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That's my final offer! Bargaining behavior with costly delay and credible commitment

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ABSTRACT

We examine laboratory bargaining experiments with symmetric and asymmetric delay costs and options for proposers to credibly commit to a bargaining position. Contrary to standard game-theoretic predictions, our experimental results suggest that commitment can be used effectively to increase the committer's payoff, particularly in a one-to-many bargaining environment where strategic holdout behavior is likely. However, we find evidence that commitment may also increase the number of failed agreements and reduce overall efficiency from exchange. To explain why behavior is inconsistent with standard game-theoretic predictions, we offer a behavioral bargaining model that allows for both "sincere" and "strategic" responders. Strategic responders behave as expected-payoff maximizers, while sincere responders behave according to a minimum-acceptable-offer (MAO) rule. We demonstrate that a mix of sincere and strategic types in the population is necessary to generate increasing equilibrium offers over time and "holdout" behavior, whereby strategic responders wait for higher offers in later periods. In response, proposers may find it optimal to commit early to an offer if commitment is possible.

1. Introduction

Bilateral and multilateral bargaining problems are particularly complex. In the case of multilateral bargaining, universal consent, if required for an exchange or transaction to occur, may be difficult to obtain in general due to transactions costs, even when an obvious surplus from exchange exists. Transactions costs are typically defined as search and information costs, bargaining and decision costs, or monitoring and enforcement costs that are above and beyond the monetary price paid in the exchange of goods or services. Transactions costs may be real "out-of-pocket" monetary costs (e.g. travel expenses or lawyers' fees), "opportunity" costs (e.g. costs associated with bargaining delay), "psychological" costs (e.g. costs related to one's desire to be treated "fairly" in social interactions), or "strategic" costs (e.g. costs associated with committing to a particular demand or course of action, or of changing, revoking or backing off such a commitment). Transactions costs are an important explanation for why otherwise mutually beneficial exchanges may fail to occur.

The transactions cost problem is likely to be compounded as the number of parties to an exchange increases beyond two, and if significant asymmetries exist in the potential payoffs to bargainers, in the delay costs faced by bargainers, or in the information available to each bargainer about the incentives and possible payoffs to other parties. Furthermore, the probability of bargaining impasse and failure may increase when parties can credibly commit to a particular strategic course of action (such as "walking away" from the bargaining table) if their demands are not met. On the other hand, credible ultimatums may reduce uncertainty about a party's future offers and may eliminate other parties' ability and incentive to strategically delay, thereby improving efficiency. The consequences of delay costs and demand commitment in multilateral bargaining are, therefore, important empirical questions.

This paper extends the experimental and behavioral analysis of the holdout problem and bargaining impasse in bilateral and multilateral bargaining. We first extend the laboratory experiments of Cadigan et al. (2009) to include bargaining environments with asymmetric delay costs and options to credibly commit to a bargaining position. To explain why behavior is inconsistent with game-theoretic predictions based on strict assumptions of payoff-maximization, we offer a simple behavioral model of bargaining that allows for both "sincere" and "strategic" responders.

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Strategic responders behave as expected-payoff maximizers, while sincere responders behave according to a minimum-acceptable-offer (MAO) rule. We show that a mix of sincere and strategic types in the population is necessary to generate a "holdout" equilibrium, whereby proposers follow an increasing-offer path and strategic responders wait for higher offers in later periods. In response to the possibility of holdout, proposers may find it optimal to credibly commit to an offer, thereby forcing acceptance of lower offers by strategic responders. Commitment, however, may also increase the probability of bargaining impasse. The ability of proposers to use commitment to increase their expected payoff is, therefore, uncertain.

Our project has important implications for both bilateral and multilateral bargaining in the context of wage negotiations (Houba and Bolt, 2000; van Ours, 1999; Gu and Kuhn, 1998; Cramton and Tracy, 1992) and land-assembly and urban renewal (Nosal, 2007; Miceli and Sirmans, 2007; Miceli and Segerson, 2007; Menezes and Pitchford, 2004a, 2004b; O'Flahery, 1994; Strange, 1995; Eckart, 1985; Coase, 1960), among other environments. The holdout problem in land assembly has been framed variously as an externality problem and a bilateral monopoly problem. While our experimental design is constructed from a simplified land-assembly framework to complement the growing literature using laboratory experiments to investigate the holdout problem inherent in land aggregation (Tanaka, 2007; Cadigan et al., 2009, 2011; Collins and Isaac, 2011; Ng, 2011; Parente and Winn, 2012; Read, Schwarz, and Zillante, 2013), our behavioral model and analysis focus primarily on the bilateral monopoly bargaining problem that may serve as a source of bargaining delay and holdout in both the bilateral and multilateral frameworks. Implicit in the model is the assumption that bargainers ignore the potential third-party effects of their own decisions when choosing to make, accept, or reject offers. Importantly, while the vast majority of the rich bilateral bargaining literature focuses on an alternating-offer framework, we demonstrate why strategic "holdout" behavior and bargaining impasse can arise even in an environment of one-sided "take-it-or-leave-it" offers, and in both bilateral and multilateral negotiations.

The remainder of the paper proceeds as follows. We first describe the experimental framework and setting followed by presentation and discussion of the experimental results. We then develop a behavioral model of bargaining that provides insight into the deviations in observed bargaining behavior from standard game-theoretic predictions. The final section summarizes our findings and conclusions.

2. The experiment

Following Menezes and Pitchford (2004b) and Miceli and Segerson (2007), consider a simple model in which a single agent (the "buyer") wishes to purchase N complementary units of a good from N other independent agents (the "sellers"). The units can be interpreted as intermediate inputs into the production of a large project. Each seller i has one unit for sale and incurs a cost c_i for this unit. The value of the project to the buyer is V if N input units can be acquired, but is zero otherwise. Let the buyer's valuation and the sellers' costs be such that

$$\sum_{i=1}^{N} c_i \leq V \tag{1}$$

indicating that there is an economic surplus $S = V - \sum_{i=1}^{N} c_i$ generated by the project.

