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# Shotgun Mechanisms for Common-Value Partnerships: The Unassigned-Offeror Problem

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# Shotgun Mechanisms for Common-Value Partnerships: The Unassigned-Offeror Problem.

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**Abstract**

Shotguns clauses are commonly included in the business agreements of partnerships and limited liability companies (LLCs), but the role of offeror typically remains unassigned. In a common-value, one-sided asymmetric information setting, unfair and inefficient outcomes occur with an unassigned offeror. Experimental results are aligned with our theory.

KEYWORDS: Business Deadlock; Shotgun Mechanisms; Asymmetric Information; Experiments.

JEL Classification: K40, C72, C90, D82.

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# 1 Introduction

Deadlocks or impasses between joint owners concerning fundamental business decisions can paralyze closely-held companies including partnerships and LLCs. When a business relationship deteriorates to the point where the joint owners cannot be reconciled, it may become necessary to dissolve the business venture and/or to dissociate one (or more) of the owners. Placing an accurate value on the business assets – a necessary step in finalizing a business divorce – can be difficult, especially when the best wisdom concerning the value of the assets is in the minds of the business owners themselves, and an outside market for the assets does not exist.

In a shotgun mechanism, one owner names a single buy-sell price and the other owner then decides whether to sell or buy at that price. Shotgun provisions are fairly common in the private business agreements of partnerships and LLCs.[1] In the words of Judge Frank Easterbrook, "[t]he possibility that the person naming the price can be forced either to buy or to sell keeps the first mover honest."[2] In private contractual settings, the identity of the offeror is typically not specified, i.e., the role of offeror remains unassigned.

Shotgun mechanisms are sometimes mandated by judges when overseeing business divorce proceedings. In *Kinzie v. Dells*, a recent business deadlock case from Canada,[3] the presiding judge describes the appropriate assignment of the role of offeror: "In a 'shot gun' sale, the court must determine the party who will make the first offer. Normally, the party who is in the best position to assess the value of the business and determine the fair market value is ordered to make the initial offer."

This article theoretically and experimentally studies shotgun mechanisms in a common-value, one-sided asymmetric information setting. When the role of offeror remains unassigned, coordination failures arise and *unfair* and *inefficient* outcomes are obtained.[4] Fair and efficient outcomes are achieved only when the role of offeror

[1]These mechanisms may also be referred to as Texas shootouts, Russian roulette, Chinese wall clauses, put-call options, dynamite or candy bar methods, or simply buy-sell mechanisms (Carey, 2005). See Crawford (1977) and Che and Hendershott (2008). See also our previous work and the references cited there (Brooks et al., 2010).

[2]*Valinote v. Ballis;* 295, F3d. 666 (Ill. 2002).

[3]*Kinzie v. Dells* 2010 BCSC 1360 (Can. B.C.). Shotgun mechanisms are rare in the United States, but see *Fulk v. Washington Serv. Assocs.* No. 17747-NC, 2002 BL 1389 (Del. Ch. June 21, 2002). See Landeo and Spier (forthcoming, (a) and (b)).

[4]Landeo and Spier (forthcoming, (a) and (b)) and Brooks et al. (2010) do not study shotgun

is assigned to the better-informed party. When the identity of the informed party is unforeseeable ex ante, a proper private implementation of the shotgun mechanism may not be possible. In contrast, an adequate judicial implementation of the mechanism might be achieved.

## 2 Theoretical Framework

Suppose that two co-venturers[5] own equal stakes in a firm with uncertain value $x$, which is drawn from a uniform distribution on the interval $[x_L, x_H]$. $\overline{x}$ is the average value. The informed player (Owner 1) knows the true value of $x$; the uninformed owner (Owner 2) does not observe the value. Thus, this game has one-sided asymmetric information with common values. We assume that there is a business deadlock; the assets will be more valuable if ownership is consolidated. Resolving the deadlock will create an additional $a$ of value, so after the consolidation of ownership the assets are worth $x + a \in [x_L + a, x_H + a]$.

In a shotgun mechanism, one owner names a single buy-sell price and the other owner is compelled to either buy or sell shares at that named price. We let $p$ represent the buy-sell prices for the shotgun mechanisms. If Owner $i$ purchases Owner $j$'s stake for price $p$, the payoff for Owner $i$ is $x + a - p$ and the payoff for Owner $j$ is $p$. If the business remains deadlocked, each owner receives $\frac{x}{2}$. The equilibrium concept is the perfect Bayesian equilibrium.

We will show that when the role of offeror is unassigned, inefficient outcomes may result as a consequence of a coordination failure between the owners. To understand this outcome, it will be useful to first restate our previous findings regarding the equilibria with informed and uninformed offerors (Brooks et al., 2010).[6] The first proposition characterizes the unique fully-separating equilibrium of the shotgun mechanism when the informed party, Owner 1, makes the buy-sell offer. Owner 1's buy-sell offer fully reveals Owner 1's type $x$ and leads to a fair division of the surplus.[7]

**PROPOSITION 1:** *Suppose Owner 1 (the informed party) makes the buy-sell*

mechanisms with unassigned offerors.

[5] According to Hauswald and Hege (2006), 80% of all joint ventures incorporated in the U.S. between 1985 and 2000 are two-partner joint ventures.

[6] See our previous work (Brooks et al., 2010) for formal discussion and proofs.

[7] There also exists a pooling equilibrium where Owner 1 offers $p(x) = \frac{\overline{x}+a}{2}$.

