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IRRECONCILABLE DIFFERENCES: JUDICIAL RESOLUTION OF BUSINESS DEADLOCK

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Irreconcilable Differences: Judicial Resolution of Business Deadlock

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Abstract

This article studies the judicial resolution of business deadlock. Asset valuation, a necessary component of business divorce procedures, can pose serious problems in case of closely-held businesses such as general partnerships and limited liability companies (LLCs). Courts face the challenge of designing valuation mechanisms that will trigger the owners to truthfully reveal their private information.

We theoretically and experimentally assess the ex post judicial design and properties of judicially-mandated Shotgun and Private Auction mechanisms. In the former mechanism, the court would require one owner to name a buy-sell price, and the other owner would be required to either buy or sell his or her shares at the named price. In the latter mechanism, the court would mandate both owners to simultaneously submit a price to buy the other owner's assets. Our experimental findings support our theory: The Shotgun mechanism with an informed offeror is superior to the Private Auction in terms of an equity criterion. In the Shotgun mechanism, the informed offeror has an incentive to truthfully reveal his private information and, as a result, an equitable outcome is more likely to be achieved. The analysis presented in this article provides an equity rationale for the judicial implementation of the Shotgun mechanism in business divorce cases, and demonstrates the empirical feasibility of our proposal.

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I. Introduction

In 1999, Ronald Mizrahi and Ezra Cohen, a dentist and an optometrist who were related by marriage, formed a limited liability company (LLC) to purchase and develop property in Brooklyn, New York.[1] The mixed-use structure housed four residential units and seven commercial units. Mizrahi established his practice in a spacious unit on the second floor of the building while Cohen occupied a first-floor storefront unit. The relationship between Mizrahi and Cohen was strained from the beginning and, because the LLC operating agreement required unanimous approval for business decisions, seemingly minor obstacles escalated into major problems. Conflicts arose over the monthly rents that Mizrahi and Cohen were paying to the LLC for use of their office space. When Cohen fell behind in his financial contributions, Mizrahi advanced sums of money to the LLC to avoid defaulting on their loans.

In 2006, Cohen, who already owed several hundred thousand dollars to the LLC, withdrew an additional $230,000 from the company coffers. Mizrahi brought suit seeking judicial dissolution of the LLC, alleging that Cohen had breached his fiduciary duty and embezzled funds.[2] In addition to determining that the LLC should be dissolved, the court found that it was "*[Its] duty to provide a mechanism* for the liquidation and distribution of [the] assets."[3] Commentators ar-

[1] They were 50/50 managing members and each contributed and initial $100,000 to the venture. See *Mizrahi v. Cohen*, 943 N.Y.S.2d 792 (2012); *Mizrahi v. Cohen* 38 Misc.3d 1213(A), No. 3865/10 (N.Y. Sup. Ct. Jan. 15, 2013).

[2] The LLC operating agreement included a provision requiring arbitration in case of deadlock: "When a vote is required on any matter under this Agreement, and insufficient votes to approve or disapprove of the matter are cast [100% required], then any member may, subject to ten (10) day notice to the other members, require that the matter be submitted to Rabbi Shlomo Churpa, or if Rabbi Michael Haber [i]s unavailable or unwilling to resolve the dispute to such person as shall be named [by] the Safardic Rabbinical Counsel of Flatbush."It was not clear if such a rabbinical counsel existed. See *Mizrahi v. Cohen*, 943 N.Y.S.2d 792 (2012).

[3] *Mizrahi v. Cohen* 38 Misc.3d 1213(A), No. 3865/10 (N.Y. Sup. Ct. Jan. 15,

gue that the court's decision reflects the current trend of more active participation by judges in the design of resolution mechanisms for business divorce.[4]

Irreconcilable differences among joint owners are all too common in business entities, including closely-held companies such as general partnerships and LLCs.[5] In practice, the resolution of business deadlock might involve the dissolution of the business entity or the dissociation of joint owners. While many joint owners foresee possible deadlocks and include resolution mechanisms in their business agreements,[6] others fail to do so.[7]Judicial involvement arises in the absence of privately-contracted divorce clauses. It may also occur when a deadlock clause was included in the business agreement but the grounds for dissociation or dissolution are not clear. In both situations, the court may be called upon to determine the appropriate remedy and to design an asset-valuation procedure.[8]

Placing an accurate value on the business assets of a closely-held company can be a difficult task. While publicly-traded companies often have active markets for ownership, closely-held companies may be very difficult for outside investors and/or appraisers to evaluate. By virtue of their experience with the business venture and their expertise, the joint owners may themselves be in the best position to accurately

2013); Italics added for emphasis.

[4]Peter Mahler, *Court Decision Boosts Equitable Buy-Out Remedy in LLC Dissolution Case*, February 19th, 2013; http://www.nybusinessdivorce.com (last visited May 21, 2013).

[5]See Claudia M. Landeo & Kathryn E. Spier, *Shotguns and Deadlocks*, Yale J. on Reg. (forthcoming).

[6] *Valinote v. Ballis*; No. 00 C 3089, 2001 WL 1135871 (N.D. Ill. Sept. 25, 2001).

[7] *Vila v. BVWebTies LLC*, No. 4308-VCS, 2010 BL 239620 (Del. Ch. Oct. 1, 2010).

[8]The Uniform Partnership Act (UPA, 1914) and the Revised Uniform Partnership Act (RUPA, 1997) include default statutory rules that govern the judicial resolution of deadlocks in case of general partnerships. The default rules for LLCs are encompassed in state statutes. See Claudia M. Landeo & Kathryn E. Spier, *Shotguns and Deadlocks*, Yale J. on Reg.(forthcoming).

pinpoint the value of the assets. Thus, the court faces the challenge of designing a deadlock resolution mechanism that induces the owners to accurately reveal the value of the business assets. To resolve the deadlock in *Mizrahi v. Cohen*, for example, the court appointed a trustee to oversee a private auction between the two co-owners for sole ownership of the LLC.[9]

In recent previous work,[10] we have argued that courts both can and should make greater use of so-called "Shotgun mechanisms" in business divorce cases. In these mechanisms, the court would require one owner to name a buy-sell price, and the other owner would be required to either buy or sell shares at the named price.[11] This proposal represents an application of the classic cake-cutting mechanism, where one party *cuts the cake* (sets the buy-sell price) and the other party *chooses a piece* (by either buying or selling shares).[12] Under ideal conditions,

[9]The *Creel* court, on the other hand, appointed an external appraiser to determine the value of the company assets; *Creel v. Lily*, 729 A.2d 385 (Md. 1999), *Horne v. Aune* 121 P.3d 1227 (Wash. App. 2005). This resolution mechanism might be associated with cost inefficiencies, unnecessary delays, and inequitable outcomes. See Claudia M. Landeo & Kathryn E. Spier, *Shotguns and Deadlocks*, Yale J. on Reg. (forthcoming).

[10]See Claudia M. Landeo & Kathryn E. Spier, *Shotguns and Deadlocks*, Yale J. on Reg. (forthcoming). This article provides legal and formal analysis of private and judicial resolution of business deadlock. Specifically, it encompasses theoretical and experimental assessment of the Shotgun mechanism with informed and uninformed offerors using a binary setting (two values of the business assets).

