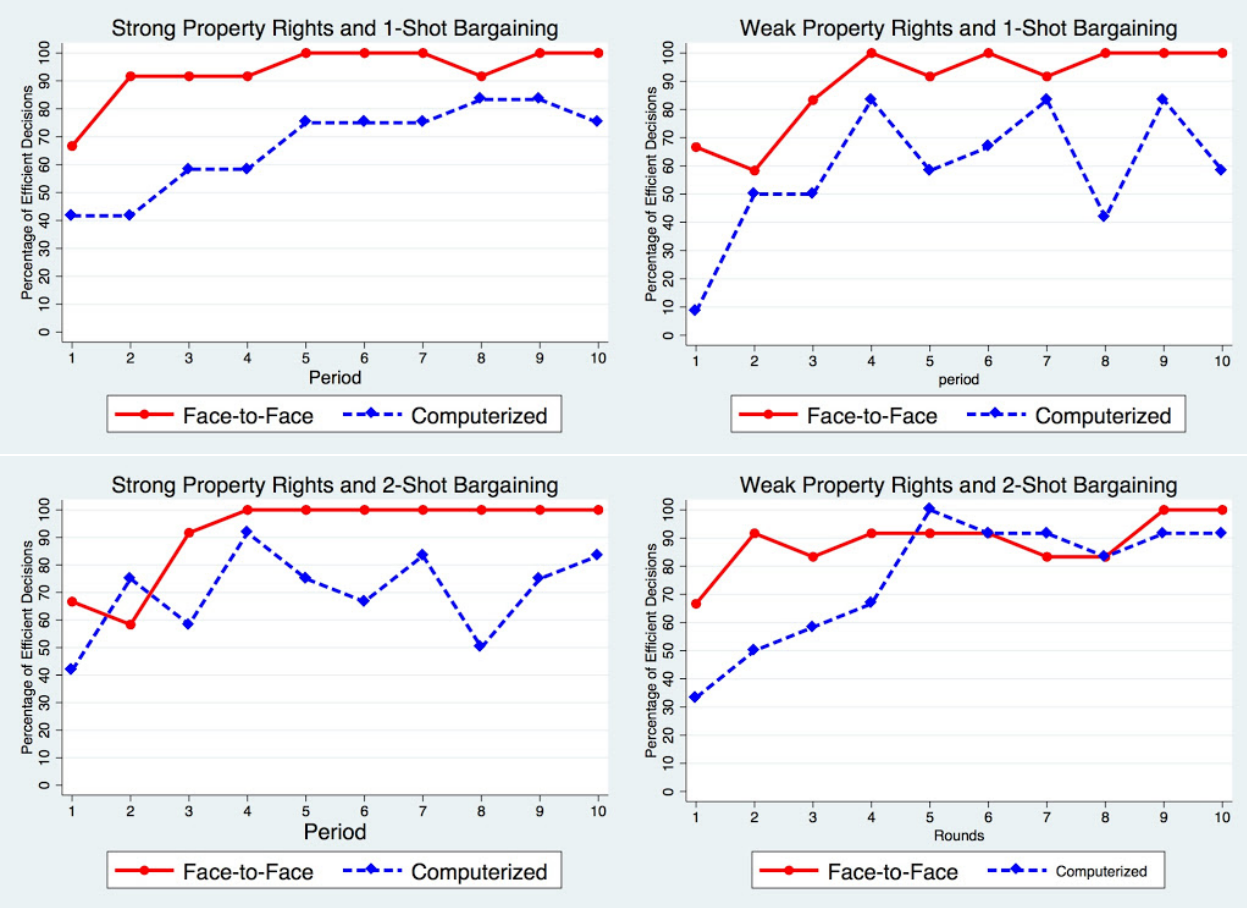

Figure 3: Each panel of Figure 3 shows the percentage of efficient decisions made in both face-to-face and computerized bargaining environments for each of our four treatment types. Each period comprises 12 decision made by 24 subjects for each of the face-to-face and computerized environments. Differences in the percentage of efficient decisions disappear entirely by the 4th period of the weak property rights, 2-shot bargaining sessions. However, a difference in the percentage of efficient decisions made across environments remains throughout sessions for all other treatment types.