*offer. There is a unique fully-separating equilibrium where Owner 1 offers* $p_1(x) = \frac{x+a}{2}$ *and Owner 2 randomizes between buying and selling with equal probability. The ex ante expected payoffs of each owner are* $\frac{\overline{x}+a}{2}$.

The second proposition characterizes the equilibrium of the shotgun mechanism when the uninformed party, Owner 2, makes the buy-sell offer. Owner 2's offer reflects the average value of the assets rather than the realized value (since $x$ is known only to Owner 1), and Owner 1 receives a greater equilibrium share of the surplus than Owner 2.

**PROPOSITION 2:** *Suppose Owner 2 (the uninformed party) makes the buy-sell offer. In equilibrium, Owner 2 offers* $p_2 = \frac{\overline{x}+a}{2}$. *Owner 1 sells his stake to Owner 2 when* $x < \overline{x}$ *and buys Owner 2's stake when* $x \geq \overline{x}$.[8] *The ex ante expected payoffs of Owner 1 and Owner 2 are* $\frac{\overline{x}+a}{2} + \frac{x_H - x_L}{8}$ *and* $\frac{\overline{x}+a}{2} - \frac{x_H - x_L}{8}$, *respectively.*

We now consider the shotgun mechanism with an unassigned offeror. In this mechanism, the two owners have the option (but not the obligation) to make simultaneous buy-sell offers. If only one offer is made, the receiver is compelled to either buy the stake of the offeror or to sell his own stake. If two offers are made, a coin flip determines which of the two offers applies. The results of our first two propositions suggest a potential conflict between the two owners in this setting. The uninformed player, Owner 2, would prefer that Owner 1 makes the buy-sell offer since $p_1(x) = \frac{x+a}{2}$ gives Owner 2 an equitable share of the surplus. Owner 1 would prefer that Owner 2 make the buy-sell offer, since receiving $p_2 = \frac{\overline{x}+a}{2}$ will allow Owner 1 to exploit his informational advantage.

When the gains from consolidation, $a$, are sufficiently large, then there are multiple equilibria. In one equilibrium, Owner 1 makes a perfectly-revealing and equitable offer $p_1(x) = \frac{x+a}{2}$ and Owner 2 mixes between accepting in rejecting (as in Proposition 1). In a second equilibrium, Owner 2 makes an offer $p_2 = \frac{\overline{x}+a}{2}$ and Owner 2 buys when $x$ is high and sells if $x$ is low (as in Proposition 2). Interestingly, there is also a mixed-strategy equilibrium where Owner 2 mixes between making an offer and does not make one, and Owner 1 offers $p_1 = \frac{x+a}{2}$ if and only if his type, $x$, is sufficiently close to the average type $\overline{x}$. In this mixed-strategy equilibrium, it is possible that neither owner makes a buy-sell offer, leaving the gains from trade, $a$,

[8] Here, we assume that the recipient buys when indifferent.

unrealized.[9]

**PROPOSITION 3:** *Suppose the role of offeror has not been assigned. If* $a < \frac{x_H - x_L}{4}$ *then Owner 1 (the informed party) makes a buy-sell offer (as in Proposition 1). If* $a \geq \frac{x_H - x_L}{4}$ *then there are multiple equilibria, including:*

*(i) Owner 1 (the informed party) makes an offer and Owner 2 does not;*

*(ii) Owner 2 (the uninformed party) makes an offer and Owner 1 does not; and*

*(iii) There is a mixed-strategy equilibrium where Owner 2 (the uninformed party) offers* $p_2 = \frac{\overline{x}+a}{2}$ *with probability* $\theta$ *and makes no offer with probability* $1-\theta$*. Owner 1 (the informed party) offers* $p_1(x) = \frac{x+a}{2}$ *when* $x \in [\overline{x} - \Delta, \overline{x} + \Delta]$ *and does not make an offer otherwise. The payoffs of Owner 1 and Owner 2 are* $\frac{\overline{x}+a}{2} + a\left(\theta - \frac{1}{2}\right)\left(1 - \frac{2\Delta}{x_H - x_L}\right)$ *and* $\frac{\overline{x}+a}{2} - a\left(\frac{1}{2} - \frac{\Delta}{x_H - x_L}\right)$*, respectively.* $\theta$ *and* $\Delta$ *are the solutions to the following system of two equations:* $2\Delta^2 - 8a\Delta = (x_H - x_L)^2 - 4a(x_H - x_L)$ *and* $\Delta = 2a(1-\theta)/\theta$*.*

**PROOF.** Suppose Owner 2 offers $p_2 = \frac{\overline{x}+a}{2}$ with probability $\theta$. Suppose $x < \overline{x}$, so Owner 1 would choose to sell when faced with this offer. If Owner 1 does not make an offer, his payoff is $(1-\theta)(\frac{x}{2}) + (\theta)(\frac{\overline{x}+a}{2})$. If Owner 1 makes an offer $p_1 = \frac{x+a}{2}$, his payoff is $(1 - \frac{\theta}{2})(\frac{x+a}{2}) + (\frac{\theta}{2})(\frac{\overline{x}+a}{2})$. Setting these expressions equal to each other verifies that Owner 1 is indifferent between making an offer and not making an offer when the asset value is $\overline{x} - \Delta$ where $\Delta = 2a(1-\theta)/\theta$. Similarly, one can establish indifference for Owner 1 between making an offer and not making one when the asset value is $\overline{x} + \Delta$.