Assuming N input units can be acquired, the payoff to the buyer is

$$\left(V - \sum_{i=1}^{N} p_i\right) \tag{2}$$

where p_i is the price paid for unit i, and each seller i receives a payoff $(p_i - c_i)$. Assume that all contracts are contingent such that no sales occur (and, therefore, all parties receive a payoff of zero) if any of the required input units are not purchased.[3] Bargaining takes place between the buyer and the sellers over one or more periods. Delay may be costly such that future payoffs are discounted according to a one-period discount rate δ. Buyers and sellers may face asymmetric delay costs.

Consistent with Cadigan et al. (2009, 2011), we use a multilateral laboratory bargaining experiment with one-sided take-it-or-leave-it bargaining rather than more complex multi-party Nash bargaining or bargaining with alternating offers. Nash bargaining does not allow one party to holdout by explicitly rejecting an offer, which is of primary interest in the current project. It would also place greater importance on risk preferences and is difficult to implement experimentally because of the likelihood of off-equilibrium decisions. We also avoid bargaining with alternating offers because it introduces an additional incentive to reject an offer in order to become the proposer.[4] To examine the importance of being the proposer, we compare separate treatments in which buyers make repeated take-it-or-leave-it *offers* to buy in some treatments, and sellers make repeated take-it-or-leave-it *demands* to sell in other treatments. Responders decide only whether to accept or reject an offer or demand.

2.1. Experimental treatments

All treatments are conducted with one buyer and two sellers, using z-Tree software (Fischbacher, 2007). We conducted eight treatments in a 4×2 design. All treatments have a maximum of ten bargaining periods in which proposers can make one offer to each responder in each period. Two treatments have costless delay (that is $\delta = 0\%$) and two treatments have symmetric, costly delay. In these costly delay treatments $\delta = 10\%$. That is, all payoffs are reduced by 10% for each additional period, *on average*, needed for agreements to be reached. For example, if one buyer is making repeated offers to two sellers, all participants' payoffs are reduced by 5% each time a seller rejects an offer. If both sellers accept in the first period, payoffs are not reduced. If both accept in the second period, all payoffs are reduced by 10%. If one seller accepts in the first period and the other in the third period, payoffs are reduced by 10%, and so on. Thus, holding out generates a payoff-reducing externality regardless of the decisions of the other subjects. These first four treatments were reported in Cadigan et al. (2009), and the results are reproduced and discussed here for comparison.

To investigate the impact of asymmetric delay costs on bargaining behavior, in two additional treatments only the buyer faces the delay cost (the sellers have costless delay). In choosing the buyer to have higher delay costs, we are appealing to the general land-assembly or patent-assembly type problem and assuming that the project is initiated by the assembler and that (1) in the absence of the development project, landowners would not have their properties on the market and, therefore, have no particular "urgency" to

[3] See Swope et al. (2011) for a theoretical and experimental treatment of non-contingent contracts.

[4] Shupp et al. (2013) investigate a multilateral bargaining model and experiment with alternating offers.

sell, and (2) buyers/developers/assemblers are likely to have made time-sensitive investments (e.g. permit acquisition, sub-contracts, etc.) that introduce potential delay costs above and beyond forgone earnings from the project. Although intuitive and plausible, we do not have specific empirical evidence to provide support for the assumption of higher delay costs on the "one" in one-to-many land-assembly type bargaining environments.

In the final two treatments, the proposer has the option of specifying after each proposal whether or not this is their "final offer". In the "final offer" treatments, only the buyer again faces a delay cost. In treatments in which the final-offer rule is imposed, the bargaining ends if a "final offer" is rejected. In the buyer–offer treatments, the buyer can make a final offer to either seller, but need not make the offer final to both in a given period. The eight total treatments are formed by conducting the four separate protocols ((1) no delay costs, (2) symmetric delay costs, (3) asymmetric delay costs, and (4) final offer commitment) with buyers making take-it-or-leave offers under each of the four protocols, and sellers making take-it-or-leave-it demands under each of the four protocols.

In each case, the party receiving the offer or demand chooses to accept or reject. If a responder rejects a "non-final" offer or demand, the proposer is able to make a new offer or demand for up to a maximum of ten periods. Unlike in the Gneezy, Haruvy, and Roth (2003) experiments, proposers in our experiment are not constrained to increase their offers (or reduce their demands) upon a rejection. If any party rejects a "final" offer (or fails to accept an offer or demand by period ten in any of the treatments) then all bargaining parties in that group receive a payoff of zero. All buyer valuations, seller costs, and delay costs (if applicable) are common knowledge. The buyer's valuation is V = \$90. The sellers' costs are symmetric such that $c_1 = c_2$ = \$30. This results in an economic surplus of \$30 that may be divided between the three participants in each bargaining group. All offers/demands (within a period) are made simultaneously. Once a seller accepts an offer from the buyer, or has a demand accepted by the buyer, that seller makes no additional decisions. Sellers do not observe offers or demands made for other sellers' units, but are informed of the amount of any accepted offer or demand.

The payoff conversion rate is \$1ED = \$1 (that is, subjects are paid what they earn during the experiment). Subjects are informed of their experimental earnings (adjusted for any delay costs) plus a \$10 show-up fee and paid privately, in cash at the end of the experiment. Experiments were one-shot. That is, subjects participated in a single three-person bargaining session with no re-matching or repetition, although each bargaining group had (up to) ten periods in which to reach agreement.

