“The Holdout Problem and Urban Sprawl: Experimental Evidence”

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Abstract
Conventional wisdom as well as economic theory suggests it is more costly to reassemble fragmented land due to transactions costs and strategic bargaining costs. Both costs are expected to increase with the number of sellers. Inefficient allocation of land resources may result including property entropy (Parisi 2002), urban sprawl (Miceli and Sirmans 2007) and deteriorating inner cities. Given the difficulty of observing actual values attached by buyers and sellers to land, little empirical evidence exists to support the conventional wisdom and theoretical work. We use experimental methods to examine transactions costs and strategic bargaining costs in a land-assembly market game with one buyer, one to four sellers, and complementary exchanges. The buyer’s final earnings vary inversely with the number of sellers, ceteris paribus, indicating an incentive to purchase consolidated land. Delay costs reduce holdout, but result in lower payoffs for both buyers and sellers. Competition between sellers reduces holdout and the buyer’s total purchase price.

Keywords: Holdout problem; land assembly; urban sprawl

JEL classification: C92 ; K11 ; J5

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1. Introduction

Land-assembly problems arise when multiple adjacent parcels must be acquired by a developer to complete an indivisible project. The potential exists for individual landholders to refuse to negotiate initially, or to strategically delay agreement, in an attempt to capture a greater share of the total surplus created by an exchange. Because of potential inefficiencies from delay costs and failed land exchanges, land assembly and the “holdout problem” have received considerable attention (e.g. Munch 1976; Eckart 1985; O’Flaherty 1994; Strange 1995; Menezes and Pitchford 2004a and 2004b; Miceli and Segerson 2007). Conventional wisdom and the theoretical work on the holdout problem suggest it is more costly to reassemble fragmented land due to transactions costs and strategic bargaining costs. Furthermore, both costs are expected to increase with the number of sellers. Inefficient allocation of land resources may result including property entropy (Parisi 2002), urban sprawl (Miceli and Sirmans 2007) and deteriorating inner cities. The holdout problem has been cited as a potential justification for eminent domain\(^1\) (Miceli and Sirmans 2007; Nosal 2007). Holdout problems may exist in other contexts as well, including wage negotiations (Houba and Bolt 2000; van Ours 1999; Gu and Kuhn 1998; Cramton and Tracy 1992), debt restructuring (Miller and Thomas 2006; Hege 2003; Datta and Iskandar-Datta 1995; Brown 1989), and corporate takeovers (Cohen 1991).

Because of the inherent difficulty in observing landowners’ reservation prices and the value a developer places on a development project, studies of land assembly and the holdout problem have been almost exclusively theoretical in nature. Our research provides empirical insight into the holdout problem through a laboratory bargaining experiment modeled after a land-assembly game. Three other empirical approaches are presented in Munch (1976), Tanaka (2007), and Cadigan, et al (2009). Munch (1976) investigates prices paid for urban renewal properties in Chicago during the 1960’s and concludes that the prices paid for properties under eminent domain do not appear to be consistent with the pattern of expected landowners’ reservation prices. Specifically, low-valued properties systematically receive less

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\(^1\) Eminent domain refers to the legal power of the state to expropriate property without the owner’s consent. Eminent domain may also be called compulsory purchase, compulsory acquisition, or expropriation.
than market value, while high-valued properties receive more. Importantly, while conventional wisdom suggests an incentive for sellers to holdout in order to increase the value of their land to a developer, she identifies a potential incentive for buyers, given the prospect of acquisition through eminent domain, to holdout in order to depress the market values of some properties to be acquired. Because of the likely correlation between property size and property value, it is important to further investigate how property sizes and the number of sellers impact bargaining behavior and efficiency in a land-assembly game.

Tanaka (2007) uses laboratory experiments to compare the efficiency of alternative market institutions for consolidating fragmented land. Importantly, in contrast to subjects in our experiment, all subjects in the Tanaka experiments are initially landowners and may subsequently be buyers or sellers of land. Although focused on comparing the efficiency of alternative market mechanisms and not holdout or bargaining behavior per se, Tanaka reports strategic holdout behavior in one of his treatments, a two-sided combinatorial market with a small number of subjects and commodities.

Cadigan, et al (2009) examine the holdout problem through six experimental bargaining treatments that vary the bargaining institution (whether buyers or sellers make the offers), the number of bargaining periods, and the costs associated with delay. The results demonstrate that holdout is common across treatments and is, on average, a payoff-improving strategy for responders. Delay costs led to more generous buyer offers and seller demands, and less overall holdout. The availability of more bargaining periods led to more aggressive initial bargaining stances by buyers and sellers (that is, lower offers by buyers and higher demands by sellers), both with and without delay costs. Importantly, they found that nearly all exchanges eventually occurred in the repeated-offer treatments, leading to a relatively high level of overall efficiency, both with and without delay costs. All of the treatments in Cadigan, et al (2009), however, involved just two sellers.