Consider Owner 2's decision. If Owner 2 does not make an offer, his payoff is

$$\int_{x_L}^{\overline{x}-\Delta} \left(\tfrac{x}{2}\right) dF(x) + \int_{\overline{x}-\Delta}^{\overline{x}+\Delta} \left(\tfrac{x+a}{2}\right) dF(x) + \int_{\overline{x}+\Delta}^{x_H} \left(\tfrac{x}{2}\right) dF(x).$$

That is, when the value of $x$ is at the extremes then Owner 1 will refrain from making an offer and the deadlock will remain, giving Owner 2 a payoff of $\frac{x}{2}$. When $x \in [\overline{x} - \Delta, \overline{x} + \Delta]$, then Owner 1 offers $p_1 = \frac{x+a}{2}$ and Owner 2 will receive a net payoff of $\frac{x+a}{2}$. Simplifying, Owner 2's payoff is:

[9] This outcome might also explain why privately-contracted shotgun clauses are rarely triggered. See Brooks et al. (2010).

$$\frac{\overline{x}}{2} + \frac{a\Delta}{(x_H - x_L)}.$$

Rearranging this expression gives the expression for Owner 2's payoff in the proposition. Adding the expected payoffs for Owners 1 and 2 as stated in the proposition, one finds that their joint expected payoff is: $\overline{x} + a - a(1-\theta)\left(1 - \frac{2\Delta}{x_H - x_L}\right)$. That is, their joint payoff is $\overline{x} + a$, which is the efficient joint surplus, minus a loss, $a(1-\theta)\left(1 - \frac{2\Delta}{x_H - x_L}\right)$, reflecting the likelihood that neither owner makes an offer. This proves the expression for Owner 1's payoff in the proposition.

If Owner 2 offers $p_2 = \frac{\overline{x}+a}{2}$ (which is an optimal offer for Owner 2 given Owner 1's strategy) then Owner 2's expected payoff is

$$\int_{x_L}^{\overline{x}-\Delta} \left(x + a - \tfrac{\overline{x}+a}{2}\right) dF(x) + \int_{\overline{x}+\Delta}^{x_H} \left(\tfrac{\overline{x}+a}{2}\right) dF(x)$$

$$+\tfrac{1}{2}\int_{\overline{x}-\Delta}^{\overline{x}} \left(x + a - \tfrac{\overline{x}+a}{2}\right) dF(x) + \tfrac{1}{2}\int_{\overline{x}}^{\overline{x}+\Delta} \left(\tfrac{\overline{x}+a}{2}\right) dF(x)$$

$$+\tfrac{1}{2}\int_{\overline{x}-\Delta}^{\overline{x}+\Delta} \left(\tfrac{x+a}{2}\right) dF(x).$$

The first two terms reflect Owner 2's payoff when the asset value $x$ is in the extremes of the distribution so Owner 1 does not make a buy-sell offer. The second two terms reflect Owner 2's payoff when the asset value is in the middle of the distribution and Owner 2 wins the coin flip and makes the active offer (which happens with probability $\frac{1}{2}$). The last term reflects Owner 2's payoff in the middle of the distribution when Owner 1's offer, $p_1(x) = \frac{x+a}{2}$, is active (which happens with probability $\frac{1}{2}$). Combining and rearranging terms, this expression becomes:

$$\frac{1}{2}\left(\frac{\overline{x} + x_L}{2} + a\right) + \frac{\Delta^2}{4(x_H - x_L)}.$$

In equilibrium, Owner 2 is indifferent between making an offer and not making an offer. Setting these two simplified expressions equal to each other and rearranging terms gives $2\Delta^2 - 8a\Delta = (x_H - x_L)^2 - 4a(x_H - x_L)$ (as in the proposition). ■

# 3 Experimental Evidence

This section reports the results from a series of experiments with human subjects paid according to their performance. We investigate whether the shotgun mechanism with an unassigned offeror generates inequitable and inefficient outcomes.[10] We consider two treatments: Shotgun mechanisms with an unassigned offeror (NO), and Shotgun mechanisms with an informed offeror (IO).[11]

## 3.1 Numerical Example

Computational demands on the subjects are reduced by using a simple numerical example. We assume that two co-venturers, Owner 1 (the informed player) and Owner 2 (the uninformed player), own equal stakes in a firm with uncertain value $x$, which is drawn from a uniform distribution on the interval $[\$400, \$1000]$. Due to business deadlock, consolidated ownership creates an additional value $a = \$200$.[12] Thus, the value of the business assets per owner under consolidation is equal to $(x + \$200)/2 \in [\$300, \$600]$.[13]

In the fully-separating equilibrium of the informed-offeror environment(IO), the offeror will propose a price equal to $(x + 200)/2$, and the uninformed offeree will randomize between buying and selling. Fair outcomes will occur. In case of the UO, as described in Proposition 3, multiplicity of equilibria will occur. One possible equilibrium resembles the IO outcome. In the second possible equilibrium, which resembles the uninformed offeror outcome, the uninformed offeror offers a price equal to 450, and the informed offeree's buys if $x \geq 450$ and sells if $x < 450$. Under the mixed-strategy equilibrium, the informed owner should decline to be the offeror

[10] Kittsteiner et al. (2012) present an experimental study of privately-contracted shotgun and auction mechanisms in private-value settings.

[11] In a previous paper on judicial resolution of deadlocks (Landeo and Spier, forthcoming, (b)), we studied three conditions: shotguns with informed and uninformed offerors and private auction. We showed that the IO is fairness superior to the other two mechanisms. We decided to use the data for the IO condition in our current study to construct the qualitative hypothesis regarding the effects of NO on the likelihood of fair outcomes. The unassigned-offeror condition was not explored in our previous paper.