2.2. Standard equilibrium predictions

Assuming complete information and that each agent behaves "strategically" according to standard game-theoretic assumptions (that is, each agent seeks to maximize his expected monetary payoff) the well-known unique subgame perfect Nash equilibrium to the single-period ultimatum game is for the proposer to offer the smallest share of the surplus possible, and for the responder to accept it. Let b_i represent a buyer's offer to buy and d_i represent a seller's demand to sell a particular unit. In the multi-seller design used here, this implies:

Proposition 1. *When the buyer makes ultimatum offers, the buyer offers each seller her cost. That is, $b_i = c_i\ \forall i$.*[5]

Proposition 2. *When sellers make ultimatum demands, multiple equilibria exist. The set of equilibria are characterized by $\sum_{i=1}^{N} d_i = V$ and $d_i \geq c_i\ \forall i$.*

Proposition 3. *Responders should accept any offer or set of demands that leaves them with a non-negative surplus.*

Proposition 1 is the standard equilibrium prediction for proposer behavior which implies here that the buyer captures all (or nearly all) of the surplus. Proposition 2 characterizes a Nash-like bargaining outcome from the perspective of sellers. Proposition 3 follows from the assumption that a positive payoff is preferred to a zero payoff.

In our simple take-it-or-leave-it bargaining framework, Propositions 1–3 are unaffected by the addition of multiple bargaining periods, with or without costly delay, or by the ability of a proposer to credibly commit to an offer or demand. Responders cannot increase their payoff by rejecting an offer or set of demands that leaves them with a non-negative surplus, because there is nothing in the standard game-theoretic predictions of proposers' behavior to indicate that they, in equilibrium, should offer a greater share of the surplus following a rejected offer or demand. However, as we demonstrate in the experimental results and behavioral model below, actual behavior in the multi-period bargaining environment deviates substantially from the standard equilibrium predictions in interesting, and perhaps predictable, ways.

Subjects for all treatments were undergraduate volunteers at Gettysburg College. Subjects participated anonymously via computer. Seven hundred and five subjects participated in 41 sessions for a total of about 30 bargaining groups per treatment.

3. Results

Table 1 shows offer/demand and earnings results across the eight treatments, and Table 2 gives information on first-period rejections, bargaining length, failed agreements, and efficiency (measured as the percentage of the economic surplus captured on average after delay costs are deducted).

The standard game-theoretic predictions, Propositions 1–3 above, clearly fail to organize the data. Instead, buyers tend to make low initial offers that rise over time, and sellers reject a very high percentage of early offers. As our principle interest with this experiment was the behavioral impact of delay costs and commitment options, we separate our discussion of noteworthy results along these lines.

3.1. Behavioral impact of delay costs

As reported in Cadigan et al. (2009) comparing treatments with no delay costs to treatments with symmetric delay costs (treatment 1–treatment 2, and treatment 5–treatment 6), agreements take much longer to be reached when delay is costless, regardless of whether buyers or sellers are proposers (6.4 periods versus 2.5 periods, and 6.5–2.67 periods, on average, respectively), and the difference is statistically significant in both cases.[6] When delay costs are on one party only (the buyers, in treatments 3 and 7) the average agreement period (4.26 when buyers propose, and 3.45 when sellers propose) fell between the costless delay

[5] Technically, each seller is indifferent between accepting or rejecting. Therefore, accepting is a weakly dominant strategy and, therefore, constitutes a best-response. One could alternatively assume that $b_i = c_i + \varepsilon$, where ε is the smallest unit of account available (one cent in our experiment). In this case each seller earns a small surplus by accepting. For simplicity, we assume that $\varepsilon \to 0$ in the limit and proceed without the more cumbersome notation.

[6] Mann–Whitney test, two-tailed significance level <0.001 in each case.

Table 1
Offer/demand and earnings results by treatment[a] (standard deviations in parentheses).

Proposer	Treatment	Mean first period offer/demand	Mean buyer first period earnings	Mean seller first period earnings	Mean real final buyer earnings	Mean real final seller earnings	Number of groups
Buyer	(1) Two-seller, no delay (no delay costs)	\$34.28 (3.31)	\$21.43 (6.26)	\$4.28 (3.31)	\$10.55 (5.25) Max = \$21.00 Min = \$0	\$9.72 (3.00) Max = \$20.00 Min = \$2.00	$N = 29$
Buyer	(2) Two-seller, symmetric delay (delay costs on all)	\$35.82 (2.57)	\$18.37 (5.08)	\$5.82 (2.57)	\$11.12 (5.67) Max = \$28.00 Min = \$0	\$7.24 (2.78) Max = \$13.50 Min = \$0	$N = 30$
Buyer	(3) Two-seller, asymmetric delay (delay costs on buyer only)	\$36.43 (3.04)	\$17.14	\$6.43 (3.04)	\$5.80 (3.31) Max = \$12.60 Min = \$0	\$8.91 (4.21) Max = \$20 Min = \$0	$N = 32$
Buyer	(4) Final offer (delay costs on buyer only)	\$35.30 (3.62)	\$19.40	\$5.30 (3.62)	\$8.92 (6.46) Max = \$20 Min = \$0	\$6.10 (4.31) Max = \$15 Min = \$0	$N = 26$
Seller	(5) Two-seller, no delay (no delay costs)	\$46.73 (7.62)	\$-3.46 (11.06)	\$16.73 (7.61)	\$10.43 (5.02) Max = \$25.00 Min = \$0	\$9.28 (3.38) Max = \$15.00 Min = \$0	$N = 30$
Seller	(6) Two-seller, symmetric delay (delay costs on all)	\$44.17 (6.86)	\$1.65 (8.94)	\$14.17 (6.86)	\$9.39 (4.90) Max = \$27.79 Min = \$2.70	\$7.80 (2.96) Max = \$15.30 Min = \$0	$N = 30$
Seller	(7) Two-seller, asymmetric delay (delay costs on buyer only)	\$48.05 (11.13)	\$−6.10	\$18.05 (11.13)	\$6.76 (4.13) Max = \$15 Min = \$0	\$9.70 (4.53) Max = \$20 Min = \$0	$N = 29$
Seller	(8) Final offer (delay costs on buyer only)	\$45.61 (7.90)	\$−1.22	\$15.61 (7.90)	\$6.41 (3.80) Max = \$18 Min = \$0	\$9.31 (4.19) Max = \$20 Min = \$0	$N = 29$

[a] All treatments have a maximum of ten bargaining periods.