4.2.2 Payoff Distributions

We now turn our focus to payoff distributions. To start, we compare the AGI across bargaining environments in Table 3. Panel 1 of Table 3 reports the average AGI of all decisions, including equal splits, across all periods of each treatment for each bargaining environment. Panel 2 of Table 3 reports the same but only includes decisions that were not equal splits. Finally, panel 3 of Table 3 reports the proportion of decisions that were not equal splits for all eight treatments.

We see from column one of panels 1 and 2 of Table 3 that moving from a face-to-face

to a computerized bargaining environment drastically increases the AGI from 0.73 to 2.96. Although we see the AGI increases when moving to the face-to-face environment regardless of the the property right assigning schemes and the repetition of bargaining, the majority of this difference is driven by treatments featuring either strong property rights, one-shot bargaining, or both. This indicates that Controllers are more likely to behave in an individually-rational way and most self-regarding in the computerized environment.

Table 3: Average Greed Index

Panel 1: AGI Including Equal Splits

	All Treatments	Weak 1-Shot	Weak 2-Shot	Strong 1-Shot	Strong 2-Shot
Face-to-Face	.7313125	.35025	.35625	.9645833	1.254167
Computerized	2.963688	3.04375	.7125	4.2335	3.865

Panel 2: AGI Without Equal Splits

	All Treatments	Weak 1-Shot	Weak 2-Shot	Strong 1-Shot	Strong 2-Shot
Face-to-Face	1.950167	1.75125	1.78125	1.483974	2.787037
Computerized	3.951583	3.727041	2.375	4.342051	4.255046

Panel 3: Proportion of Non-Equal Splits

	All Treatments	Weak 1-Shot	Weak 2-Shot	Strong 1-Shot	Strong 2-Shot
Face-to-Face	.375	.2	.2	.65	.45
Computerized	.75	.8166667	.3	.975	.9083333
Observations	960	240	240	240	240

We can now turn our attention to Figure 4. The four panels of this figure show the proportion of efficient decisions and corresponding payoff distributions (in terms of proportions) for each of our eight treatments.

Notice that behavior is most similar across environments in our weak property rights, 2-shot bargaining sessions. This is true of both efficiency and payoff distributions. In fact, the per-period average earnings of Controllers and Bargainers across environments in this

treatment are statistically indistinguishable. Removing the strategic considerations of repeated bargaining or using strong property rights both cause a large and highly-significant reduction in average Bargainer earnings in computerized sessions but has a relatively small impact (albeit weakly significant) in the face-to-face environment. Each change compels Controllers in computerized sessions to behave in a strongly self-regarding manner. This finding aligns with the notion that Controllers in these treatments, regardless of environment, may desire to behave in a self-regarding manner but do not do so in a face-to-face setting because this desire is crowded out by Controllers' desires to avoid uncomfortable or perhaps tense interpersonal interaction in the face-to-face setting.