[12] The value of $a$ allows us to replicate the theoretical environment that triggers multiplicity of equilibria in the unassigned-offeror environment.

[13] The experimental setting satisfies the assumptions of the theory. To ensure control and replicability, only few labels are used to motivate the experimental environment.

for values of the business assets per owner under consolidation outside the interval $[408, 492]$, i.e., in 72% of the cases; the uninformed owner should be *gun shy* in 17% of the cases; and hence, both owners should be *gun shy* in 12% of the cases. Inefficient and unfair outcomes will occur under the mixed-strategy equilibrium of the NO environment. The hypotheses are as follows.

**HYPOTHESIS 1:** *The shotgun mechanism with an unassigned offeror reduces the likelihood of fair outcomes and the payoff for the uninformed owner (with respect to the shotgun mechanism with an informed offeror).*

**HYPOTHESIS 2:** *The shotgun mechanism with an unassigned offeror produces inefficient outcomes.*

## 3.2 Games and Sessions

Subjects played 8 practice rounds and 16 actual rounds using networked computer terminals.[14] Before the beginning of the first actual round, the computer randomly assigned a role to the subjects: Player 1 or Player 2 (Player 1, the informed player, was the offeror in the Informed Offeror condition, and both players were potential offerors in the unassigned-offeror condition). Before the beginning of each actual round, the computer also randomly formed pairs.[15] Subjects were not paired with the same partner in any two immediately consecutive rounds. Then, the computer randomly chose the value of the business assets.[16] This value was revealed only to Player 1.[17]

In the shotgun mechanism with an informed-offeror condition (IO), the subjects played a two-stage game. In the first stage, the informed offeror made a buy-sell offer $p \geq 0$ to the other subject, who played the role of the offeree. In the second

[14]Subjects were undergraduate and graduate students at the University of Alberta recruited from electronic bulletin boards. Players were completely anonymous to one another. Hence, this experimental environment did not permit the formation of reputations. The purpose of the practice rounds was to allow subjects to become familiar with the experimental environment. During the practice rounds, subjects experienced each role four times.

[15]Given the randomization process used to form pairs, and the diversity of offer categories and prices that subjects confronted, the sixteen actual rounds do not represent identical repetitions of the game. Consequently, we can treat each round as a one-shot experience.

[16]The computer got the realization of the value of the business assets under joint ownership from the interval $[400, 1000]$. Only even integers were considered.

[17]Both players knew that Player 1 received this information.

stage, the offeree was required to respond to the offer by either buying or selling at the named price. In the unassigned offeror condition (NO), Player 1 and Player 2 simultaneously decided whether to be the offeror and propose a buy-sell price. If both players decided to be the offeror, the computer randomly allocated the role of the offeror (with equal likelihood). The offeree then decided whether to buy or to sell at the proposed price. If neither player decided to be the offeror, joint ownership was preserved and the game ended.

We ran two sessions (90- and120-minute sessions, for the IO and NO conditions, respectively; 36 subjects in total) at the University of Alberta School of Business computer laboratories. The subject pool (undergraduate and graduate students from the University of Alberta) received their monetary payoffs in cash ($27 CAD game earnings, on average) at the end of the session.[18] Our laboratory currency, the "token," was converted to Canadian dollars using a commonly-known exchange rate (427 tokens =1 Canadian dollar).

## 3.3 Results

Our results indicate that the shotgun mechanism with an unassigned offeror (NO) negatively affected the uninformed offeror's mean payoff, increased the informed offeror's mean payoff, reduced the fair allocation rate, and increased the inefficiency rate (with respect to the IO treatment).[19]

[18]The participation fee was $10 CAD.

[19]Given the consistency of the aggregate data across rounds since early stages, we decided to include the 16 rounds in our analysis. The qualitative results still hold when only the last 8 rounds of play are considered. The buy rate is defined as the percentage of total pairs in which offerees decided to buy. The equitable outcome rate is defined as the percentage of total pairs involving a 50-50 allocation (i.e., the uninformed owner's payoff is 50% of the sum of payoffs (for the unassigned-offeror condition (NO), only consolidated ownership cases, i.e., cases in which one or both owners decide to be the offeror, are considered). The inefficiency rate is defined as the percentage of total pairs in which inefficient joint ownership is preserved (i.e., the percentage of total cases in which neither the informed nor the uninformed owner decide to be the offeror). For exposition, rounded values (integers) are presented. The main descriptive statistics are as follows (standard errors in parentheses): mean informed owner's prices are 463 (113) and 428 (68), for the IO and NO conditions, respectively; mean uninformed owner's prices are 461 (146) in the UO condition; buy rates are 44, 45, and 39%, for the case of the IO, NO-Informed Offeror, and NO-Uninformed Offeror conditions, respectively; mean informed owner's payoffs are 410 (138) and 445 (144), for the IO and NO conditions, respectively; mean uninformed owner's payoffs are 453 and

**Efficiency**

In theory, inefficiency (i.e., instances in which neither the informed nor the uninformed owner decided to be the offeror) will occur in the unassigned offeror environment (NO) under the mixed-strategy equilibrium. Our data indicate that the informed and uninformed owners were *gun shy* in 33 and 63% of the cases, respectively.[20] Importantly, inefficiency occurred in 24% of the cases (a rate significantly different from zero; $p$ - value $< .001$).[21] These findings support Hypothesis 1.