[11]Judges seldom use Shotgun mechanisms to resolve business deadlocks in the United States. But see *Fulk v. Washington Serv. Assocs.* No. 17747-NC, 2002 BL 1389 (Del. Ch. June 21, 2002), a closely-held corporation case, for a rare example. In contrast, judges in Canada commonly use Shotgun mechanisms to resolve business deadlocks; *Kinzie v. Dells* 2010 BCSC 1360 (Can. B.C.); *Lee v. Lee* (2002), 3 B.C.L.R. 4th 129 (Can. B.C.); *Whistler Service Park Ltd. v. Glacier Creek Development* 2005 BCSC 1942 (Can. B.C.); *Safarik v. Ocean Fisheries Ltd.*, (1996) 17 B.C.L.R. 3d 354 (Can. B.C.C.A.).

[12]See Steven Brams & Alan Taylor, Fair Division: From Cake-Cutting to Dispute Resolution (1996); Saul Levmore, *Self-Assessed Valuation Systems for Tort and Other Law*, 68 Va. L. Rev. 771 (1982); Lee Anne Fennell, *Revealing Options*, 118 Harv. L. Rev. 1399 (2005); Ian Ayres & Eric Talley, *Solomonic*

Shotgun mechanisms have the desirable feature that the owner who makes the buy-sell offer has an incentive to name an accurate and fair price, since he or she may end up on either side of the transaction.[13]

Our previous research has also demonstrated that Shotgun mechanisms may lead to inequitable outcomes when owners have asymmetric information, asymmetric capabilities, and asymmetric financial resources. Importantly, these risks are likely to be mitigated in judicial settings. Since courts have the ability to design valuation mechanisms ex post rather than ex ante, they may well have enough information to identify the presence of asymmetries and tailor the Shotgun mechanism appropriately.[14] For example, the court may assign the role of offeror to the better-informed party, and may give the parties adequate time to arrange for external financing.

This article extends our work on the judicial resolution of business deadlocks by theoretically and experimentally studying the ex post judicial design and properties of the Shotgun and Private Auction mechanisms.[15] We first construct a simple theoretical framework.[16] In this framework, a business venture with two joint owners is deadlocked,

Bargaining: Dividing a Legal Entitlement to Facilitate Coasean Trade, 104 YALE L. J. 1027 (1994); Richard W. Brooks, Claudia M. Landeo, & Kathryn E. Spier, *Trigger Happy or Gun Shy? Dissolving Common-Value Partnerships with Texas Shootouts*, 41 RAND J. ECON. 649 (2010), and the references cited there.

[13]In his opinion in *Valinote v. Ballis;* 295, F3d. 666 (Ill. 2002), Judge Easterbrook states that "The possibility that the person naming the price can be forced either to buy or to sell keeps the first mover honest."

[14]In contrast, when parties include Shotgun provisions in their ex ante business agreements, unforeseen events may arise. The asymmetries generated by these contingencies may lead to serious shortcomings of the privately-contracted Shotgun mechanism.

[15]The Private Auction mechanism refers to a first-price sealed-bid auction between the owners. We will use the terms *auction*, *private auction*, and *first-price sealed-bid auction* interchangeably.

[16]The Shotgun mechanism environments are simplified version of the more general settings discussed in Richard W. Brooks, Claudia M. Landeo, & Kathryn E. Spier, *Trigger Happy or Gun Shy? Dissolving Common-Value Partnerships with Texas Shootouts*, 41 RAND J. ECON. 649 (2010).

and the value of the business assets will be higher if ownership is consolidated in the hands of just one owner. The owners are equally capable at managing the firm, and both owners have adequate liquidity to purchase the stake of the other.[17] The two owners differ, however, in how much information they possess about the future cash flows from the business assets. Owner 1 is assumed to be well-informed about the future value of the cash flows, while Owner 2 is uninformed and also realizes that he is at an informational disadvantage. This theoretical setting involves "common values," since the information that is in the hands of Owner 1 is directly relevant for the future payoff of Owner 2 if Owner 2 were to maintain an ownership stake in the company. We assume that the value of the business assets is randomly drawn from a range of equally likely values (so the density of asset values is uniform).

We derive several important theoretical predictions. First, an equitable outcome is obtained by the judicially-mandated Shotgun mechanism when the better-informed party, Owner 1, is forced to make the buy-sell offer. Since Owner 1 may be on either the buying end or the selling end of the deal, Owner 1 has an incentive to fully reveal the value of the assets and split the surplus evenly with Owner 2. Second, an equitable division of surplus is clearly not obtained when Owner 2 is put in the position of making the buy-sell offer. Since Owner 2 lacks accurate information, the best he can do is make an offer that reflects the average value of the assets. Owner 1, being rational and self-interested, will sell his stake to Owner 2 when the asset value is low and buy Owner 2's stake when the asset value is high. So, when forced to make the buy-sell offer, Owner 2 is guaranteed to receive the proverbial "short end of the stick."Third, we show that the Private Auction does not lead to an equitable outcome either, as Owner 1 shades his bid below the equitable value, thereby profiting from his

[17]Our previous work also discusses asymmetries in managerial capabilities and financial differences between the two owners. See Claudia M. Landeo & Kathryn E. Spier, *Shotguns and Deadlocks*, YALE J. ON REG. (forthcoming).

informational advantage.[18]

We then conduct a series of controlled laboratory experiments with human subjects to assess whether the judicially-mandated Shotgun and Auction mechanisms will have the predicted effects. Our experimental environment simulates a deadlocked business venture where two owners need to divide the business assets, and only one of the two owners knows the true value of the business assets. Two Shotgun treatments are included in our experimental design. In the first Shotgun treatment, the better-informed owner is compelled to make buy-sell offer; in the second treatment, the less-informed owner is compelled to make the offer. Our design also encompasses a Private Auction treatment where both owners propose bids to purchase the stake of the other. Our subject pool, undergraduate and graduate students from the University of Alberta, were paid according to their performance.

Our experimental findings support the theory: The Shotgun mechanism with an informed offeror leads to a more equitable division of the assets than the other Shotgun mechanism and the Private Auction. The Shotgun mechanism induces the informed offeror to truthfully reveal his private information and, as a result, an equitable outcome is more likely to be achieved. Moreover, the uninformed owner is better off on average and the informed owner is worse off on average in this treatment.

The results in this article, taken together with the legal and formal analysis presented in our earlier work,[19] suggest that Shotgun mechanisms can and should play a larger role in the judicial resolution of business deadlocks. Importantly, our proposal, which involves the active participation of judges in the evaluation of the environments surrounding the legal cases and the choice and design of the most appropriate resolution mechanism, is aligned with current ju-

[18] A second-price sealed-bid auction would not yield an equal division of the surplus in this common-value setting either. See Paul Klemperer, *Auction Theory: A Guide to the Literature* 13 J. Econ. Surveys 227 (1999).