Table 2
Holdout and efficiency results by treatment.[a]

Proposer	Treatment	Percent of first-period rejections	Average agreement period	Number of failed agreements	Efficiency	Number of groups
Buyer	(1) Two-seller, no delay (no delay costs)	96.6%	6.40	0	100%	N = 29
Buyer	(2) Two-seller, symmetric delay (delay costs on all)	66.7%	2.47	0	85.3%	N = 30
Buyer	(3) Two-seller, asymmetric delay (delay costs on buyer only)	78.1%	4.26	3	78.8%	N = 32
Buyer	(4) Final offer (delay costs on buyer only)	73.1%	3.63 "Final offer" used by 23 of 26 buyers[b]	7	70.4%	N = 26
Seller	(5) Two-seller, no delay (no delay costs)	91.7%	6.50	1	96.7%	N = 30
Seller	(6) Two-seller, symmetric delay (delay costs on all)	71.7%	2.67	0	83.3%	N = 30
Seller	(7) Two-seller, asymmetric delay (delay costs on buyer only)	75.9%	3.45	2	86.1%	N = 29
Seller	(8) Final offer (delay costs on buyer only)	77.6%	3.38 "Final offer" used by 20 of 58 sellers[c]	3	84.6%	N = 29

[a] All treatments have a maximum of ten bargaining periods.
[b] The mean "final offer" by buyers was $38.28.
[c] The mean "final demand" by sellers was $40.78.

and symmetric delay cost outcomes. If delay costs represent a general disincentive to take a tough initial bargaining position, then this result is intuitive, as both parties have an incentive to take a tough stance and wait when delay is costless, but neither party has the same incentive when delay is costly to all. In the buyer–offer treatments 1–3 the difference in average agreement period in the asymmetric treatment is statistically significant compared to both the symmetric and no delay cost treatments.[7] For the seller-demand treatments 5–7, only the difference between the asymmetric and no delay cost average agreement period is statistically significant.[8]

There is some evidence that asymmetry may lead to an increased likelihood of bargaining impasse.[9] Three groups failed to reach agreements in treatment 3 with buyers proposing, and two groups failed in the comparable treatment 7 with sellers proposing, compared to only a single failed agreement across the four symmetric delay cost treatments.[10]

Comparing first-period offers and demands across these same treatments, a consistent and intuitive pattern emerges. Both buyers and sellers take tougher initial bargaining stances when delay is costless. Imposing symmetric costly delay caused average initial offers to rise by $1.54, and initial demands to fall by $2.56, relative to the costless delay treatments, and the differences are statistically significant.[11] Furthermore, when only buyers faced a delay cost, they took the weakest initial bargaining stance and made the highest initial offers ($36.43, on average, in treatment 3) across all of the buyer–offer protocols. Similarly, when buyers faced the delay cost, but sellers made demands (treatment 7), sellers took the toughest initial bargaining stance and made the highest initial demands ($48.05, on average) across all of the seller-demand protocols. These results suggest that bargaining position matters, behaviorally.

The weakness of the buyer's bargaining position in the asymmetric delay cost treatments is also evident in final earnings. Buyers had lower final earnings in all of the treatments in which they alone faced delay costs (treatments 3, 4, and 7, 8) compared to the symmetric delay cost treatments, and the differences are statistically significant in each of the relevant pairwise comparisons in each case, except when the buyer had the final offer option (treatment 4).[12]

3.2. Behavioral impact of commitment

Interestingly, buyers are able to use the ability to credibly commit to a bargaining position to their advantage in treatment 4. Mean buyer earnings rose from $5.80 when no commitment was available to $8.92 when buyers could make "final offers", and the difference is statistically significant.[13] Buyers are able to use the ability to commit to mitigate sellers' ability to hold out. However, committing to a bargaining position risks bargaining impasse. Indeed, the number of failed agreements more than doubled when commitment was available (from 3 failed agreements to 7 failed agreements), and efficiency levels subsequently fell. In total, 23 out of 26 buyers (or 88%) chose to make a "final offer", and all did so within the first three bargaining periods. In the buyer–offer treatment with "final offers", of the 39 "final offers" made by buyers, 14 occurred in period 1, 13 occurred in period 2, and 12 occurred in period 3. The mean final offer was $38.28, which would have

[7] Mann–Whitney test, two-tailed significance level <0.001 in each case.
[8] Mann–Whitney test, two-tailed significance level <0.001.
[9] The number of failed agreements overall is too small to establish statistical significance.
[10] There was one failed agreement in treatment 4 (costless delay with sellers proposing).
[11] Mann–Whitney, two-tailed significance levels = 0.002 and 0.030, respectively.
[12] Mann–Whitney, two-tailed significance level <0.05 for each comparison, except when buyers had the final offer option. That is, the difference in buyers' payoffs in treatment 4 was not significantly different than in treatments 1 and 2.
[13] Mann–Whitney, two-tailed significance level = 0.031.

left sellers (if all accepted) with a mean final offer surplus of $8.28, somewhat less than a third of the available $30 surplus. Eleven buyers made simultaneous final offers of the same amount to both sellers at the same time. Two buyers made simultaneous final offers of differing amounts, and one seller made sequential final offers (two different periods) of the same amount to each seller.