**RESULT 1:** *The shotgun mechanism with an unassigned offeror generates inefficient outcomes.*

**Fairness**

We use regression analysis to test the effects of shotguns with an unassigned offeror on the likelihood of fair outcomes and the uninformed player's payoff. Our analysis involves robust standard errors which account for the possible dependence of observations within condition. We take pairs of conditions and estimate probit and OLS models. Each model includes a treatment dummy variable as its regressor and a round variable.[22] Table 1 summarizes these findings.

Our results indicate that the unassigned offeror environment significantly reduces the likelihood of fair outcomes and the uninformed player's payoff, with respect

389, for the IO and N conditions, respectively; equitable outcome rates are 28 and 10%, for the IO and NO, respectively; inefficiency rate is 24% in case of the NO condition; mean asset values under ownership consolidation are 431 (89) and 441 (83), for the case of the IO and NO conditions, respectively (the asset value differences between conditions were not statistically significant); and, observations are 144, for each condition.

[20] The frequency of offers made by the informed owner inside and outside of the interval $[408, 492]$ were equal to 70 and 65%, respectively.

[21] To control for possible non-independence of observations, our binomial one-sided probability test used the data for the first actual round only (the inefficiency rate was equal to 33% in the first round; our findings also hold if we consider all rounds). Our findings suggest that inefficiency also occurred in case of business asset values inside the interval $[408, 492]$.

[22] The dummy variable takes a value equal to 1 if the observation pertains to the NO condition, and a value equal to 0 if the observation pertains to the IO condition. The round variable controls for learning effects across rounds. Data for the NO and IO are pooled (in case of the probit model, the NO data does not include cases in which neither owner 1 nor owner 2 decided to be the offeror and make a buy-sell offer).

**Table 1: Effects of the Shotgun Mechanism with an Unassigned Offeror on the Probability of Fair Outcomes and the Uninformed Owner's Mean Payoff**

(Tests of Differences between Conditions)

| Conditions | Prob. Fair Outcomes (Marginal Effects) | Uninf. Owner's Mean Payoff (Coefficients) |
|---|---|---|
| IO versus NO | $-0.047^{***}$ | $-63.535^{***}$ |
| | (0.014) | (15.203) |
| Observations | 240 | 288 |

Note: The columns report the change in the probability of fair outcomes and difference between the means (uninformed owner's payoff) due to the Shotgun mechanism with informed offeror (IO); marginal effects reported in case of the probit models; robust standard errors are in parentheses; $^{***}$ denotes significance at the 1% level; observations correspond to number of pairs.

to the informed offeror setting.[23] In fact, as a result of the unassignment of the role of offeror, a lower likelihood of fair outcomes is observed: 10 v. 28%, for the NO and IO conditions, respectively. Similarly, the mean payoff for the uninformed players is lower under the NO condition: 389 v. 453, for the NO and IO conditions, respectively. These findings provide strong support to Hypothesis 2.

**RESULT 2:** *The shotgun mechanism with an unassigned offeror decreases the likelihood of fair outcomes and the mean payoff for the uninformed owner (compared to the shotgun mechanism with an informed offeror).*

# 4 Conclusion

This article theoretically and experimentally studies shotgun mechanisms in a common-value setting with one-sided asymmetric information. Our findings support our theory regarding the unfair and inefficient outcomes under the shotgun mechanism with an unassigned offeror. The design and implementation of the shotgun mechanism with an informed offeror, possible under the ex post judicial resolution of deadlocks, might preclude the occurrence of these undesirable outcomes.

[23]The variable round was not significant in any model.

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[Supplementary Material (Not for Publication).]

# Shotgun Mechanisms for Common-Value Partnerships: The Unassigned-Offeror Problem

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## Appendix

This appendix first presents the proofs for Propositions 1 and 2.[1] Second, it includes additional data material.

### PROOFS

**PROOF OF PROPOSITION 1.** If Owner 1's equilibrium proposal is $p_1(x) = \frac{x+a}{2}$ then Owner 2 is indifferent between buying and selling, since Owner 2's payoff would be $\frac{x+a}{2}$ in either case. Suppose Owner 2 randomizes $50-50$ between buying and selling for all price offers. Suppose that Owner 1 is of type $x$. Owner 1's expected payoff from offering a price $p_1$ would be $\frac{1}{2}(x+a-p_1)+\frac{1}{2}(p_1) = \frac{x+a}{2}$. This is independent of $p_1$ so Owner 1 of type $x$ is indifferent over the level of the offer and offering $p_1(x) = \frac{x+a}{2}$ is therefore incentive compatible. Thus, the strategies outlined in the Proposition constitute a perfect Bayesian equilibrium. ■

**PROOF OF PROPOSITION 2.** An offer by Owner 2, $p_2$, creates a cutoff $y = 2p_2 - a$ where Owner 1 sells his stake to Owner 2 for $p_2$ if $x < y$ and Owner 1 buys Owner 2's stake for $p_2$ if $x \geq y$. So Owner 2's problem may be written as choosing the cutoff $y$ and the corresponding price $p_2 = \frac{y+a}{2}$ to maximize his payoff:

$$\int_{x_L}^{y} \left(x + a - \tfrac{y+a}{2}\right) dF(x) + \int_{y}^{x_H} \left(\tfrac{y+a}{2}\right) dF(x).$$

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[1]These results follow from Propositions 1 and 2 presented in our previous work (Brooks et al., 2010).