In this paper we extend the experimental analysis by examining the extent to which holdout behavior and efficiency, as well as the distribution of the surplus, are affected by changes in the number of sellers. If an increase in the number of sellers, ceteris paribus, decreases the buyer’s payoff because of
transactions costs and strategic bargaining costs, then potential developers may have an incentive *ex ante* to seek consolidated land for development even if the total economic surplus from such projects is smaller than that of a project assembling more fragmented land. This bias for consolidated land may lead to inefficient land allocation and associated costs from urban sprawl, as land tends to be more fragmented near city centers (Henderson 1985).

To this end we examine bargaining treatments with one to four sellers. We maintain the same institutional framework as Cadigan, et al (2009) by using a repeated-offer bargaining game, where the buyer makes take-it-or-leave-it offers to buy in half of the treatments, and the sellers make take-it-or-leave-it demands to sell in the others. Of the ten total treatments, four have costless delay and six have costly delay.

It is important to empirically investigate the impact of competition and the number of sellers on holdout, efficiency, and the distribution of the economic surplus. Most land-assembly models associate holdout and delay with efficiency losses because players are assumed to discount future payoffs. Both Strange (1995) and Eckart (1985) find in their models that increasing the number of landowners (by reducing the size of individual landholdings) increases the total asking price of landowners, resulting in greater delay and efficiency loss. While this may be consistent with common perceptions of small landholders holding up large development projects, the impact has yet to be empirically demonstrated or quantified, and the potential justification for using eminent domain rests largely on the severity of the holdout problem. Competition between landowners, on the other hand, should result in lower landowner asking prices, therefore largely mitigating potential holdout problems.

As in Cadigan, et al (2009), we find that holding out is a payoff-improving strategy, on average, in each of the treatments studied. However, the introduction of extraneous sellers in our competition treatments increases the speed at which agreements take place, thereby increasing efficiency. Qualitatively consistent with equilibrium predictions, the presence of extraneous sellers also serves to increase the bargaining payoff of buyers relative to sellers, particularly when sellers make take-it-or-
leave-it demands to the buyer. However, increasing the number of required consenting sellers, ceteris paribus, results in significantly greater delay, more failed agreements, and lower overall efficiency. The increase in the deadweight loss here appears to come primarily from the buyer’s share of the surplus. The bargaining institution (that is, which side is making the offers) has relatively little effect on either the distribution of the surplus or the efficiency of exchange.

In section 2 we describe the basic model that motivates the experimental design. Section 3 describes the experimental treatments and provides equilibrium predictions. Experimental results are given in section 4. Section 5 presents an alternative behavioral model to explain the results. Section 6 concludes.

2. Modeling Framework

Following Menezes and Pitchford (2004b), Miceli and Segerson (2007), and Cadigan, et al (2009) consider a simple model in which a single risk-neutral agent (the “buyer”) wishes to purchase $N$ complementary units of a good from $N$ other independent, risk-neutral 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

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

indicating that there is an economic surplus generated by the project.

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

$$(V - \sum_{i=1}^{N} p_i)$$

where $p_i$ is the price paid for unit $i$, and each seller $i$ receives a payoff $(p_i - c_i)$. We assume that the buyer is able to write contingent contracts such that all parties receive a payoff of zero if any of the
required input units are not purchased. To examine holdout, we allow bargaining over several periods. Delay is costly such that payoffs are reduced by a factor $\delta$ (where $0 \leq \delta \leq 1$) for each additional period, on average, needed for agreements to be reached. For example, payoffs would be reduced by $\delta$ if all agreements were reached in the second period, reduced by $2\delta$ if agreements were reached in the third period, and so on. This is equivalent to assuming that the economic surplus $V - \sum_{i=1}^{N} C_i$ shrinks by $\delta$ from period to period. Competition between sellers is introduced by allowing for the possibility that there are $N + M$ total sellers, where $M \geq 0$. That is, there may be extraneous sellers to the larger exchange.

3. The Experiment

As in Cadigan, et al (2009) we use one-sided repeated-offer bargaining rather than more complex multi-party Nash bargaining\(^2\) 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 for the present purposes because it introduces an additional incentive to reject an offer in order to become the proposer. 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 with those in which sellers make repeated take-it-or-leave-it demands to sell. In each treatment, responders decide only whether to accept or reject an offer or demand.