Comparing payoffs, 23 out of 26 buyers used the "final offer" button, for an average payoff of $8.79 (st.dev. = $6.69). Seven of those buyers had payoffs of $0 due to failed agreements. Three out of 26 buyers never used the final offer button, and had average payoff of $9.98 (st.dev. = $5.26). All of these buyers reached agreements. The difference in average payoffs between buyers who did and did not use the "final offer" button is not statistically significant, which may be due in part to the very small number of buyers (three) who chose not to use the "final offer" option.[14]

Noteworthy is that the sellers used the ability to make final demands much less often than buyers when they were the proposers (only 20 out 58 sellers, or 34%, used the "final offer" option), and this difference is highly significant.[15] Final demands by sellers were also more spread out across rounds – five occurred in period 1, six in period 2, six in period 3, one in period 4, and one in period 5. The mean final demand was $40.78. Unlike in the buyer–offer case, sellers actually earned marginally less, on average, when commitment was available compared to when it was not.[16] It is unclear whether this hesitation to resort to an ultimatum demand was due to the coordination problem faced by sellers (unlike when a buyer makes offers, a seller cannot control the other demand when making an ultimatum), or because the sellers faced no delay costs. Only additional investigation can answer this interesting question.

Comparing payoffs, those sellers who made final demands had lower average payoffs than those who did not exercise the "final offer" option. The average payoff of those choosing to make a final demand was $8.10 (st.dev. = $4.45), compared to $9.96 (st.dev. = $3.95). The difference is statistically significant.[17]

To summarize our main experimental findings, proposers generally follow rejected proposals with more generous offers (or lower demands). This provides a potential incentive for some responders to strategically delay agreement in hopes of receiving a higher-payoff. The extent of delay varies inversely with delay costs, and asymmetric delay costs negatively impact the bargaining position and final earnings of the party with the higher cost of delay. Proposers may respond to potential "holdout problems" by offering an ultimatum, that is, by credibly committing to an offer. The precise dynamics of bargaining, holdout, and commitment behavior depend on a complex interaction of delay costs and proposers' beliefs about the behavior of responders. We investigate these possible dynamics in the following alternative behavioral model of bargaining that organizes the data much better than standard equilibrium predictions based on the assumption that subjects are strictly strategic payoff-maximizers.

4. A behavioral model of bargaining

As Propositions 1–3 presented earlier indicate, standard game-theoretic predictions allow little room for the kinds of behavior we observe in our experiment, including "holdout" decisions by responders and the use of "commitment" opportunities by proposers in response. Proposers should capture virtually the entire surplus, and responders should be resigned with walking away with very little of the bargaining pie. Adding additional bargaining periods and delay costs does not change this fundamental prediction, unless we relax the assumption of strict, payoff-maximizing behavior on the part all subjects. Once we do so, we gain some potentially useful insight into the nature of bargaining behavior in both bilateral and multilateral bargaining environments.

For simplicity, normalize the buyer's value to $V = 1$ throughout the following analysis so that offers can be framed as shares of the bargaining surplus. As in Cadigan et al. (2011) assume sellers' each have a minimum acceptable offer (MAO) of $\underline{x}_i$ that is private information distributed independently and identically according to a publicly known continuous uniform distribution with probability density function $f(\underline{x}_i) = \begin{cases} N & \text{for} \quad 0 \le \underline{x}_i \le 1/N \\ 0 & \text{for} \quad \underline{x}_i < 0 \quad \text{or} \quad \underline{x}_i > 1/N \end{cases}$ where N is the total number of sellers. Therefore, a non-negative economic surplus is always generated from the transfer of all sellers' units to the buyer, regardless of the number of sellers. Furthermore, by assuming MAOs are distributed from 0 to an upper limit of $1/N$ the expected surplus is held constant as the number of sellers increases.[18] That is, multiple small sellers are no more "greedy" than a single large seller. Alternatively, the expected cost of multiple small sellers is no greater than the expected cost of a single large seller. It should be noted that all of the following analysis could be generalized to other distributions of MAOs. The uniform distribution and parameters used here are chosen for simplicity and tractability only.

The MAO's may be interpreted as unknown sellers' costs, as in Shupp et al. (2013). Alternatively, in an environment with complete information about the buyer's value and sellers' costs (as in Cadigan et al. (2009, 2011)), MAOs may be interpreted as arising from heterogeneous preferences for fairness (e.g. Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000) where the MAO is the offer level above which the responder would receive positive net utility, and below which responder utility from accepting would be negative. Finally, MAOs may arise as the result of satisficing behavior on the part of responders (Simon, 1955, 1959). Of course, MAOs may arise as a combination of factors. The primary concern of the current study is not the origin of MAOs, but rather their potential impact on the bargaining behavior of proposers and responders.

Our MAO approach with "sincere" and "strategic" responders is qualitatively similar to the bilateral bargaining approach of Abreu and Gul (2000) who assume players may either be "rational" or "irrational" types. Irrational types demand a particular share of the surplus, and accept the first offer that yields a share greater or equal to this amount. While both our approach and that of Abreu and Gul represent a departure from the assumption of complete information, the difference is that the former examine a framework with two-sided "continuous-time" offers and demands while we use finite-period one-sided take-it-or-leave offers (which may originate with either the buyer or sellers in a one-to-many or many-to-one framework). Our simplifications also allow us to relate the behavioral predictions of the model to laboratory experiments, which are not part of the Abreu and Gul analysis.

A model that includes all variables of interest simultaneously (e.g. number of sellers, number of periods, delay costs, and

[14] Mann–Whitney, two-tailed significance level >0.100.

[15] Proportions test, two-tailed significance level <0.001.

[16] The difference in sellers' earnings between treatments 7 and 8 is not statistically significant.

[17] Mann–Whitney, two-tailed significance level = 0.067.