[19] Claudia M. Landeo & Kathryn E. Spier, *Shotguns and Deadlocks*, Yale J. on Reg. (forthcoming).

dicial practices regarding the management of business divorce in the United States.[20]

The Article is divided into three sections. Section II explores the judicial design of the Shotgun and Private Auction mechanisms in a simple analytical framework. Section III presents experimental evidence on the properties of these deadlock resolution mechanisms, and establishes that the Shotgun mechanism with an informed offeror leads to a more equitable outcome than the Private Auction mechanism. Section IV discusses the empirical feasibility of the judicial design and implementation of the Shotgun mechanism and presents concluding remarks.

II. Theoretical Framework

Suppose that two co-venturers, Owner 1 and Ownwer 2, own equal stakes in a firm with uncertain value x, which is drawn from a uniform distribution on the interval $[\$400, \$1000]$.[21] Then, every value of the business assets in this interval is equally likely. The average asset value in this interval is $\overline{x} = (\$400 + \$1000)/2 = \$700$. We assume that Owner 1 is the informed owner, i.e., she knows the true value of x; and, Owner 2 is the uninformed owner, i.e., he does not observe the value of the business assets but does know that any value in the interval is equally likely. Thus, this game has one-sided asymmetric information with common values. We also assume that there is a business deadlock; the assets will be more valuable if ownership is consolidated. Resolving the deadlock will create an additional $200 of

[20] *Mizrahi v. Cohen*, 943 N.Y.S.2d 792 (2012); *Mizrahi v. Cohen* 38 Misc.3d 1213(A), No. 3865/10 (N.Y. Sup. Ct. Jan. 15, 2013).

[21] The Shotgun mechanism environments studied here are simplified versions of the more general environments presented in Richard W. Brooks, Claudia M. Landeo, & Kathryn E. Spier, *Trigger Happy or Gun Shy? Dissolving Common-Value Partnerships with Texas Shootouts*, 41 Rand J. Econ. 649 (2010). General versions of the propositions and formal proofs are included in this article. A formal proof of the Private Auction environment is available upon request.

value, so after the consolidation of ownership the assets per owner are worth $(x + \$200)/2$, with values on the interval $[\$300, \$600]$.

We study the ex post judicial design of two deadlock resolution mechanisms: the Shotgun mechanism and the Private Auction. Under the former, one owner names a single buy-sell price and the other owner is compelled to either buy or sell shares at that named price. Under the latter, both owners propose a price and the higher bidder buys the assets of the other owner. We let p represent the buy-sell prices for the Shotgun mechanisms and the prices (bids) in the Auction mechanism.[22] If Owner 1 purchases Owner 2's stake for price p, the payoff for Owner 1 is $x + \$200 - \$p$ and the payoff for Owner 2 is $\$p$.[23]

A. *Shotgun Mechanism*

Suppose that, in the final step of resolving the business deadlock, the court orders the parties to participate in a Shotgun mechanism. Two judicially-mandated Shotgun environments are analyzed: a Shotgun mechanism with an informed owner and a Shotgun mechanism with an uninformed owner. We will demonstrate that only the court-mandated Shotgun mechanism with an informed offeror generates equitable outcomes.

[22]The equilibrium concepts used are perfect Bayesian and Nash Bayesian equilibrium concepts, for the case of the Shotgun mechanism and the Private Auction, respectively. For more general statements and proofs, see the working paper version of this article: Claudia M. Landeo & Kathryn E. Spier, *Irreconcilable Differences: Judicial Resolution of Business Deadlock* Harvard University, John M. Olin Center for Law, Economics, and Business, Discussion Paper (2013).

[23]If the business would remain deadlocked, each owner would receive $x/2$. This outcome does not occur in any of the three mechanisms considered in the current paper. It may arise endogenously in non-mandatory environments, however. See Richard W. Brooks, Claudia M. Landeo, & Kathryn E. Spier, *Trigger Happy or Gun Shy? Dissolving Common-Value Partnerships with Texas Shootouts*, 41 Rand J. Econ. 649 (2010).

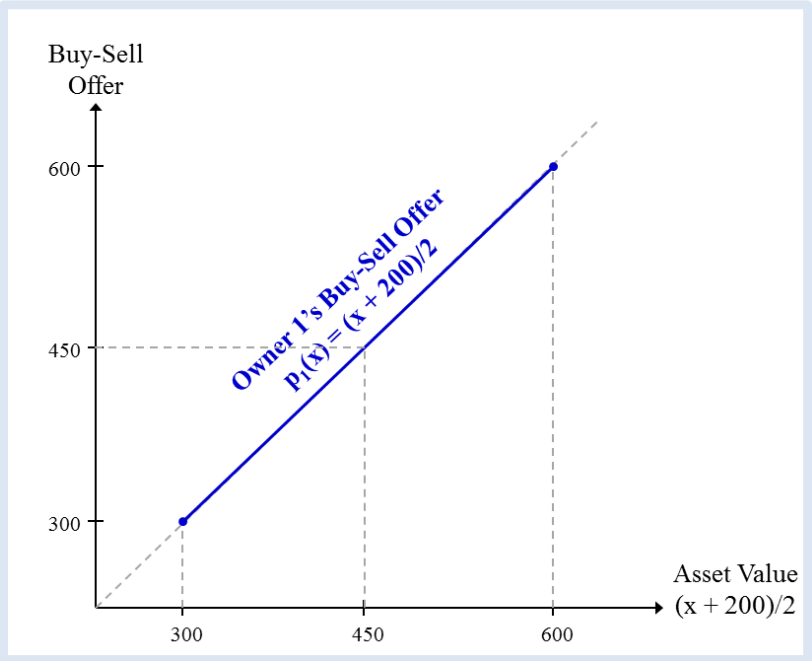

Figure 1: Shotgun Mechanism with an Informed Offeror

1. *Shotgun Mechanism with an Informed Offeror*

Suppose that the court assigns the role of the offeror to the better informed party, Owner 1. Proposition 1 characterizes the outcome in this environment.[24]

PROPOSITION 1: *Suppose Owner 1 (the informed party) makes the buy-sell offer. In equilibrium, Owner 1 offers* $p_1(x) = (x + \$200)/2$ *and Owner 2 randomizes between buying and selling with equal probability. The mean payoff of each owner is* $\$450$.

Figure 1 illustrates these findings. Intuitively, when the informed owner is the offeror, there is full revelation of private information. To

[24]This proposition refers to the fully-separating equilibrium. Note that there are also pooling equilibria. See Richard W. Brooks, Claudia M. Landeo, & Kathryn E. Spier, *Trigger Happy or Gun Shy? Dissolving Common-Value Partnerships with Texas Shootouts*, 41 RAND J. ECON. 649 (2010).

see how this *revelation mechanism* would work, suppose that Owner 2 believes that Owner 1 always makes offers aligned with the true asset values. In other words, imagine that Owner 2 believes that Owner 1 is always *telling the truth*.

In this scenario, when he receives an offer of \$450, for example, Owner 2 believes that the assets have a value equal to \$450, and given this belief Owner 2 is indifferent between selling and buying. It is a toss-up from Owner 2's perspective, and Owner 2 may rationally either buy or sell shares. The possibility that the better-informed Owner 1 could end up on either end of the deal is what keeps him honest and creates no incentive to misrepresent the value of the company.