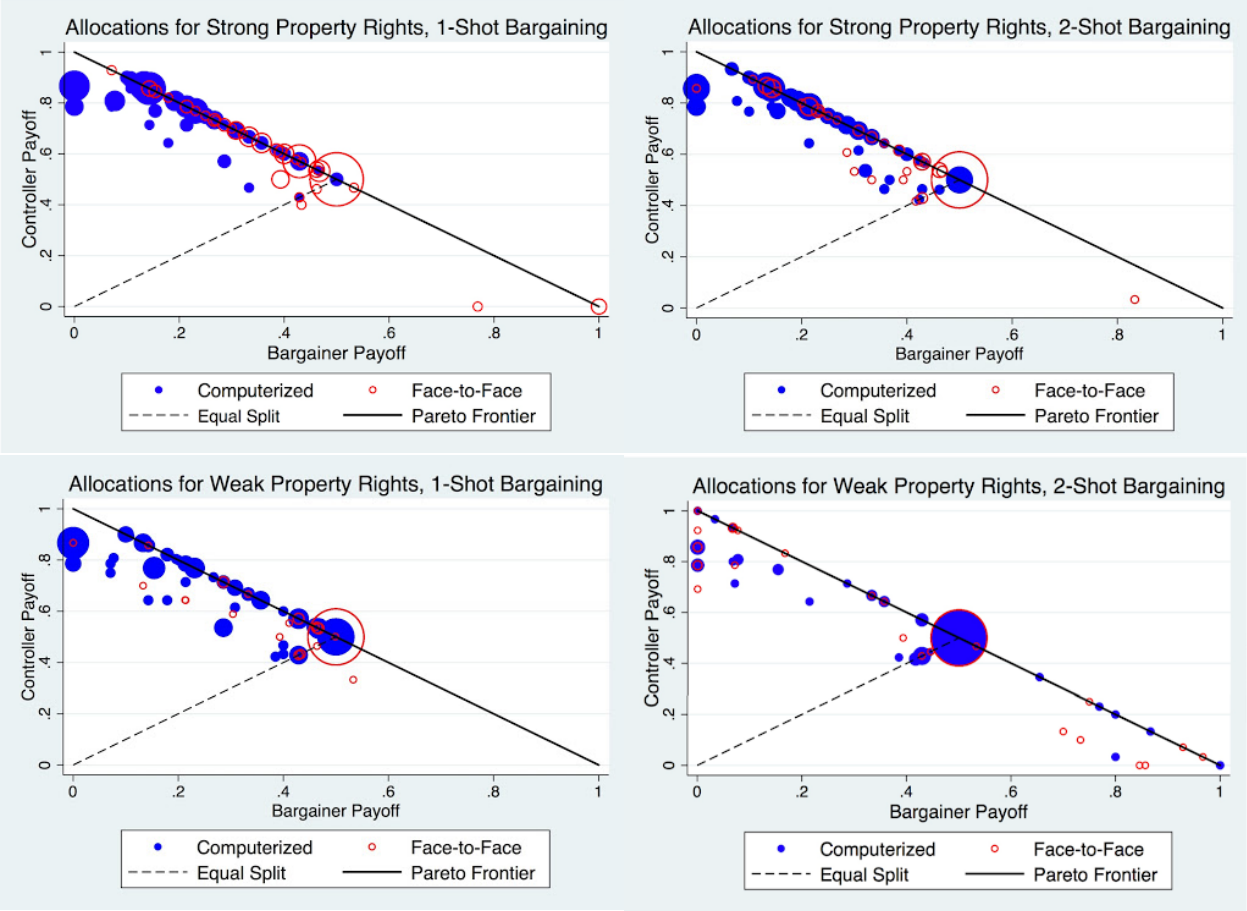

Figure 4

If, for example, the high level of other-regarding behavior observed in the face-to-face setting was truly driven by other-regarding preferences, then we would not expect to see such

a drastic shift in payoff distributions as a result of migrating our bargaining experiment to a computerized environment. We see then in the weak property rights, two-shot bargaining sessions, where both strategic concerns and moral ambiguity persist, that other-regarding behavior is invariant to the differences in our two environments. Introducing ambiguity and removing the threat of interpersonal conflict reveals to us that what HS and Harrison, McKee identified as other-regarding behavior is perhaps instead a sort of self-regarding behavior motivated by a desire to avoid interpersonal conflict. Note that moving in any direction away from the weak property rights, two-shot sessions causes a drastic and highly-significant reduction in average Bargainer earnings.

4.2.3 Discussion

Before concluding, we briefly discuss a possible explanation for the difference in efficiency we observe between the two bargaining environments. We argue that the difference in efficiency between the two bargaining environments is likely driven by a higher likelihood for Controllers to deny disadvantageous proposals in the computerized environment relative to the face-to-face environment. This, we think, results from the introduction of anonymity, social distance, loss of interpersonal connection, and loss of social and non-verbal cues in the computerized environment. This is corroborated by our findings that Bargainers, on average, earn less in the computerized environment (Table 3), Controllers sacrifice less money in the computerized environment (Table 3, Table 5), and Controllers more often insist on earning at least the unilateral maximum amount in the computerized bargaining (Table 4). We take this as suggestive evidence that Controllers in face-to-face bargaining settings may actually prefer self-regarding outcomes but are sacrificing earnings to avoid uncomfortable interpersonal interactions.

Because Controllers in this environment do not face the same interpersonal pressure during negotiations faced by Controllers in the face-to-face environment, they more often deny disadvantageous deals they may have otherwise accepted if bargaining face-to-face.