[18] The distribution of sellers' MAOs from 0 to $1/N$ has intuitive appeal if MAOs are interpreted as arising from satisficing behavior or reservation prices arising from unknown sellers' costs. However, if MAOs are interpreted as arising from heterogeneous preferences for fairness, then a distribution of MAOs from 0 to $1/(N+1)$ may be more appealing, as $1/(N+1)$ indicates a strictly egalitarian division of the surplus. The actual distribution of MAOs does not qualitatively change the insights of the model.

proportion of strategic versus sincere responders) is not tractable. Therefore, we proceed by systematically investigating individual features of the bargaining problem independently while holding all other features constant.

Cadigan et al. (2011) consider specifically how an increase in the number of sellers affects proposals (particularly the joint offer made by the buyer and the collective demands made by sellers) and the likelihood of failed agreements, so we do not explicitly examine this feature here. Instead, we assume $N=1$ and frame the multilateral bargaining problem as separate bilateral negotiations between the buyer and each seller,[19] and we characterize the multi-period bargaining solution for the case of one buyer and one seller in which the buyer can make offers in each of T periods, with the seller responding sincerely according to an MAO in each period, and delay is costless. We then examine a two-period, one-seller model in which responders may respond either sincerely in the first period (e.g. accept any offers that exceed their MAO) or strategically (e.g. reject first-period offers in favor of a higher expected offer in period 2). In this section we show how first- and second-period offers compare to the optimal single-period offer. We also demonstrate how an increase in the cost of delay or the proportion of sincere types affects equilibrium offers and the behavior of strategic responders. In the final section we demonstrate when and how a proposer can use credible commitment to increase his expected payoff when faced with the prospect of strategic holdout by responders.

4.1. Multiple-period bargaining with a sincere seller

In the field, bargainers typically have multiple opportunities to make and receive proposals. Rejected proposals may impose transactions costs or delay costs on one or both bargaining parties, but rejected proposals may also convey information to the proposer about the responder's willingness to accept a given offer. In the following subsection we consider the possibility that proposers have more than one opportunity to reach an agreement with responders. To focus the analysis on the impact of adding additional bargaining periods, we consider first the simplified case of a buyer who can make an offer to a single seller in each of T periods, and delay is costless.[20] The seller is assumed to respond sincerely according to an MAO.

Consider the case of a single buyer who can make one offer in each of T periods to a sincere seller whose MAO is a draw from a uniform distribution over the unit interval. For simplicity, we consider only the case of a buyer making offers to a seller, as the seller's demand problem is symmetric in this case.

If the buyer's offer in period $(T-1)$ is rejected by the seller, then the buyer's updated beliefs about the seller's MAO and the probability that an offer b_T will be accepted is[21]

$$P\left\langle \underline{x}_i \leq bT | \underline{x}_i > b_{T-1} \right\rangle = \frac{(b_T - b_{T-1})}{(1-b_{T-1})}. \tag{3}$$

In period T, the buyer solves:

$$\max_{bT}(1-b_T)\cdot\left(\frac{b_T-b_{T-1}}{1-b_{T-1}}\right) \tag{4}$$

which yields

$$b_{T*} = b_{T-1} + \frac{1-b_{T-1}}{2} \tag{5}$$

In period $(T-1)$ the buyer solves

$$\max_{bT-1}(1-b_{T-1})\cdot\left(\frac{b_{T-1}-b_{T-2}}{1-b_{T-2}}\right)+\left(\frac{1-b_{T-1}}{1-b_{T-2}}\right) \cdot\left((1-b_{T*})\cdot\left(\frac{b_{T*}-b_{T-1}}{1-b_{T-1}}\right)\right) \tag{6}$$

Substituting for b_{T^*} and simplifying yields

$$\max_{bT-1}(1-b_{T-1})\cdot\left(\frac{b_{T-1}-b_{T-2}}{1-b_{T-2}}\right)+\left(\frac{1-b_{T-1}}{1-b_{T-2}}\right)\cdot\left(\frac{1-b_{T-1}}{4}\right)$$

The optimal b_{T-1} is given by

$$b_{T-1*} = b_{T-2} + \frac{1-b_{T-2}}{3} \tag{7}$$

Similarly,

$$b_{T-2*} = b_{T-3} + \frac{1-b_{T-3}}{4}$$

$$\ldots$$

$$b_{3*} = b_2 + \frac{1-b_2}{T-1}$$

$$b_{2*} = b_1 + \frac{1-b_1}{T}$$

$$b_{1*} = \frac{1}{T+1}.$$

Note that the first term on the right hand side of each period's optimal offer expression is the lower bound for $\underline{x}_i$; this is 0 in period 1. The basic intuition here is that a rejection in period t leads the buyer to update beliefs regarding the lower bound on the MAO distribution. In period $(t+1)$ the buyer adds a fraction of the updated distribution to the period t offer, where the fraction depends on the number of remaining periods (in the last period the buyer updates the offer by adding 1/2 of the remaining distribution; in $T-1$, the buyer offers 1/3 of the remaining distribution, etc.). Substituting the formula for b_{1*} into the formula for b_{2*}, and similar recursive substitution, yields the following general expression for b_{t*}:

$$b_{t*} = \frac{t}{T+1}. \tag{8}$$

Result 1. In the T period case with one buyer and one sincere seller the buyer's optimal offer in period t is $t/(T+1)$. The path of buyer offers is increasing; the buyer begins with an offer of $1/(T+1)$ and increases the offer by $1/(T+1)$ in each period. The probability of a successful exchange is $T/(T+1)$, which is increasing in T. For sufficiently large T, the buyer's surplus approaches $1-\underline{x}_i$.

Result 1 illustrates the basic strategic advantage conveyed to a buyer who can make multiple offers to a sincere seller. Given the opportunity to make T offers, the buyer effectively partitions the MAO distribution into T sections. As T gets large, the buyer is able to start with a very low offer and increment it by small amounts in successive periods. In the limit, the buyer is able to increment each additional offer by such a small amount that the MAO is accepted.