2. *Shotgun Mechanism with an Uninformed Offeror*

Suppose now that the court assigns the role of the offeror to the less informed party, Owner 2. Owner 2 is at a significant disadvantage when making a buy-sell offer. Suppose that Owner 2 makes an offer equal to the average value of the business assets per owner after consolidation $(\$700 + \$200)/2 = \$450$. In the best-case scenario, where the assets per owner are worth $(\$700 + \$200)/2 = \$450$, Owner 1, the fully informed offeree, would be indifferent between buying and selling and both owners would ultimately walk away with payoffs of $(\$700 + \$200)/2 = \$450$. This is an equitable outcome.

In an alternative scenario, where the assets per owner are really worth less than $(\$700 + \$200)/2 = \$450$, say \$400, then Owner 1 (the offeree) would surely decide to sell his stake to Owner 2. Owner 1 would receive the \$450 selling price, and Owner 2 would net \$350 because he will become the sole owner of a business with value lower than \$900 by transferring \$450 to Owner 1 (for assets with value \$400). In sum, Owner 2 will get a net payoff of \$350, while Owner 1 will get a net payoff of \$450, an inequitable outcome. Proposition 2 characterizes the outcomes in this environment.

PROPOSITION 2: *Suppose Owner 2 (the uninformed party) makes the buy-sell offer. In equilibrium, Owner 2 offers the average value of*

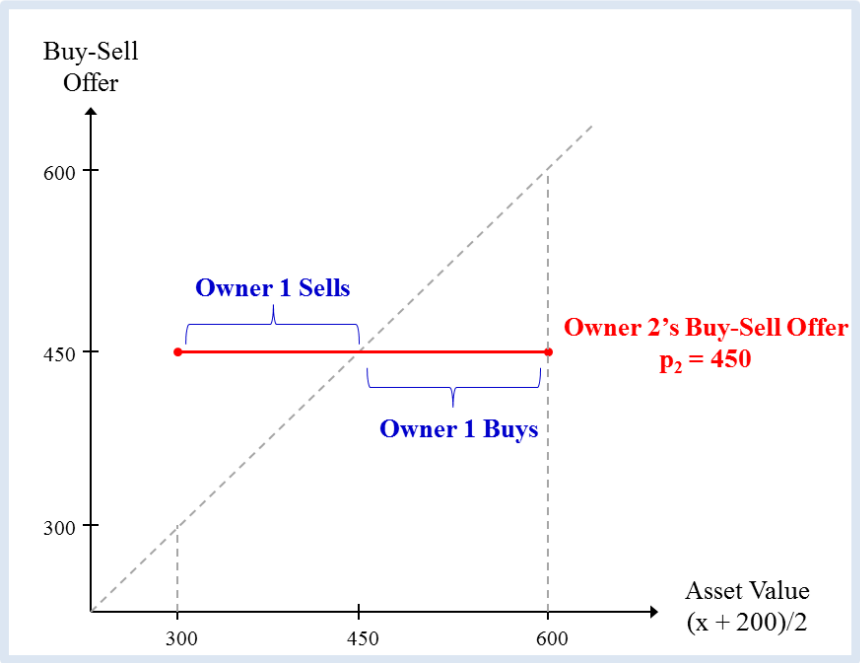

Figure 2: Shotgun Mechanism with an Uninformed Offeror

the business assets per owner, $p_2 = (\overline{x}+\$200)/2 = \$450$. *Owner 1 sells his stake to Owner 2 when the actual asset value is below the average value,* $(x + 200)/2 < \$450$, *and buys Owner 2's stake when the actual asset value is above the average value,* $(x + 200)/2 \geq \$450$. *The mean payoffs of Owner 1 and Owner 2 are* $\$525$ *and* $\$375$, *respectively.*

Figure 2 illustrates these findings. Intuitively, by offering a price equal to the average value of the business assets \$450, Owner 2 will maximize his average payoff given his information disadvantage. However, this strategy does not preclude inequitable outcomes. As we demonstrated in the previous section, Owner 2 would do much better if the better-informed Owner 1 made the buy-sell offer instead.

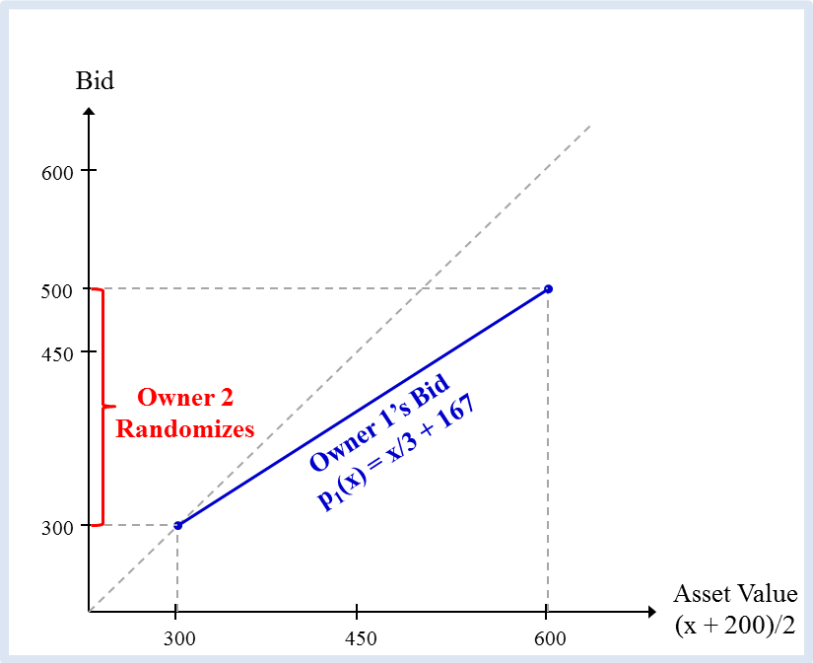

Figure 3: Private Auction

B. *Private Auction Mechanism*

Suppose now that, in the final step of resolving the business deadlock, the court mandates the parties to participate in a first-price sealed-bid auction. In this Private Auction (i.e., an auction with just the two owners bidding), the party who submits the highest bid purchases the asset from the other party, and pays a price equal to his own bid. The "winner" of the auction is the buyer and the "loser" of the auction is the seller. Proposition 3 summarizes the outcomes of this environment, and Figure 3 illustrates these findings.

PROPOSITION 3: *Suppose Owner 1 and Owner 2 participate in a Private Auction where the party making the higher bid purchases the stake of the other bidder. There is an equilibrium where the informed Owner 1 bids* $p_1(x) = \frac{x}{3} + \$167$. *The uninformed Owner 2's bid* p_2 *is drawn from the interval* $[\$300, \$500]$ *with uniform density (equally*

likely values). The expected payoffs of Owner 1 and Owner 2 are $500 and $400, respectively.

Intuitively, the bidding strategies in this common-value auction involve a degree of randomization in the sense that the less informed party randomizes over a range of prices. The better informed owner's bid is equal to $\frac{x}{3} + \$167$. Importantly, this bid is lower than or equal to $(x + \$200)/2$, the price offered by the better informed party in the Shotgun mechanism with an informed offeror (for all the relevant values of the business assets per owner under consolidation).[25] The better-informed party is at a strategic advantage in the Private Auction mechanism. On average, the party with the better information will receive a higher payoff than the less informed party ($500 versus $400).[26]

C. *Qualitative Hypotheses*

The qualitative hypotheses are as follows.