3.1 Experimental treatments

All treatments in our 5x2 design were conducted using z-Tree software (Fischbacher 2007). In all treatments, the buyer has a maximum of ten periods to acquire the necessary units from sellers, otherwise

\(^2\) Under Nash bargaining, all parties submit a demand for their share of the surplus. If the sum of the demands is less than or equal to the surplus, each party is paid their demand. If the sum of the demands exceeds the surplus, all parties receive zero.
all participants receive a payoff of zero. The One seller protocol involves bargaining between one buyer and one seller. The Two seller protocol involves bargaining between one buyer and two sellers, and the buyer must acquire one unit from each seller. Delay is costless ($\delta = 0$) in both the One seller and Two seller protocols. Sellers’ costs in the two-seller protocol are half of the seller’s cost in the one-seller protocol, meaning the total economic surplus from exchange is kept constant.

The Two seller delay cost protocol is identical to the two-seller protocol except that there is a 10% delay cost ($\delta = 0.10$). The Competition protocol involves bargaining between one buyer and three sellers, and the buyer must acquire two of the three available units to receive a positive payoff. That is, one seller is extraneous. The Four seller protocol involves bargaining between one buyer and four sellers, and the buyer must acquire one unit from each seller. As in the Two seller delay cost protocol, the Competition and Four seller treatments each have a 10% delay cost ($\delta = 0.10$). Again, relative to the Two seller delay cost protocol we double the number of sellers in the Four seller protocol, but reduce sellers’ costs by half. This maintains the same total sellers’ costs and the same total surplus from the exchange in all of the treatments in which the number of sellers alone changes.

The ten total treatments are generated by conducting the (1) One seller, (2) Two seller, (3) Two seller delay cost, (4) Competition, and (5) Four seller protocols with buyers making offers in five treatments, and sellers making demands in the other five treatments. In each case, the party receiving the offer or demand chooses to accept or reject the offer. If a responder rejects an offer or demand, the proposer is able to make a new offer or demand (one per period) for up to a maximum of ten periods. Unlike in the Gneezy, et al (2003) experiments, proposers in our experiment are not constrained to increase their offers (or reduce their demands) upon a rejection.

Valuations and costs are common knowledge. The buyer’s valuation is $V = \$ 90$ in all treatments. The sellers’ costs are symmetric such that $c_1 = \$ 60$ in the one-seller treatments, $c_1 = c_2 = \$ 30$ in the two-seller treatments, $c_1 = c_2 = c_3 = \$ 30$ in the Competition treatments, and
$c_1 = c_2 = c_3 = c_4 = $15 in the four-seller treatments. This results in an economic surplus of $30 that may be divided between the participants\(^3\). Within each period, all offers or demands take place simultaneously. Once a seller accepts an offer from the buyer, or has a demand accepted by the buyer, that seller makes no additional decisions. In the costly delay treatments, holding out incurs a payoff-reducing externality regardless of the decisions of the other subjects. 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.

3.2 Equilibrium predictions

Assuming complete information and that each agent seeks to maximize his monetary self-interest, 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 One seller, Two seller, Two seller costly delay and Four seller treatments used here, this implies:

**Proposition 1:** When the buyer makes offers to sellers, the buyer offers each seller her cost. That is, 
\[
b_i = c_i \quad \forall i.
\]

**Proposition 2a:** When \( N \) sellers make demands, multiple equilibria exist. The set of equilibria are characterized by 
\[
\sum_{i=1}^{N} d_i = V \quad \text{and} \quad d_i \geq c_i \quad \forall i.
\]

**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 2a characterizes a Nash-like bargaining

\(^3\) Note that at least one participant in the competition treatments must necessarily have a payoff of zero.

\(^4\) Technically, each seller is indifferent between accepting or rejecting. Therefore, accepting is a weakly dominate strategy and, therefore, constitutes a best-response. One could alternatively assume that \( b_i = c_i + \varepsilon \), where \( \varepsilon \) is the smallest unit of account available. 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.
outcome from the perspective of sellers. Proposition 3 follows from the assumption that a positive payoff is preferred to a zero payoff.

However, in the Competition treatments, we must modify the second proposition to

**Proposition 2b:** When \( N+M \) sellers make demands, sellers demand their cost. That is, \( d_i = c_i \ \forall i. \)

Propositions 1 – 3 are unaffected by the addition of multiple periods and delay costs. 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 to indicate that they, in equilibrium, should offer a greater share of the surplus following a rejected offer or demand. That is, the equilibrium predictions given for a one-period game above are also subgame perfect for the ten-period game.

The Competition and Four seller treatments were conducted at Michigan State University. The remaining treatments were conducted at Gettysburg College. Subjects for all treatments were undergraduate volunteers who participated anonymously via computer and were paid the show-up fee plus their experimental earnings privately, in cash, after each experimental session. One thousand and eighteen subjects participated for a total of between 27 and 33 bargaining groups per treatment.