Table 4: Instances of Unilateral Maximization

Treatment	Computerized	Face-to-Face
Strong PR, 2-shot	59%	19.2%
Strong PR, 1-shot	67.5%	6.7%
Weak PR, 2-shot	12.5%	9.2%
Weak PR, 1-shot	42.5%	1.7%

This table reports the percentage of bargaining interactions where controllers unilaterally maximize earnings. Differences in proportions are highly significant between environments within treatment type ($p < 0.001$) except for the weak property rights, 2-shot bargaining treatments (p $\approx$ .41).

Though the effect of anonymity on self-regarding behavior is well documented, this would be the first time, to our knowledge, that an experiment has documented the impact of anonymity on efficiency in this sort of bargaining environment. We do so by looking at the the amount of money a Bargainer requests a Controller sacrifice when bargaining.

Looking at the results in Table 5, We see that Bargainers initially ask Controller's to split money roughly evenly, as they do successfully in face-to-face bargaining, but learn with experience to ask for less over time. Additionally, this is also positively correlated with cases of unilateral maximization. We also note that the requested sacrifice converges to the actual average sacrifice and a general downward trend in the amount of unilateral decisions. Unilateral decisions in periods 4 and 8 are a bit higher because the unilateral maximum allocation for these periods included non-zero payoffs for Bargainers, which reduced the available surplus, thereby reducing the rewards to bargaining. This made it harder to strike mutually advantageous deals, which aligns with Harrison and McKee (1985).

Table 5: Sacrifice Rates

Period	1	2	3	4	5	6	7	8	9	10
Requested Average Sacrifice	.62	.47	.38	.39	.4	.37	.26	.3	.24	.24
Actual Average Sacrifice	.21	.22	.18	.18	.22	.16	.12	.11	.16	.17
Unilateral Decisions	16	12	9	9	7	11	5	13	8	10

Let S be Sacrifice, U be the unilateral maximum amount available to a Controller, and B the payoff to the Controller conditional on accepting a Bargainer's contracted offer. Then we define the following measure, $S = \frac{U-B}{U}$,as a measure of the amount of money a Bargainer requests a Controller sacrifice when bargaining.

5 Conclusion

This experiment replicated and extended seminal works addressing the Coase theorem in the bargaining literature: Hoffman and Spitzer (1982, 1985). To do this, we tested CBT using a 2x2x2, between-subjects design that varied the method of assigning property rights, whether or not subjects engaged in repeated bargaining, and whether subjects bargained face-to-face or in a computerized environment.As did HS, we either reinforced property rights with entitlement priming (strong property rights) or instead used neutral language (weak property rights) to further sharpen the notion of property rights in our strong property rights treatments.

We replicate several key findings from the early work of HS: subjects often choose the efficient allocation when bargaining, efficiency is equivalently high for one- and two-shot bargaining, and efficiency is invariant to the strength of property rights. We also find that weak property rights produce equitable allocations whereas strong property rights produce self-regarding behavior. However, when using comparable data, we do not replicate the finding from Hoffman and Spitzer (1982) that one-shot bargaining produces more self-regarding behavior than does two-shot bargaining[16].

We find in the computerized setting that subjects choose efficient allocations significantly less often than do subjects who bargain face-to-face, conditional on subjects bargaining with strong property rights and/or in one-shot bargaining treatments. Subjects engaging in two-shot bargaining with weak property rights converge to similar behaviors (in terms of efficiency and payoff distributions) in both environments. Additionally, we find that subjects greatly improve their ability to achieve efficient bargaining outcomes with practice in both environments. This learning occurs at about the same rate in both environments and tapers out at about the same time in both environments.

Finally, we argue using suggestive evidence that this difference in efficiency between environments is driven by an increase in the willingness of Controllers in the computerized

[16]We cannot rule out that this is driven by a tit-for-tat strategy.

environment to insist on making advantageous deals that yield at least the unilateral maximum payoff. This is likely due to the introduction of anonymity, social distance, loss of interpersonal connection, and loss of social cues in the computerized environment. Given that efficiency and other-regarding behavior are not invariant to negotiating environment, these results suggest that Coase's theorem may require additional behavioral considerations; in particular, the theorem may lack predictive power whenever negotiations occur under the veil of anonymity.

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