HYPOTHESIS 1: *The Shotgun environment with an informed offeror increases the likelihood of equitable outcomes (relative to the other Shotgun and Auction environments).*

HYPOTHESIS 2: *The Shotgun environment with an informed offeror increases the expected payoff of the uninformed owner (relative to the other Shotgun and Auction environments).*

Our theory indicates that equitable outcomes will be achieved only in the Shotgun mechanism with an informed offeror environment. Similarly, our theoretical point predictions suggest that the uninformed owner gets the highest possible payoff in this environment.

[25] The relevant values of the business assets are represented by the values of $(x + \$200)/2$ on the interval $[\$300, \$600]$.

[26] A second-price sealed-bid auction does not produce equitable outcomes either. A sequential auction mechanism where the informed player places the first bid and the uninformed player places the second bid would generate the same outcome as the Shotgun mechanism with an informed offeror.

III. Experimental Evidence

This section reports the results from a series of experiments with human subjects paid according to their performance.

A. *Games and Sessions*

We investigate whether the behavior of the subjects supports our theoretical predictions.[27]

We considered three different conditions: Shotgun mechanism with the informed owner making a buy-sell offer (Informed Offeror environment, IO), Shotgun mechanism with the uninformed owner making a buy-sell offer (Uninformed Offeror environment, UO), and Private Auction (First-Price Sealed-Bid Auction environment, A).[28]

[27]The experimental setting satisfies the assumptions of the theory. To ensure control and replicability, only few labels are used to motivate the experimental environment. A concern with our study, a concern that is common to all experimental research, is its external validity. Although our experiment cannot predict the effects of resolution mechanisms in richer environments, the experiment provides evidence regarding whether the Shotgun mechanism and the Private Auction in an environment such as the one we have structured here will have the predicted effects. Importantly, if the theoretical predictions do not hold in these simple experimental settings, there is little hope that the theory will work in more complex environments. Hence, our experimental findings will provide useful feedback to theorists.

[28]The Shotgun mechanism and the non-mandatory Shotgun mechanism (settings in which the offeror can choose simple offers to buy or to sell instead) with informed and uninformed owners have been experimentally studied in common-value *binary* environments with one-sided asymmetric information (Claudia M. Landeo & Kathryn E. Spier, *Shotguns and Deadlocks*, Yale J. on Reg. (forthcoming); and, Richard W. Brooks, Claudia M. Landeo, & Kathryn E. Spier, *Trigger Happy or Gun Shy? Dissolving Common-Value Partnerships with Texas Shootouts*, 41 Rand J. Econ. 649 (2010)). Common-value auctions with asymmetric information have been experimentally studied in settings involving an informed bidder and multiple uninformed bidders (John H. Kagel and Dan Levin, *Common Value Auctions with Insider Information*, Econometrica (1999)); they have been also studied using field experiments (Glenn W. Harrison and John A. List, *Naturally Occurring Markets and Exogenous Laboratory Experiments: A Case Study of the*

Procedural regularity was accomplished by developing a software program that permits subjects to play the game by using networked personal computers.[29] In the Shotgun mechanism conditions, the subjects played a two-stage game. In the first stage, the offeror made a buy-sell offer to the other subject, the offeree. The offeror's chosen price $p \geq 0$ was then revealed to the offeree. In the second stage, the offeree was required to respond to the offer by either buying or selling at the named price. In the Private Auction condition, the subjects played a simultaneous-move game. Player 1 and Player 2 each made offers to buy the other owner's assets and the highest bidder became the buyer.[30]

We ran three 90-minute sessions of 18 subjects each (1 session per condition; 54 subjects in total) at the University of Alberta School of Business computer laboratories. The subject pool was recruited from undergraduate and graduate classes at the University of Alberta by posting advertisement on electronic bulletin boards. We used a laboratory currency called the *token* (427 tokens = 1 Canadian dollar).

The experimental sessions encompassed 8 practice rounds[31] and 16 actual rounds.[32] Before the beginning of the first actual round, the computer randomly assigned a role to each of the subjects: Player 1 or Player 2 (Player 1, the informed player, was the offeror in the Informed Offeror condition and the offeree in the Uninformed Offeror condition;

Winner's Curse, Economic J. (2008)). See also John H. Kagel and Dan Levin, *Auctions: A Survey of Experimental Research, 1995-2010*, in John H. Kagel and Alvin E. Roth (eds.), The Handbook of Experimental Economics (forthcoming).

[29]Software screens and instructions are available upon request.

[30]In case of equal bids, the computer randomly allocated the role of the offeror (with equal likelihood).

[31]The outcomes for the eight practice rounds were not considered in the computation of the payoffs. Hence, during the practice rounds, subjects had an incentive to experiment with the different options and become familiar with the experimental environment. During the practice rounds, the subjects experienced each role four times.

[32]The information per condition (number of subjects, number of pairs for the 16 actual rounds) is (18, 144).

and Players 1 and 2 were bidders in the auction condition). Before the beginning of each actual round, the computer also randomly formed pairs. 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.[33] This value was revealed only to Player 1.[34]

Communication between players was done through a computer terminal and, therefore, players were completely anonymous to one another. Hence, this experimental environment precluded the formation of reputation.[35] The average payoff was $27 CAD.[36] At the end of each session, subjects received their monetary payoffs in cash.

B. *Results*

The main findings will be presented in a series of results.

1. *Data Summary*

Table 1 presents the descriptive statistics for all experimental treatments,[37] including information about the mean prices and payoffs for informed and uninformed owners. 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.[38] Mean asset

[33]The computer obtained the realization of the initial value of the business assets from the interval $[400, 1000]$. To allow for equitable divisions of the business assets, only even integers were considered.

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

[35]Given the randomization process used to form pairs, and the diversity of asset values 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.

[36]The participation fee was $10 CAD.

[37]For exposition, rounded values (integers) are presented.

[38]The equitable outcome rates under the less-empirically relevant definition involving an exact 50-50 allocation are 28, 0, and 1%, for the IO, UO, and A conditions,respectively.

Table 1: Descriptive Statistics for All Treatments

	Shotgun Mechanism		Auction
	IO	UO	A
Informed Owner's Price[(a)]	463	–	378
	(113)	–	(99)
Uninformed Owner's Price[(a)]	–	449	363
	–	(73)	(80)
Informed Owner's Payoff	410	541	492
	(138)	(113)	(118)
Uninformed Owner's Payoff	453	358	401
	(132)	(110)	(113)
Equitable Outcome Rate	43	6	8
Asset Value[(b)]	431	441	446
	(89)	(86)	(90)
Observations[(c)]	144	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.

values per owner under ownership consolidation are presented.[39]

The data indicate that the Shotgun mechanism with an informed offeror (IO) positively affected the uninformed offeror's mean payoff (with respect to the other treatments), reduced the informed offeror's mean payoff (with respect to the other treatments), and increased the equitable allocation rate (with respect to the other treatments).

Regarding the offerees' buying decisions in the informed offeror (IO) environment, in theory, uninformed offerees should randomize 50-50 between buying and selling. Our data suggest that, on average, the uninformed owner bought his partner's assets in 44% of the total cases. Interestingly, when the value of the business assets was lower than 450, uninformed offerees bought in 60% of the total cases; and, when the

[39]The asset value differences across conditions were not statistically significant.