4. Results

Tables 1 and 2 present offer, demand, and earnings results from the ten treatments. Table 1 shows the results from both the buyer-offer and seller-demand treatments. The table gives the mean first period offer or demand, as well as the mean real final payoff for buyers and sellers. Real payoffs are adjusted for

Proposition 2b must be modified if sellers have heterogeneous costs. If sellers are homogenous, Bertrand competition drives equilibrium demands to costs, and the buyer accepts \( N \) randomly selected demands. If sellers are heterogeneous, normalize the ordering of sellers from lowest cost to highest cost. Sellers submit demands such that

\[
d_i = c_{N+1} \ \forall i \leq N + 1 \text{ and } d_i = c_i \ \forall i > N \text{ if } N^*c_{N+1} \leq V
\]

\[
d_i = (c_i, c_{N+1}) \text{ such that } \sum_{i=1}^{N} d_i = V \ \forall i \leq N + 1 \text{ and } d_i = c_i \ \forall i > N \text{ if } N^*c_{N+1} > V
\]

The buyer accepts the \( N \) lowest demands. The uniqueness of the equilibrium depends on \( N \) relative to \( N+M \) and on the exact structure of costs.
any delay costs. For comparison, the table also gives the mean buyer and seller earnings that would have resulted *had all first-period offers or demands been accepted.*

**[Insert Table 1 here]**

Table 2 provides rejection, holdout, and efficiency statistics. Holdout is calculated as the average period in which agreements were reached.\(^6\) Efficiency is calculated as the actual total group earnings divided by the maximum possible (which is $30 per group, the value of the original surplus).

**[Insert Table 2 here]**

We discuss the earnings results and holdout and efficiency results separately.

*Buyer and seller earnings results*

The standard game-theoretic predictions indicate that the buyer should capture the entire surplus in the buyer-offer treatments (and all competition treatments), and none of the surplus in the seller-demand, non-competition treatments. In principle, therefore, the buyer should be indifferent between bargaining with one seller or multiple sellers, ceteris paribus. However, conventional wisdom, as well as our experimental results, suggests something quite different.

From Table 1, in the buyer-offer treatments, the buyer’s highest average final earnings occurred with one seller ($16.10). The buyer’s average final earnings fell significantly to $10.55 when a second seller was added, ceteris paribus.\(^7\) Similarly, the buyer’s average earnings with two sellers and costly delay was $11.12, falling significantly to $7.24 with four sellers, ceteris paribus. The addition of a competing seller, however, raised the buyer’s average earnings from $11.12 to $13.65. These earnings differences are both meaningful in scale and statistically significant.

Furthermore, these earnings changes could be predicted based on buyers’ first-period offers. Although the majority of first-period offers are rejected, the pattern of first-period offers is consistent with

\(^6\) For calculation purposes, agreement period is recorded as period 11 for any bargaining pair that failed to reach an agreement by period 10.

\(^7\) Using a Mann-Whitney Test, all two-tailed significance levels were less than 0.10 for all of the comparisons across treatments discussed here. For brevity, we note only when differences are not statistically significant at the 10% level or below.
the pattern of final earnings. That is, buyers offered more to two sellers as a group ($8.56 jointly, on average) in the first period compared to one seller ($5.58). Buyers offered more to four sellers as a group ($14.16) than to two sellers ($11.64 in the two-seller, costly delay treatment), ceteris paribus, but less to sellers as a group ($9.48) when there was competition. Thus, it is clear that buyers’ understood the likely impacts on their final earnings even in the very first period.

The results were remarkably similar when the sellers made demands on the buyer. The buyers earned $14.08 on average with one seller, but only $10.43 with two sellers, ceteris paribus. With two sellers and costly delay buyers earned $9.39 on average, but only $5.30 with four sellers, ceteris paribus. Adding a competing seller increased buyers’ earnings, from $9.39 to $16.73. Indeed buyers earned significantly more on average when sellers made demands under competition ($16.73) than they did when buyers made offers under the same competitive conditions ($13.65). Again, all of these earnings differences are meaningful and statistically significant.

As in the buyer-offer treatments, the final earnings results in the seller-demand treatments can also be seen in the pattern of first-period demands. The average first-period demand of the surplus with one seller was $22.53, while two-sellers jointly demanded even more than the available surplus in the first period ($33.46 on average). Similarly, with costly delay two sellers demanded an average of $28.34 of the surplus in the first period, while four sellers jointly demanded a whopping $43.64. However, sellers’ first-period joint demand dropped to $16.58 on average when there was competition. Again, the pattern of first-period demands, though generally rejected at a very high rate, are consistent with and foreshadow the pattern of buyer earnings.