As negotiation occurs over multiple periods in this case, it may be appropriate to introduce discounting of buyer and seller payoffs by the single period discount factor δ. Importantly, the basic intuition behind Result 1 is not affected by including a discount rate, in the sense that the buyer still partitions the MAO distribution and offers a finer partition the greater is the number of periods.

Yet the presence of a discount rate $(1-\delta)$ does affect the starting offer (and subsequent offers) in a straightforward manner. Because there is a cost to failing to reach an agreement in the current period,

[19] We believe that many of the behavioral origins of holdout and bargaining impasse in bilateral and multilateral negotiations are similar, although the multilateral environment introduces additional complexities that may not be present for one-to-one bargaining (see Cadigan et al., 2011).

[20] We do not consider the important and interesting, but significantly more complex, case of alternating offers or other bargaining institutions. These are examined in Shupp et al. (2013).

[21] This follows from Bayesian updating.

the optimal buyer offer path lies to the right of the path without discounting. For example, when $T = 3$ and there is no discounting, the optimal offer path is {¼, ½, ¾}. With discounting, the optimal path of offers is $\{¼ + \delta/(2(1+\delta)); ½ + \delta/(2(1+\delta)); ¾ + \delta/(4(1+\delta))\}$. In the extreme case when $\delta = 1$, we have a one-period game, and the optimal single-period offer with one seller is ½.

Result 1 utilizes the assumption that responders are sincere. This assumption leads to a substantive departure from the standard game theoretic prediction (not affected by multiple bargaining periods or the imposition of delay costs) that proposers offer, and responders accept, the smallest allowable share of the bargaining pie.[22] We note that the standard game theoretic prediction is not consistent with conventional wisdom and observed bargaining behavior. Although our model does not generate quantitative predictions that we can compare directly to individual decisions in the experiment, proposers do appear to take more aggressive bargaining stances (i.e. make lower offers or higher demands) in the early periods of multi-offer bargaining environments both with and without delay costs, and follow rejected offers or demands with higher offers and lower demands (Cadigan et al., 2009). Furthermore, proposers in the lab tend to make higher offers (and lower demands) when delay is costly compared to when it is costless, consistent with the qualitative predictions of the model.

Note also that there is no incentive for a proposer to commit to an offer (i.e. make a credible final offer or ultimatum) when bargaining with a sincere responder, as commitment cannot increase the probability that a given offer will be accepted. While our modeling approach leads to equilibrium predictions that fit the experimental data quite well qualitatively, we recognize that the assumption that all responders are sincere is particularly strong in the multi-period case, where the equilibrium path of offers is increasing.

In fact, one of our main points is that when faced with such a bargaining environment, some responders may choose to strategically 'hold out' for better offers. Whereas the sincere responders considered thus far are assumed to follow a simple decision rule based on MAOs, strategic responders are assumed to consciously predict an expected path of offers, and wait for the offer that maximizes their payoff. This rationale for holdout is novel in that it does not rely on the assumption of incomplete information about the buyer's value of the project (Eckart, 1985; Strange, 1995) or the ability of sellers to delay entering into negotiation with the buyer (Menezes and Pitchford, 2004a, 2004b; Miceli and Segerson, 2007), as previous models of holdout have assumed. Note, however, that when all responders behave strategically, a rejection in period t does not contain any information about a seller's MAO. And if proposers do not believe that a responder's decision conveys credible information about a responder's type (e.g. the responder is behaving strategically), then the proposer's optimal subsequent proposals would be unaffected by a rejection. Thus, for holdout of this type to occur in equilibrium there must be a mix of sincere and strategic responders. We next outline a possible extension of the model when the seller can behave either sincerely or strategically.

4.2. Multi-period bargaining with sincere and strategic sellers

Assume that all sellers are one of two types: sincere or strategic. Define a *sincere* seller as one who accepts an offer if the offer exceeds the seller's MAO. A *strategic* seller accepts an offer only if it yields a payoff at least as high as the payoff yielded by any other expected offer. That is, *strategic* responders are assumed to maximize payoffs and holdout for the highest payoff, while *sincere* responders do not. Strategic sellers have no MAO.[23] Our assumptions regarding minimum acceptable offers are consistent, in general, with data from laboratory experiments. For example, in an ultimatum game with a $15 pie where responders were forced to indicate a binding minimum acceptable offer, Schmitt et al. (2008) report that one-fourth of all responders committed to accepting offers of $0.01 or less, while others committed to accepting nothing less than half of the pie.

For simplicity, consider the case where there is a single buyer and a single seller, and the buyer can make a second-period offer if his first-period offer is rejected. If sellers face no delay costs (as in all of our treatments except treatments 2 and 6), strategic sellers would always choose to holdout to the second period, as the buyer's optimal offer path must be non-decreasing. However, if sellers face delay costs, then the decision to hold out or not depends on sellers' expectations about the buyer's offer path. The buyer's optimal offer path, in turn, depends simultaneously on the buyer's beliefs about the proportion of sellers who behave sincerely and the likelihood that a given offer will be rejected. The nature of an equilibrium, if one exists, in both offers and responses depends on the distribution of sincere sellers' MAOs and the percentage of the population of responders who behave sincerely.

A model general enough to handle a t-period, N-responder bargaining game that also allows simultaneously for delay costs and a mix of sincere and strategic responders is intractable. However, in Appendix A we present a simple two-period bargaining model with symmetric delay costs that allows for a fraction of the population to behave sincerely. The model provides insight into the possible bargaining dynamics that result. Importantly, we show that when there are both sincere and strategic responder types and delay costs are low, a pooling equilibrium exists in which strategic sellers holdout. When delay costs are high and a large proportion of sellers are assumed to be sincere, a separating equilibrium exists in which strategic types do not holdout, and only high MAO sincere types reject initial offers.