Table 2: Average Price Offered per Asset Value Group[(a)]

Condition	$300-400$	$401-500$	$501-600$	Total Offers
IO	400	480	546	144
	(79)	(103)	(107)	
UO	459	435	454	144
	(69)	(56)	(92)	
A				
-Inf. Bidder	283	392	466	144
	(75)	(52)	(47)	
-Uninf. Bidder	378	349	359	144
	(91)	(77)	(68)	

Note: [(a)]Asset value refers to the value of assets per owner under ownership consolidation $(x+200)/2$; standard deviations are presented in parentheses.

value of te business assets was higher than or equal to 450, uninformed offerees sold in 79% of the total cases. In case of the uninformed offeror (UO) condition, our theory indicates that the informed offeree should buy if the value of the business assets per owner under ownership consolidation $(x + 200)/2 \geq 450$. Our data suggest the following informed offerees' responses: When the value of the business assets per owner under ownership consolidation was greater than or equal to 450, the informed owner bought her partner's assets in 88% of the total cases; when the business assets were lower than 450, the informed owner sold her business assets to her partner in 83% of the cases.

Table 2 describes the mean offers made by the owners per asset value group. Asset value refers to the value of the business assets per owner under consolidated ownership, $(x + 200)/2$.[40] For example, in the UO condition, the uninformed owner's mean offer was equal to 454 when the value of the business assets per owner under ownership

[40]We classified the data into three different groups, according to the value of the business assets per owner under ownership consolidation, $(x+200)/2$: the first group corresponds to $(x + 200)/2 \in [300, 400]$, the second group corresponds to $(x+200)/2 \in [401, 500]$, and the third group corresponds to $(x+200)/2 \in [501, 600]$.

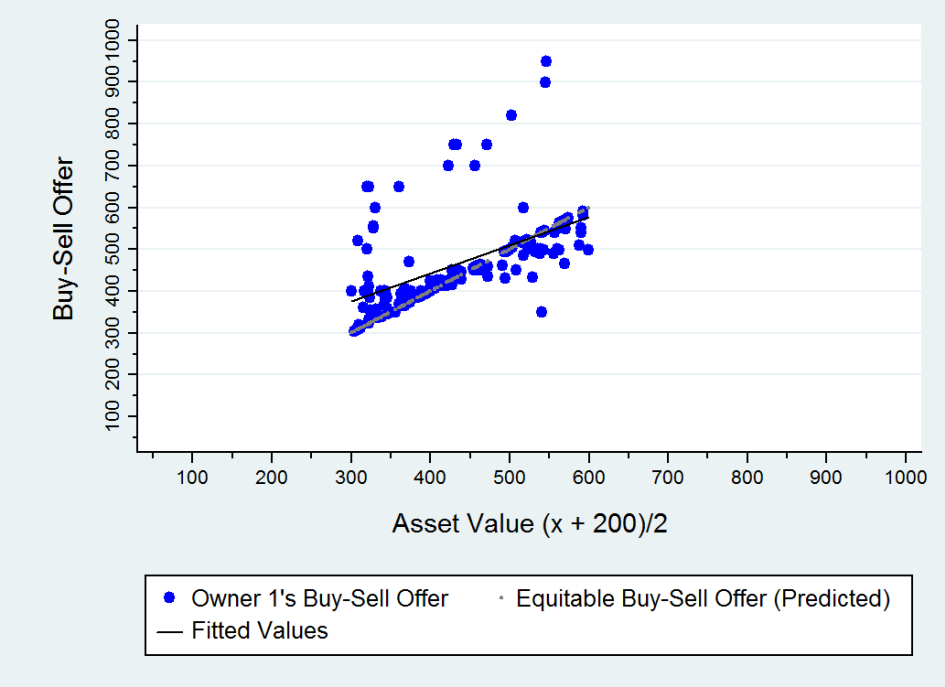

Figure 4: Shotgun Mechanism with an Informed Offeror

consolidation lay in the interval $[501, 600]$.

Our theoretical framework indicates that the prices proposed by Owner 1, the informed owner, should be increasing in the value of the business assets x in both the Shotgun mechanism with an informed offeror (IO) and the Private Auction (A) environments. Our data indicate a positive relationship between mean prices and the value of the business assets per owner under ownership consolidation in these settings. Our theory also suggests that a price equal to 450 should be proposed by the uninformed owner in the Shotgun mechanism with an uninformed offeror (UO) environment. In our data, the mode price offer in this setting was equal to 450.

More detailed information about the patterns of offers in the Shotgun mechanism with informed and uninformed offerors and in the Private Auction environment (informed and uninformed bidders) is provided in Figures 4 - 7. In addition to the information about observed offers, these figures include information about offers that pro-

Figure 5: Auction Mechanism - Informed Bidder

duce equitable outcomes (Equitable Buy-Sell Offer and Equitable Bid, for the cases of the Shotgun and Auction mechanisms, respectively); information about the outcome predicted by the theory (Predicted Buy-Sell Offer and Predicted Bid, for the cases of the Shotgun and Auction mechanisms, respectively); and, Fitted Values (predicted linear relationship between the offers and the asset values resulting from the application of OLS methods).[41] These figures suggest that the data is aligned with our theoretical predictions.

Specifically, Figures 4 and 5 illustrate the offer behavior of the informed owners. The fitted values line suggests that the offers increase with the value of the business assets. In case of the Shotgun mechanism with an informed offeror (Figure 4), the patterns of the data suggest that the offerors generally made offers higher than the equitable prices for low levels of the business assets, and offers lower

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

Figure 6: Shotgun Mechanism with an Uninformed Offeror

than the equitable offers for high levels of the business assets.[42] In case of the Auction mechanism (Figure 5), the patterns of the data also suggest that the informed bidders generally offer prices that are lower than the equitable bids. Interestingly, the comparison between the fitted value line and the predicted bids also suggests that the bids tended to be lower on average than those predicted by theory.

Figure 6 and 7 illustrate the offer behavior of uninformed owners. Not surprisingly, the fitted values lines are quite flat, suggesting that the offers did not systematically increase with the value of the business assets. Interestingly, in the case of the Shotgun mechanism with an uninformed offeror (Figure 6), the fitted values line and the predicted buy-sell offer (equal to 450) are remarkably aligned. In case of the Auction mechanism (Figure 7), the patterns of the data suggest that the uninformed bidder made offers within the 300 to 500

[42]Remember that the uninformed offerees generally bought for low realized values of the business assets and sold for high realized values of the business assets.