Holdout and efficiency results

In analyzing the change in buyers’ earnings from treatment to treatment, it is important to distinguish changes that occur due to delay costs and failed agreements, from strategic changes in the offers and demands themselves (and thus, sellers’ earnings). Consider first the two buyer-offer treatments with no delay costs. Because there are no delay costs and no failed agreements, the change in buyers’
average final earnings (from $16.10 with one seller to $10.55 with two sellers) can only have arisen because buyers’ offered more to sellers as a group in the latter treatment. Interestingly, this appears to have occurred voluntarily as the average agreement period (our measure of holdout) was actually somewhat higher with one seller (period 7.39) compared to two sellers (period 6.40), though the difference in delay is not statistically significant.\footnote{Using Mann-Whitney Test, two-tailed significance level = 0.330.}

Comparing the two-seller, buyer-offer treatment (with delay costs) to the four-seller treatment, the average agreement period was higher with four sellers (period 2.98 compared to 2.47)\footnote{The difference is statistically significant (two-tailed significance level = 0.08).} and there were two failed agreements in the four-seller treatment and none in the two-seller treatment. Interestingly, as a group the sellers in the four-seller treatment who reached agreements with the buyer earned only about a dollar more ($15.40) on average compared to the two-seller groups ($14.48), while the buyer earned nearly $4 less than on average. Thus, we can conclude that the decrease in the buyer’s average earnings between these treatments occurred because of all three types of costs, delay costs, strategic bargaining costs, and failed agreements.

Comparing the buyer-offer, two-seller (with delay costs) treatment to the buyer-offer with competition treatment, sellers as a group earned slightly more in the former ($14.48) than the latter ($13.44), and there were no failed agreements. The extent of holdout in the competition treatment was considerably less, however, with agreements occurring, on average, in period 1.85 with competition, and period 2.47 without. This difference in delay is statistically significant. The buyer earned about $2.50 more, on average, when there was competition, so we can conclude that about 60% of this increase (about $1.50) was the avoidance of delay costs and 40% (about $1.00) was because offers could be strategically reduced.

The results are very similar across the seller-demand treatments. In the one-seller and two-seller treatments with no delay costs, there were an equal number of failed agreements (one) in each. As a group, sellers made $18.56 on average, while the average seller earnings in the one-seller treatment was
$15.31. The buyer earned $3.65 less on average when there were two sellers. Because there were no delay costs, the change in buyer’s average earnings was due almost solely to strategic bargaining costs arising because of the increase in the number of sellers. Interestingly, as in the buyer-offer treatments, it actually took slightly longer for agreements to be reached with one seller (period 7.27 on average) compared to with two sellers (period 6.50), though the difference is not highly significant.\textsuperscript{10}

Comparing the seller-demand (costly delay) treatment with two-sellers versus four sellers, sellers as group earned almost exactly the same amount between the two treatments ($15.60 with two sellers versus $15.84 with four). There were four failed agreements with four sellers and none with two sellers. The average agreement period was slightly higher (period 3.05) with four sellers compared to two (2.67). The buyer earned just over $4 less in the four-seller treatment. Thus, we can conclude that the decrease in buyer’s earnings were due primarily to delay costs and failed agreements.

Comparing the seller-demand treatments with and without competition, there were no failed agreements in either the two-seller, costly delay treatment or the competition treatment. However, agreements were reached more quickly when there was competition (by period 1.85, on average) compared to without competition (by period 2.67, on average). Sellers earned $5.56 less as a group when there was competition ($10.24 versus $15.80) while the buyer earned $7.34 more, on average, when there was competition. Thus, we can conclude that about 75% of the increase in the buyer’s earnings occurred from the reduction in strategic bargaining costs, and about 25% from reduced delay costs.

The introduction of delay costs alone significantly reduced holdout, but also resulted in lower overall efficiency of exchange. Comparing the two-seller, buyer-offer treatments with and without delay costs, the average agreement period fell significantly (from 6.40 to 2.47) when delay was costly. However, overall efficiency also fell from 100% to 85.3%. Similarly, in the two-seller, seller-demand treatments with and without delay costs, the average agreement period fell significantly (from 6.50 to 2.67) when delay was costly. Efficiency fell from 96.7% to 83.3%.

\textsuperscript{10} Significance level = 0.15.
5. An Alternative Behavioral Model

Why does an increase in the number of sellers reduce the buyer’s expected earnings regardless of whether offers originate from the buyer or the sellers? Some of the decrease arises from delay costs, but much of the decrease appears to come from strategic bargaining costs. The following model provides a possible explanation for this result. For simplicity, normalize the buyer’s value to $V = 1$ throughout the following analysis. Assume sellers’ each have a minimum acceptable offer (MAO) of $x_i$ that is private information distributed independently and identically according to a publicly known continuous uniform distribution with probability density function

$$f(x_i) = \begin{cases} N & \text{for } 0 \leq x_i \leq 1/N \\ 0 & \text{for } x_i < 0 \text{ or } x_i > 1/N \end{cases}$$

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.\(^\text{11}\) That is, multiple small sellers are no more demanding 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.