**Table A1: Descriptive Statistics**

| | IO | NO |
|---|---|---|
| Informed Owner's Price$^{(a)}$ | 463 | 428 |
| | (113) | (68) |
| Uninformed Owner's Price$^{(a)}$ | – | 461 |
| | – | (146) |
| Informed Owner's Payoff | 410 | 445 |
| | (138) | (144) |
| Uninformed Owner's Payoff | 453 | 389 |
| | (132) | (125) |
| Equitable Outcome Rate | 28 | 10 |
| Inefficiency Rate | 0 | 24 |
| Asset Value$^{(b)}$ | 431 | 441 |
| | (89) | (83) |
| Observations$^{(c)}$ | 144 | 144 |

Note: $^{(a)}$Mean prices are presented; $^{(b)}$mean asset values per owner under ownership consolidation are presented; $^{(c)}$sample sizes correspond to the number of pairs for the 16 rounds; standard deviations are presented in parentheses.

The derivative of this expression with respect to $y$ equals $\frac{1}{2} - F(y)$. Setting the derivative equal to zero confirms that $y = \overline{x}$ and therefore $p_2 = \frac{\overline{x}+a}{2}$. Player 2's payoff is $\int_{x_L}^{\overline{x}} (x + a)\, dF(x) = \frac{1}{2}E(x + a \mid x \leq \overline{x})$. ■

## ADDITIONAL DATA MATERIAL

Table A1 provides the descriptive statistics.[2] Information about the mean prices and payoffs for informed and uninformed owners is included. The equitable outcome rate is defined as the percentage of total pairs in which the uninformed owner's payoff was between 49% and 51% of the sum of payoffs; for the unassigned-offeror condition (NO), only consolidated ownership cases (i.e., cases in which one or both owners decided to be the offeror) are considered. The inefficiency rate is defined as the percentage of total pairs in which inefficient joint ownership is preserved (i.e., the percentage of total cases in which neither the informed nor the uninformed owner decided to be the offeror). Mean asset values per owner under ownership consolidation are presented.[3]

The results regarding the offerees' responses are as follows. (1) NO - Informed Offeror: offerees decided to buy in 45% of the total cases (the buy rates were equal

[2]Given the consistency of the aggregate data across rounds since early stages, we decided to include the 16 rounds in our analysis. The qualitative results still hold when only the last 8 rounds of play are considered. For exposition, rounded values (integers) are presented.

[3]The asset value differences between conditions were not statistically significant.


**Figure 1: Shotgun Mechanism with an Informed Offeror**

to 65 and 28%, in case of asset values per owner under consolidation $< 450$ and $\geq 450$, respectively; (2) NO - Uninformed Offeror: offerees decided to buy in 39% of the total cases (the buy rates were equal to 6 and 71%, in case of asset values per owner under consolidation $< 450$ and $\geq 450$, respectively); (3) IO condition: offerees decided to buy in 44% of the total cases (the buy rates were equal to 60 and 21%, in case of asset values per owner under consolidation $< 450$ and $\geq 450$, respectively)

More detailed information about the patterns of offers in the shotgun mechanism with informed and in the unassigned offeror environments (informed and uninformed offerors) is provided in Figures 1 - 3. In addition to the information about observed offers, these figures include information about offers that produce fair outcomes (Fair Buy-Sell Offers); information about the outcome predicted by the theory (Predicted Buy-Sell Offer); and, Fitted Values (predicted linear relationship between the offers and the asset values resulting from the application of OLS methods).[4] These figures suggest that the data is aligned with our theoretical point predictions.

Specifically, Figure 1 illustrates the offer behavior of the informed owner. The fitted values line suggests that the offers increase with the value of the business assets. The patterns of the data suggest that the offerors generally made offers higher than the fair prices for low levels of the business assets, and offers lower than

[4]The OLS regression involves the offer as a function of the asset value $(x + 200)/2$.


**Figure 2: Shotgun Mechanism with an Unassigned Offeror - Informed Offeror**

the fair offers for high levels of the business assets.[5]

Figure 2 and 3 illustrate the offer behavior of informed and uninformed owners in the unassigned-offeror environment. In case of the informed owner (Figure 2), the fitted values line suggests that the offers increase with the value of the business assets. In case of the uninformed owner (Figure 3), the fitted values line is quite flat, suggesting that the offers did not systematically increase with the value of the business assets. Importantly, the fitted values line and the predicted buy-sell offer (equal to 450) are closely aligned.

[5]The uninformed offerees generally bought for low realized values of the business assets and sold for high realized values of the business assets.


**Figure 3: Shotgun Mechanism with an Unassigned Offeror - Uninformed Offeror**

[Supplementary Material (Not for Publication) - Written Instructions NO Condition.]

***PLEASE GIVE THIS MATERIAL TO THE EXPERIMENTER AT THE END OF THE SESSION***

# INSTRUCTIONS

This is an experiment in the economics of decision-making. Several academic institutions have provided the funds for this research.

In this experiment you will be asked to play an economic decision-making computer game. The experiment currency is the "token." The instructions are simple. If you follow them closely and make appropriate decisions, you may make an appreciable amount of money. At the end of the experiment you will be paid your total game earnings in CASH along with your participation fee. If you have any questions at any time, please raise your hand and the experimenter will go to your desk.

# SESSION AND PLAYERS

The session is made up of 24 rounds. The first 8 rounds are practice rounds and will not be counted in the determination of your final earnings.

1) Before the beginning of each practice round, the computer will randomly form pairs of two people: One **Player 1** and one **Player 2**. The roles will be randomly assigned. During the practice rounds, each person will play 4 times the roles of **Player 1** and **Player 2**.

2) After the last practice round, 16 rounds will be played.

- Every participant will be randomly assigned a role. This **ROLE WILL REMAIN THE SAME until the end of the session**.