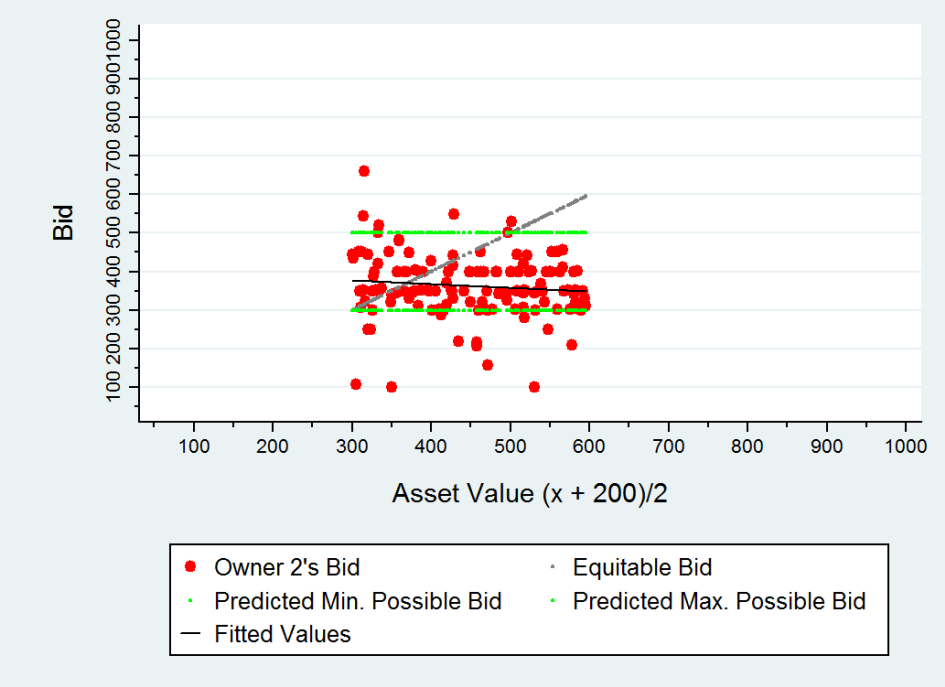

Figure 7: Auction Mechanism - Uninformed Bidder

interval as predicted by the theory. The fitted values line reflects the concentration of the bids in the lower part of the theoretical interval.[43]

2. *Analysis*

Table 3 presents the effects of the Shotgun mechanism with informed offeror (with respect to the other Shotgun mechanisms and the Private Auction) on the equitable outcome rate (second column), and on the uninformed owner's mean payoff (third column). We take pairs of conditions and estimate probit models and OLS regression models, respectively. Each probit or regression model includes a treatment dummy variable and round as its regressors. The treatment dummy variable is constructed as follows.[44] The standard errors computed are

[43]The sample mean bid was equal to 363, lower than the predicted mean bid of 400.

[44]For example, for the case of the probit model that assesses the effects of the Shotgun mechanism with informed offeror (versus the Shotgun mechanism

Table 3: Effects of the Shotgun Mechanism with an Informed Offeror on the Probability of Equitable Outcome and the Uninformed Owner's Mean Payoff

(Tests of Differences between Conditions)

Conditions	Prob. Equitable Outcome (Marginal Effects)	Uninf. Owner's Mean Payoff (Coefficients)
UO versus IO	0.375***	94.882***
	(0.046)	(14.360)
Observations	288	288
A versus IO	0.355***	52.056***
	(0.047)	(14.491)
Observations	288	288

Note: The columns report the change in the probability of equitable outcome 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.

robust to general forms of heteroskedasticity and hence, they account for the possible dependence across rounds.[45]

Equitable Outcome Rates

The effects of the Shotgun mechanism with an informed offeror

with uninformed offeror), the dummy variable will take a value equal to one if the observation pertains to the condition IO, and a value equal to zero if the observation pertains to the condition UO. The data for conditions IO and UO are pooled to estimate this probit model. Given that probit magnitudes are difficult to interpret, we report the marginal effects.

[45]Note that each person plays 16 rounds and interacts with other player during the session. Regression estimations for all treatments and data corresponding to the last 8 rounds of play are available upon request. Note that all qualitative results still hold when only the last eight rounds of play are considered. The variable round was not statistically significant.

on the probability of equitable outcomes are reported in the second column of Table 3. The Shotgun mechanism with an informed offeror significantly increases the likelihood of equitable outcomes. In fact, as a result of this mechanism, higher equitable outcome rates are observed: 6 versus 43 percent for the UO and IO conditions, respectively; and, 8 versus 43 percent for the A and IO conditions, respectively.[46] Thus, there is clear support to Hypothesis 1.[47]

RESULT 1: *The Shotgun mechanism with an informed offeror significantly increases the equitable outcome rate (relative to the other Shotgun and Auction mechanisms).*

Uninformed Owner's Mean Payoff

The effects of the Shotgun mechanism with an informed offeror on the uninformed owner's mean payoff are reported in the third column of Table 3. The Shotgun mechanism with an informed offeror significantly increases the uninformed owner's mean payoff. As a result of this mechanism, higher mean payoffs for the uninformed owners are observed: 358 versus 453 for the UO and IO conditions, respectively; and, 401 versus 453 for the A and IO conditions, respectively. These findings support Hypothesis 2.

RESULT 2: *The Shotgun mechanism with an informed offeror significantly increases the uninformed owner's mean payoff (relative to the other Shotgun and Auction mechanisms).*

Our theoretical insights regarding the equity-superiority of the Shotgun mechanism with an informed offeror are largely confirmed

[46]Given that the equitable outcomes rate under the 50-50 allocation definition was equal to 0% for the UO condition, a probit model comparing IO and UO could not be estimated; the qualitative results of the probit model comparing IO and A are robust to this alternative definition of equitable outcomes (p-value < 0.001).

[47]In a previous work, we studied the IO and UO environments in a binary-setting (i.e., only two values of the business assets). The IO versus UO findings are aligned with our previous results. See Claudia M. Landeo & Kathryn E. Spier, *Shotguns and Deadlocks*, Yale J. on Reg. (forthcoming).

by our laboratory experiments.

IV. Discussion and Conclusion

In recent previous work,[48] we asserted that Shotgun mechanisms can and should play a larger role in the judicial management of business divorce. This article extends our previous work by experimentally investigating the judicial design and properties of the Shotgun and Private Auction mechanisms in an environment where one business owner has better information about the value of the business assets. Our experimental findings support our theory: The frequency of equitable outcomes was higher when the better-informed owner made the Shotgun offer. Interestingly, when obligated to make a buy-sell offer, the better-informed owner frequently revealed his private information to the less-informed owner. Specifically, we demonstrate that the Shotgun mechanism with an informed offeror outperforms the other Shotgun mechanisms and the Private Auction in terms of an equity criterion.

Kinzie v. Dells,[49] a Canadian case, demonstrates the empirical feasibility of our proposal, and provides an interesting example of a careful judicial implementation of the Shotgun mechanism:

> 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 ... If either party is unable to obtain financing to complete the purchase of the shares within the 90-day time limit, having made reasonable efforts to do so, the [assets] shall be listed for sale on the open market with the parties having joint conduct of sale.

The *Kinzie* court clearly addressed the issue of offeror assignment. In addition, the court mitigated the adverse effects associated with

[48] Claudia M. Landeo & Kathryn E. Spier, *Deadlocks and Shotguns*, Yale J. on Reg. (forthcoming).

[49] *Kinzie v. Dells* 2010 BCSC 1360 (Can. B.C.).

financial constraints by providing the winning party a sufficiently long period of time to raise the necessary capital.