These results suggest that strategic holdout is virtually guaranteed in our treatments in which responders face no delay costs, and may also be likely in our symmetric delay cost treatments as our imposed delay costs are fairly low. The empirical results are consistent with these equilibrium predictions, as agreements took multiple bargaining periods to be reached, and took longer when delay was costless. Furthermore, agreements took longer to be reached when sellers faced lower delay costs (relative to buyers – treatments 3 and 7) compared to the symmetric delay cost treatments (treatments 2 and 6).

Faced with the prospect of strategic responders holding out for higher offers, which may incur an additional cost on the proposer in the form of discounted payoffs, an interesting question to ask is, can proposers generate a higher expected payoff by committing to an offer and thus threatening to "walk away" from the bargaining

[22] This result holds if delay costs are symmetric. If delay costs are asymmetric such that the proposer (e.g. the developer) faces positive delay costs, but the responder (e.g. the landowner) faces no delay cost, the proposer should offer $T\varepsilon$ in the first period, where T is the total number of periods and ε is the smallest unit of account. The responder should accept in the first period. This is because the responder would be indifferent between accepting ε in period 1 versus period T, so rejecting ε in every period but the last is a best response. If the proposer faces a positive delay cost, the proposer's best response in period $T-1$ is to offer $\varepsilon + \varepsilon$ so that the responder accepts earlier. Assuming ε is a very small amount, $(T-1)\varepsilon$ is still a very small amount.

[23] We assume strategic sellers have no MAO for simplicity. Alternatively, one could assume that all sellers have an MAO, but that some respond sincerely and some respond strategically subject to this MAO. While more complex and less tractable, we do not believe that this possibility would qualitatively change the main results of the model.

table if the offer is rejected, assuming such a commitment opportunity exists? In the next section we explore the possibility of credible commitment in the context of bilateral and multilateral negotiations.

4.3. Commitment

We examine the prospect of proposers committing to an offer or demand which, if rejected, will end negotiations. For simplicity, consider again the case of a buyer making offers to sellers in each of two periods. If all sellers are assumed to be sincere, then it is clear that it is never optimal to commit to an offer in period 1, as the buyer cannot increase the probability of acceptance of an offer (or his expected payoff) by committing. Similarly, if all sellers are assumed to be strategic, it is trivial to show that the buyer should immediately commit to the subgame-perfect equilibrium offer ($b_1 = \varepsilon$) in the first period, as the seller would accept with probability 1.

Aside from these extreme cases, however, the decision to commit (and, thus, threaten to "walk away" from negotiations) depends crucially on two things: (1) the costs of delay faced by both the proposer and the responders, and (2) the proposer's prior beliefs and if the proposer updates his beliefs (following a rejection) as to whether or not the responder is behaving sincerely or strategically. For example, as we show in a simplified two-period model in Appendix B, a necessary condition for commitment to be useful is that delay costs and the proportion of sincere responders must be sufficiently low that a pooling equilibrium exists, otherwise, proposers would not have an incentive to commit if it were believed that all strategic responders would accept in period 1 anyway (a separating equilibrium). Commitment would only reduce one's expected payoff by eliminating the prospect of reaching an agreement with high MAO sincere responders in period 2.

In our experimental results, we find that 23 out of 26 buyers used the commitment device, and did so within the first three bargaining periods. Given that sellers in this treatment faced no delay costs (making holdout by strategic responders a near certainty), this use of commitment may indicate that buyers expected a relatively low portion of sincere responders and/or that the MAOs of sincere responders were not too high. The average "final offer" was $38.28.

However, buyers who used the commitment device also risked bargaining impasse (and, thus, a payoff of zero), if the seller with whom they were matched was indeed a sincere type with MAO in excess of the final offer. Although the mean buyer earnings rose significantly in our experiment when a final offer option was added, the number of failed agreements also more than doubled (from 3 to 7), indicating that commitment is not without risk and comes at the price of overall efficiency of the market.

5. Conclusions

Bargaining behavior is quite complex. It is difficult to capture all of the significant dynamics in a single model or experiment. However, this paper attempts to gain insight into bilateral and multilateral bargaining problems through a laboratory land-assembly experiment (with one buyer and two sellers) and a behavioral model that systematically investigates important features of the bargaining problem and explains some of the stylized features of observed bargaining behavior in bilateral and multilateral laboratory bargaining experiments.

In general, and consistent with the behavioral model, we find a pattern of low initial buyer offers that tend to rise over time, and high initial seller demands that tend to fall over time. Furthermore, symmetric delay costs result in bargainers taking weaker initial bargaining positions, in general, while asymmetric delay costs lead parties with the lower delay cost to take tougher bargaining positions. Lastly, bargainers facing disadvantageous delay costs were able to increase their payoffs, on average, by presenting an "ultimatum" in the form of a final offer, thereby credibly committing to a particular offer. However, commitment led to an increase in the number of failed agreements, consistent with the predictions of the model.

According to our model, this pattern of behavior can only be explained by assuming the population of responders consists of a mix of "strategic" and "sincere" responders, where strategic responders behave as expected-payoff maximizers, while sincere responders behave according to a minimum-acceptable-offer (MAO) rule. A population that consists of only sincere responders would not generate commitment incentives, while a population that consists only of strategic responders would not generate offers that rise over successive bargaining periods, and commitment should occur immediately. Indeed, a population of purely strategic responders would lead to behavior that is consistent with the standard equilibrium predictions for the one-period ultimatum game assuming payoff-maximizing behavior. Laboratory experiments have consistently rejected these predictions for the one-period game. Taken as a whole, our experimental results and behavioral bargaining model provide useful insight into the dynamics of the multiple-period bargaining problem. They also demonstrate why efficiency losses from bargaining delay and impasse are possible even in an environment without alternating offers and characterized by seemingly "complete" information about bargainers' potential payoffs from exchange. Designing institutions that mitigate these losses, while at the same time maintaining voluntary exchange and free markets, remains an open challenge.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.socec.2014.02.005.

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