- **At the beginning of each round, NEW PAIRS**, one **Player 1** and one **Player 2** will be randomly formed.

You will not know the identity of your partner in any round. You know, however, that **at the beginning of each round, NEW PAIRS** of two people, **Player 1** and **Player 2** will be randomly formed.

# ROUND STAGES

## <u>STAGE 1</u>

1) **Player 1** and **Player 2** jointly own a business. Each business partner owns 50% of the initial value of the business assets.

2) **The computer** randomly determines the **initial value of the business assets** and <u>**reveals this information ONLY to Player 1**</u>. **Player 2** will <u>**NOT**</u> know the initial value of the business assets until the end of the round.

   The initial values of the business assets can be <u>**any even integer number between 400 tokens and 1000 tokens**</u>. In other words, the initial value of the business assets can be 400 tokens, 402 tokens, …, 998 tokens, or 1000 tokens. <u>**Each value is equally likely**</u>.

   The Players have no choice over the initial value of the business assets.

# STAGE 2

1) **Player 1** and **Player 2** play a **partnership-dissolution game**.

- If the business partnership is dissolved, the value of the business assets **increases by 200 tokens**.

- If the business partnership is not dissolved, the value of business assets **remains at its initial value**.

# DECISION TO BECOME THE OFFEROR

2) **Player 1** and **Player 2** simultaneously decide whether they want to become the OFFEROR, i.e., whether they want to make a **buy/sell** price offer to the other player, that the other player will use **to buy** the offeror's share of the business assets or **to sell** his/her share of the business assets to the offeror.

- If **BOTH** players decide they want to become the OFFEROR, then the computer randomly determines which player will become the OFFEROR. Each player has an equal chance of becoming the offeror.

- If only **ONE** player decides he/she wants to become the OFFEROR, then this player becomes the OFFEROR.

- If **NEITHER PLAYER 1 NOR PLAYER 2** decides he/she wants to become the OFFEROR, then the business partnership is not dissolved. The GAME ENDS. Each player receives a payoff equal to half of the initial value of the business assets.

# IF PLAYER 1 BECOMES THE OFFEROR

## PLAYER 1'S OFFER

3) **Player 1** makes a **buy/sell** price offer that **Player 2** will use **to buy Player 1**'s share of the business assets **or to sell** his/her share of the business assets to **Player 1**. **Player 1** can choose **<u>any price greater than or equal to 0</u>** (no decimals).

## PLAYER 2'S RESPONSE

4) After observing the price offer, **Player 2** will decide whether **to buy Player 1**'s share of the business assets at the proposed price, or **to sell** his/her share of the business assets to **Player 1** at the proposed price.

- If **Player 2** decides to **BUY** Player 1's share of the business assets, **Player 2** transfers to **Player 1** an amount of tokens equal to the price proposed. The business partnership is dissolved. **Player 2** is now the sole owner of the business. The GAME ENDS.

**Player 1**'s payoff = price proposed by **Player 1**
**Player 2**'s payoff = initial value of the business assets + 200 tokens – price proposed by **Player 1**

- If **Player 2** decides to **SELL** his/her share of the business assets to **Player 1**, **Player 1** transfers to **Player 2** an amount of tokens equal to the price proposed. The business partnership is dissolved. **Player 1** is now the sole owner of the business. The GAME ENDS.

**Player 1**'s payoff = initial value of the business assets + 200 tokens – price proposed by **Player 1**
**Player 2**'s payoff = price proposed by **Player 1**

# IF PLAYER 2 BECOMES THE OFFEROR

# PLAYER 2'S OFFER

3) **Player 2** makes a **buy/sell** price offer that **Player 1** will use **to buy Player 2**'s share of the business assets **or to sell** his/her share of the business assets to **Player 2**. **Player 2** can choose **<u>any price greater than or equal to 0</u>** (no decimals).

# PLAYER 1'S RESPONSE

4) After observing the price offer, **Player 1** will decide whether **to buy Player 2**'s share of the business assets at the proposed price, or **to sell** his/her share of the business assets to **Player 2** at the proposed price.

- If **Player 1** decides to **BUY Player 2**'s share of the business assets, **Player 1** transfers to **Player 2** an amount of tokens equal to the price proposed. The business partnership is dissolved. **Player 1** is now the sole owner of the business. The GAME ENDS.

| |
|---|
| **Player 1**'s payoff = initial value of the business assets + 200 tokens – price proposed by **Player 2**<br>**Player 2**'s payoff = price proposed by **Player 2** |

- If **Player 1** decides to **SELL** his/her share of the business assets to **Player 2**, **Player 2** transfers to **Player 1** an amount of tokens equal to the price proposed. The business partnership is dissolved. **Player 2** is now the sole owner of the business. The GAME ENDS.

| |
|---|
| **Player 1**'s payoff = price proposed by **Player 2**<br>**Player 2**'s payoff = initial value of the business assets + 200 tokens – price proposed by **Player 2** |

# IF NEITHER PLAYER 1 NOR PLAYER 2 BECOMES THE OFFEROR

The GAME ENDS.

| |
|---|
| **Player 1**'s payoff = initial value of the business assets/2 |
| **Player 2**'s payoff = initial value of the business assets/2 |

# ROUND PAYOFF: PLAYER 1 BECOMES THE OFFEROR

The Payoff Table shows the round payoffs for **Player 1** and **Player 2**, under the possible outcomes of the partnership-dissolution game.