Sellers are assumed to accept any offer that exceeds their MAO. 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. Alternatively, in an environment with complete information about the buyer’s value and sellers’ costs (as in Cadigan et al (2009)), MAOs may be interpreted as arising from heterogeneous preferences for fairness (e.g. Fehr and Schmidt (1999) and Bolton and Ockenfels (2000)) where the MAO is the offer level above which the responder would receive

\(^{11}\) 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 except that in the latter case, sellers as a group become more demanding as the number of sellers increases.
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 here is not the origin of MAOs, but rather their impact on the bargaining behavior of buyers and sellers as the number of sellers increases.

**Buyer offers to N sellers**

Let the buyer be the proposer with sellers deciding to accept or reject the buyer’s offer according to the MAO rule. Given the known distribution of MAOs, the buyer makes symmetric offers \( b \) to the sellers that maximize the buyer’s expected payoff. Each seller accepts the offer if \( b \geq x_i \). The probability that seller \( i \) accepts an offer of \( b \) is \( P(x_i \leq b) = b/(1/ N) = N b \). Because each of the \( N \) sellers must accept the offer for an exchange to be realized, the probability the buyer receives the associated payoff of \( (1 – N b) \) is \( (N b)^N \). Therefore, the buyer solves

\[
\max_b \ (1 – N b) \cdot (N b)^N
\]

which yields

\[ b^* = \frac{1}{N + 1}. \]

The buyer’s joint offer to sellers as a group is

\[ N b^* = \frac{N}{N + 1}. \]

The probability of a successful exchange \( (P^*) \) is

\[ P^* = \left(\frac{N}{N + 1}\right)^N. \]

We summarize these results as Result 1.

**Result 1:** As the number of sellers \( N \) increases, the buyer’s optimal offer to each seller decreases, the sum of the shares offered to sellers increases, the probability of a successful exchange decreases, and the buyer’s expected payoff decreases.
Result 1 demonstrates why the buyer would voluntarily make a higher joint offer to sellers as a group as the number of sellers increases, even if sellers are no more greedy (based on MAO’s) as a group. Because the agreement requires unanimous consent, the probability that a given joint offer is accepted by all decreases as the number of sellers increases. To maximize his expected payoff, the buyer must offset this with a relatively higher collective offer to sellers.

*N sellers demands on a single buyer*

Alternatively, consider the case where *N* sellers each make a single take-it-or-leave-it demand *d*_i on a buyer. Similar to the case above, assume the buyer has an MAO that is private information drawn from the publicly known uniform distribution *x* ∼ U[0,1]. The buyer accepts the set of sellers’ demands if *x* ≤ 1 − ∑ _i=1^N_ *d*_i. The probability that the buyer accepts the sellers’ joint demands is

\[ P(\sum_{i=1}^{N} d_i \leq 1 - \sum_{i=1}^{N} d_i) = 1 - \sum_{i=1}^{N} d_i. \]

Sellers make simultaneous demands and choose demands non-cooperatively. Seller *i* chooses *d*_i to solve

\[ \max_{d_i} \left( 1 - \sum_{i=1}^{N} d_i \right) \]

Assuming a symmetric equilibrium in sellers’ demands, the equilibrium individual seller’s demand is

\[ d_i^* = \frac{1}{N+1}. \]  

(8)

The sellers’ joint demand from the buyer is

\[ N d_i^* = \frac{N}{N+1}. \]  

(9)

Notice that the sellers’ equilibrium individual and joint demands are identical to equilibrium offers made by the buyer above. The probability of a successful exchange (*P*^*) is

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12 Again, the buyer’s MAO may be interpreted as unknown project valuation, as in Eckart (1985) and Strange (1995). Alternatively, the buyer’s MAO may arise from heterogeneous preferences for fairness or satisficing behavior. Each of these cases is consistent with the model presented here.
\[ P^* = \left(\frac{N}{N+1}\right)^N. \]  

(10)

We summarize these results as Result 2.

**Result 2:** As the number of sellers \(N\) increases, the individual seller’s equilibrium demand from the buyer decreases, the sellers’ joint demand on the buyer increases, and the probability of a successful exchange decreases.

The intuition behind Result 2 is that sellers face a Cournot-like problem with respect to demands. In setting his demand, each seller ignores the externality imposed on other sellers as he raises his demand. This results in excessively high demands and a lower probability of acceptance relative to the case when sellers cooperate in their demand decisions. It is straightforward to show that individual optimal cooperative demands are

\[ d_{i\text{ cooperate}} = \frac{1}{2N} \]  

(11)

and that

\[ d_{i\text{ cooperate}} < d_i^* \]  

(12)

whenever there are multiple sellers.