### Payoff Table: PLAYER 1 MAKES A BUY/SELL PRICE OFFER

| | **PAYOFFS IF PLAYER 2 DECIDES TO BUY HIS/HER PARTNER'S SHARE OF THE BUSINESS ASSETS** |
|---|---|
| **PLAYER 1** | price proposed by Player 1 |
| **PLAYER 2** | initial value of the business assets + 200 tokens – price proposed by Player 1 |
| | **PAYOFFS IF PLAYER 2 DECIDES TO SELL HIS/HER SHARE OF THE BUSINESS ASSETS TO HIS/HER PARTNER** |
| **PLAYER 1** | initial value of the business assets + 200 tokens – price proposed by Player 1 |
| **PLAYER 2** | price proposed by Player 1 |

# EXERCISES

Two exercises related to the Payoff Table are presented below. Please fill the blanks.

**Exercise 1.**

Suppose that the **initial value of the business assets is C tokens**, **Player 1** proposes a **buy/sell price offer equal to U tokens**, and **Player 2** decides to **sell** his/her share of the business assets. Then, **Player 1**'s payoff is equal to __________________________ tokens, and **Player 2**'s payoff is equal to _______________________________ tokens.

**Exercise 2.**

Suppose that the **initial value of the business assets is D tokens**, **Player 1** proposes a **buy/sell price offer equal to Y tokens**, and **Player 2** decides **to buy** his/her partner's share of the business assets. Then, **Player 1**'s payoff is equal to __________________________________ tokens, and **Player 2**'s payoff is equal to _______________________________ tokens.

# ROUND PAYOFF: PLAYER 2 BECOMES THE OFFEROR

The Payoff Table shows the round payoffs for **Player 1** and **Player 2**, under the possible outcomes of the partnership-dissolution game.

**Payoff Table: PLAYER 2 MAKES A BUY/SELL PRICE OFFER**

| | |
|---|---|
| | **PAYOFFS IF PLAYER 1 DECIDES TO BUY HIS/HER PARTNER'S SHARE OF THE BUSINESS ASSETS** |
| **PLAYER 1** | initial value of the business assets + 200 tokens – price proposed by **Player 2** |
| **PLAYER 2** | price proposed by **Player 2** |
| | **PAYOFFS IF PLAYER 1 DECIDES TO SELL HIS/HER SHARE OF THE BUSINESS ASSETS TO HIS/HER PARTNER** |
| **PLAYER 1** | price proposed by **Player 2** |
| **PLAYER 2** | initial value of the business assets + 200 tokens – price proposed by **Player 2** |

# EXERCISES

Two exercises related to the Payoff Table are presented below. Please fill the blanks.

**Exercise 1.**

Suppose that the **initial value of the business assets is C tokens**, **Player 2** proposes a **buy/sell price offer equal to W tokens**, and **Player 1** decides to **sell** his/her share of the business assets. Then, **Player 1**'s payoff is equal to ________________________ tokens, and **Player 2**'s payoff is equal to _____________________________ tokens.

**Exercise 2.**

Suppose that the **initial value of the business assets is D tokens**, **Player 2** proposes a **buy/sell price offer equal to Z tokens**, and **Player 1** decides **to buy** his/her partner's share of the business assets. Then, **Player 1**'s payoff is equal to ________________________________ tokens, and **Player 2**'s payoff is equal to _____________________________ tokens.

# ROUND PAYOFF: NEITHER PLAYER 1 NOR PLAYER 2 BECOMES THE OFFEROR

The Payoff Table shows the round payoffs for **Player 1** and **Player 2**, under the possible outcomes of the partnership-dissolution game.

### Payoff Table: NEITHER PLAYER 1 NOR PLAYER 2 DECIDE TO BE THE OFFER0R

| |
|---|
| **Player 1**'s payoff = initial value of the business assets/2 |
| **Player 2**'s payoff = initial value of the business assets/2 |

# EXERCISES

Two exercise related to the Payoff Table is presented below. Please fill the blanks.

**Exercise 1.**

Suppose that the **initial value of the business assets is C tokens**. Neither **Player 1** nor **Player 2** decide to **be the OFFEROR**. Then, **Player 1**'s payoff is equal to __________________________ tokens, and **Player 2**'s payoff is equal to ________________________________ tokens.

**Exercise 2.**

Suppose that the **initial value of the business assets is D tokens**. Neither **Player 1** nor **Player 2** decide to **be the OFFEROR**. Then, **Player 1**'s payoff is equal to __________________________ tokens, and **Player 2**'s payoff is equal to ________________________________ tokens.

# SESSION PAYOFF

The session earnings in tokens will be equal to the sum of payoffs for the 16 rounds. The session earnings in dollars will be equal to (session earnings in tokens)/427 (427 tokens = 1 dollar). The total earnings in dollars will be equal to the participation fee plus the session earning in dollars.

# GAME SOFTWARE

The game will be played using a computer terminal. You will need to enter your decisions by using the mouse. In some instances, you will need to wait until the other players make their decisions before moving to the next screen. Please **be patient**. There will be two boxes, displayed in the upper right-hand side of your screen, that indicate the "Round Number" and "Your Role."

Press the NEXT >> button to move to the next screen. Please, **do not try to go back** to the previous screen and **do not close the browser**: The software will stop working and you will lose all the accumulated tokens.

Next, the **8 PRACTICE ROUNDS** will begin. After that, 16 rounds will be played. **You can consult these instructions at any time during the session**.

# THANKS FOR YOUR PARTICIPATION IN THIS STUDY!!

***PLEASE GIVE THIS MATERIAL TO THE EXPERIMENTER AT THE END OF THE SESSION***`

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