The experimental results are strongly consistent with the predictions given in Results 1 and 2. That is, the buyer’s expected earnings are clearly inversely related to the number of sellers. There is also some evidence that the likelihood of a successful exchange is inversely related to the number of sellers, as the majority of failed exchanges occurred in the treatments with four sellers. However, due to the high agreement rate in general, there is not conclusive support for this result.

The simple alternative behavioral model based on minimum acceptable offers also does not capture the interesting strategic effects that a multi-period bargaining game allows. It does explain, however, why increasing the number of sellers reduces the buyer’s expected earnings. Both the first-period offer and demand results and final earnings results from the experiment are strongly consistent with the model’s predictions.
6. Conclusion

As O’Flaherty (1994) notes in his theoretical analysis of land assembly, a variety of different bargaining institutions may be employed in the context of land assembly. Specifically, he states:

The developer can make offers one at a time or simultaneously to a group of lot owners; the lot owners can respond one at time or simultaneously; the lot owners can make offers one at a time or simultaneously; or the developer and lot owners can alternate offers in some fashion. The rules can specify the order in which lot owners are dealt with, or the order can be endogenous. The developer can have the ability to resell, or not. The players can have different discount rates. All these different games can and do have different equilibria; and a particular game may even have multiple equilibria. The distribution of rent, in particular, is very sensitive to the exact structure chosen…” (p. 292)

While our study leaves many interesting empirical questions about the land assembly problem unanswered, it does provide some insight into why the number of sellers, ceteris paribus, is an important determinant of the buyer’s payoff and, therefore, the incentives to acquire and develop property. Our study also provides a better link between the theoretical analysis of land assembly games and the experimental analysis of behavior in bargaining games. We have explored several of the institutional details highlighted by O’Flaherty, and examined these in environments with varied group sizes and competition between sellers.

Both the theoretical and experimental results indicate a consistent decrease in the buyer’s earnings as the number of sellers is increased, ceteris paribus, from one to two to four. Importantly, these results provide empirical support to the theoretical argument and conventional wisdom that buyers would prefer to bargain with a smaller number of sellers. Development projects in the field may involve anywhere from one to possibly hundreds of landowners, so the importance of the number of sellers for the distribution of the surplus and the efficiency of exchange cannot be overstated.

Future research is necessary to identify whether our results are robust to further changes in the bargaining institution. In particular, alternating offer and Nash bargaining are two examples yet to be adequately explored in the context of multilateral land-assembly-type bargaining games. Furthermore, we should note that all treatments investigated here involved complete information, and that most bargaining
environments in the field are likely to be characterized by incomplete or asymmetric information about buyers’ values or sellers’ costs. There is little doubt that information plays a key role in these bargaining outcomes, and it is important that this role be investigated both theoretically and empirically.
6. References


7. Tables

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

<table>
<thead>
<tr>
<th>Proposer</th>
<th>Treatment</th>
<th>Mean first period offer/demand</th>
<th>Mean buyer first period earnings</th>
<th>Mean seller first period earnings</th>
<th>Mean real final buyer earnings</th>
<th>Mean real final seller earnings</th>
<th>Number of groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buyer</td>
<td>One-seller</td>
<td>$65.58 (5.00)</td>
<td>$24.42 (5.00)</td>
<td>$5.58 (5.00)</td>
<td>$16.10 (3.19)</td>
<td>$13.90 (3.19)</td>
<td>N = 33</td>
</tr>
<tr>
<td>Buyer</td>
<td>Two-seller</td>
<td>$34.28 (3.31)</td>
<td>$21.43 (6.26)</td>
<td>$4.28 (3.31)</td>
<td>$10.55 (5.25)</td>
<td>$9.72 (3.00)</td>
<td>N = 29</td>
</tr>
<tr>
<td>Buyer</td>
<td>Two-seller (delay costs)</td>
<td>$35.82 (2.57)</td>
<td>$18.37 (5.08)</td>
<td>$5.82 (2.57)</td>
<td>$11.12 (5.67)</td>
<td>$7.24 (2.78)</td>
<td>N = 29</td>
</tr>
<tr>
<td>Buyer</td>
<td>Four-seller, (delay costs)</td>
<td>$18.54 (1.64)</td>
<td>$15.85 (6.31)</td>
<td>$3.54 (1.64)</td>
<td>$7.24 (4.27)</td>
<td>$3.85 (1.73)</td>
<td>N = 30</td>
</tr>
<tr>
<td>Buyer</td>
<td>Competition (delay costs)</td>
<td>$34.74 (3.48)</td>
<td>$20.53 (6.55)</td>
<td>$4.74 (3.48)</td>
<td>$13.65 (6.09)</td>
<td>$6.72 (3.25)</td>
<td>N = 29</td>
</tr>
<tr>
<td>Seller</td>
<td>One-seller</td>
<td>$82.53 (5.67)</td>
<td>$7.47 (5.67)</td>
<td>$22.53 (5.67)</td>
<td>$13.85 (5.05)</td>
<td>$15.04 (5.18)</td>
<td>N = 27</td>
</tr>
<tr>
<td>Seller</td>
<td>Two-seller</td>
<td>$46.73 (7.62)</td>
<td>$3.46 (11.06)</td>
<td>$16.73 (7.61)</td>
<td>$10.43 (5.02)</td>
<td>$9.28 (3.38)</td>
<td>N = 30</td>
</tr>
<tr>
<td>Seller</td>
<td>Two-seller (delay costs)</td>
<td>$44.17 (6.86)</td>
<td>$1.65 (8.94)</td>
<td>$14.17 (6.86)</td>
<td>$9.39 (4.90)</td>
<td>$7.80 (2.96)</td>
<td>N = 30</td>
</tr>
<tr>
<td>Seller</td>
<td>Four-seller (delay costs)</td>
<td>$25.91 (9.68)</td>
<td>$13.63 (18.14)</td>
<td>$10.91 (9.68)</td>
<td>$5.30 (4.16)</td>
<td>$3.96 (2.80)</td>
<td>N = 28</td>
</tr>
<tr>
<td>Seller</td>
<td>Competition (delay costs)</td>
<td>$40.74 (6.19)</td>
<td>$13.41 (5.11)</td>
<td>$8.29 (3.52)</td>
<td>$16.73 (4.05)</td>
<td>$5.12 (2.57)</td>
<td>N = 33</td>
</tr>
</tbody>
</table>

\(^{13}\) Assumes buyer accepts two lowest demands.  
\(^{14}\) Includes the earnings of the two sellers with the lowest demands. Excludes earnings of seller with the highest demand.
### Table 2. Holdout and efficiency results

<table>
<thead>
<tr>
<th>Proposer</th>
<th>Treatment</th>
<th>Percent of first-period rejections</th>
<th>Average agreement period</th>
<th>Number of failed agreements</th>
<th>Efficiency</th>
<th>Number of groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buyer</td>
<td>One-seller</td>
<td>97.0%</td>
<td>7.39</td>
<td>0</td>
<td>100%</td>
<td>N = 33</td>
</tr>
<tr>
<td>Buyer</td>
<td>Two-seller</td>
<td>96.6%</td>
<td>6.40</td>
<td>0</td>
<td>100%</td>
<td>N = 29</td>
</tr>
<tr>
<td>Buyer</td>
<td>Two-seller (delay costs)</td>
<td>66.7%</td>
<td>2.47</td>
<td>0</td>
<td>85.3%</td>
<td>N = 30</td>
</tr>
<tr>
<td>Buyer</td>
<td>Four-seller, (delay costs)</td>
<td>71.6%</td>
<td>2.98</td>
<td>2</td>
<td>75.5%</td>
<td>N = 29</td>
</tr>
<tr>
<td>Buyer</td>
<td>Competition (delay costs)</td>
<td>63.4%</td>
<td>1.85</td>
<td>0</td>
<td>90.3%</td>
<td>N = 31</td>
</tr>
<tr>
<td>Seller</td>
<td>One-seller</td>
<td>97.3%</td>
<td>7.27</td>
<td>1</td>
<td>97.3%</td>
<td>N = 27</td>
</tr>
<tr>
<td>Seller</td>
<td>Two-seller</td>
<td>91.7%</td>
<td>6.50</td>
<td>1</td>
<td>96.7%</td>
<td>N = 30</td>
</tr>
<tr>
<td>Seller</td>
<td>Two-seller (delay costs)</td>
<td>71.7%</td>
<td>2.67</td>
<td>0</td>
<td>83.3%</td>
<td>N = 30</td>
</tr>
<tr>
<td>Seller</td>
<td>Four-seller (delay costs)</td>
<td>66.1%</td>
<td>3.05</td>
<td>4</td>
<td>70.4%</td>
<td>N = 28</td>
</tr>
<tr>
<td>Seller</td>
<td>Competition (delay costs)</td>
<td>48.5%&lt;sup&gt;15&lt;/sup&gt;</td>
<td>1.85</td>
<td>0</td>
<td>89.9%</td>
<td>N = 33</td>
</tr>
</tbody>
</table>

<sup>15</sup> Assumes the maximum number of acceptable offers is two per group. Therefore, this calculation is (max # of acceptances – actual # of acceptances)/max number of acceptances = (66 – 34)/66 = 48.5%.