Our proposal involves the active participation of the court in the evaluation of the environment surrounding the legal case, and the choice and design of the most appropriate resolution mechanism. This proposal is aligned with current judicial practices regarding management of business divorce cases in the United States. Brooklyn Commercial Division Justice Carolyn E. Demarest's insightful design of the deadlock resolution mechanism in the *Mizrahi v. Cohen* case reflects this trend.[50] As commentators argue, Justice Demarest employed the court's equitable powers "[T]o avoid the glaring injustice that would have resulted in *Mizrahi* had the court stayed within the strict confines of the LLC agreement."[51] In fact, the mechanism selected by the court derives not from the LLC agreement but from the court's discretion to exercise the principle of equity.

The analysis presented in this article provides an equity rationale for the judicial design and implementation of the Shotgun mechanism in business divorce cases under the appropriate conditions, and demonstrates the empirical feasibility of our proposal.

[50] *Mizrahi v. Cohen*, 38 Misc.3d 1213(A), No. 3865/10 (N.Y. Sup. Ct. Jan. 15, 2013). Justice Demarest's ruling includes a careful description of the implementation of a private auction mechanism. Note that both owners were managing members of the LLC. Then, it is likely that they were symmetrically informed about the value of the business assets. Under symmetric information, the Private Auction mechanism also produces equitable outcomes. Hence, the court's resolution mechanism choice seems to be appropriate. See Claudia M. Landeo & Kathryn E. Spier, *Shotguns and Deadlocks*, YALE J. ON REG. (forthcoming).

[51] Peter Mahler, *Court Decision Boosts Equitable Buy-Out Remedy in LLC Dissolution Case*, February 19th, 2013; http://www.nybusinessdivorce.com (last visited May 21, 2013).

[Supplementary Material (Not for Publication).]

Irreconcilable Differences: Judicial Resolution of Business Deadlock

Claudia M. Landeo* and Kathryn E. Spier†

Appendix

This appendix presents the propositions and proofs for the Shotgun mechanism with informed and uninformed offeror,[1] and the Private Auction environment.

Suppose that two co-venturers own equal stakes in a firm with uncertain value x, which is drawn from a uniform distribution on the interval $[x_L, x_H]$ and let $\overline{x}$ be 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 $x + a \in [x_L + a, x_H + a]$.

With the 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. The equilibrium concepts are perfect Bayesian and Bayesian Nash equilibria, for the shotgun and auction mechanisms, respectively.

Shotgun Mechanism with an Informed Offeror

The first proposition characterizes the unique fully-separating equilibrium of the Shotgun mechanism when the informed party, Owner 1, makes the buy-sell offer. In

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[1]These results follow from Propositions 1 and 2 in Brooks et al. (2010).

this equilibrium, Owner 1's buy-sell offer fully reveals Owner 1's type x and leads to an equal division of the surplus.

PROPOSITION A1: (Informed Offeror) *Suppose Owner 1 (the informed party) makes the buy-sell offer. There is a unique fully-separating equilibrium*[2] *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* $\frac{\overline{x}+a}{2}$.

PROOF. 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. ■

Shotgun Mechanism with an Uninformed Offeror

We characterize the equilibrium of the Shotgun mechanism when the uninformed party, Owner 2, makes the buy-sell offer. Not surprisingly, Owner 2's offer reflects the average value of the assets rather than the realized value (since x is known only to Owner 1). As a consequence, Owner 1 is at an informational advantage in this mechanism and receives a greater equilibrium share of the surplus than Owner 2.

PROPOSITION A2: (Uninformed Offeror) *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* $x \geq \overline{x}$.[3] *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.*

PROOF. 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:

[2]There also exists a pooling equilibrium where Owner 1 offers $p(x) = \frac{\overline{x}+a}{2}$ for all types x. Owner 2 is indifferent between buying and selling and mixes with equal likelihood. This equilibrium is easily supported. If Owner 1 were to make an out-of-equilibrium offer, p, then Owner 2's beliefs are that Owner 1's type is $x = 2p - a$, creating indifference on the part of Owner 2 between buying and selling and prompting Owner 2 to mix with equal likelihood. Since Owner 2 will randomize $50-50$ between buying and selling for any buy-sell offer made by Owner 1, whether the offer is on or off the equilibrium path, it is an equilibrium for Owner 1 to offer $p(x) = \frac{\overline{x}+a}{2}$ regardless of his type x. Other equilibria may exist as well.

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

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

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 $\int_{x_L}^{\overline{x}} (x + a)\, dF(x) = \frac{1}{2}E(x + a \mid x \leq \overline{x})$. ■

Private Auction

We characterize the equilibrium of the first-price sealed-bid auction. We show that Owner 1's bid is an increasing linear function of his type, x, but is everywhere less than the level that would create an equal division of the surplus, $\frac{x+a}{2}$. This latter property, that Owner 1's bid is lower than that required for equal division, creates an incentive for the less-informed Owner 2 to participate in the auction and protects Owner 2 from falling victim to the winner's curse. Owner 2's equilibrium bid is a random draw from a uniform distribution on the range of equilibrium offers for Owner 1. Owner 2's randomization strategy creates an incentive for Owner 1 to place a higher bid when the value of the assets, x, is higher.

We also show that Owner 1 is at an advantage in the auction mechanism, and receives a greater share of the surplus than Owner 2. The outcome is less equitable than the Shotgun mechanism with an informed offeror (Proposition 1) but is more equitable than the Shotgun mechanism with an uninformed offeror (Proposition 2).

PROPOSITION A3: *Suppose Owners 1 and 2 participate in a first-price sealed bid auction where the party making the higher bid purchases the stake of the other bidder. There is an equilibrium where the informed Owner 1 bids* $p_1(x) = \frac{x+a}{2} - \frac{x-x_L}{6}$. *The uninformed Owner 2's bid* p_2 *is drawn from the interval* $[p_L, p_H] = [p_1(x_L), p_1(x_H)]$ *with uniform density. The ex ante expected payoffs of Owner 1 and Owner 2 are* $\frac{\overline{x}+a}{2} + \frac{x_H - x_L}{12}$ *and* $\frac{\overline{x}+a}{2} - \frac{x_H - x_L}{12}$, *respectively.*

PROOF. Suppose Owner 2 randomizes and makes an offer $p_2 \in [p_L, p_H]$ with uniform density g(p) as in the proposition. Note that the lower bound of this distribution, $p_L = p_1(x_L) = \frac{x_L+a}{2}$. We will first consider Owner 1's choice of offer given asset value x. Owner 1's payoff as a function of his offer p_1 is:

$$\int_{p_L}^{p_1} (x + a - p_1) dG(p_2) + \int_{p_1}^{p_H} p_2 dG(p_2).$$

The first term reflects Owner 1's payoff when $p_2 < p_1$ so Owner 1 buys Owner 2's stake at price p_1, and the second term reflects Owner 1's payoff when $p_2 > p_1$ where Owner 1 sells his stake to Owner 2 for price p_2. Differentiating this expression with respect to p_1 and setting the derivative equal to zero gives $p_1 = \frac{x+a+p_L}{3}$. Substituting $p_L = p_1(x_L) = \frac{x_L+a}{2}$ gives the bidding function $p_1(x)$ in the Proposition.

Now consider Owner 2's strategy. We let $z(p)$ denote the inverse of Owner 1's bidding function $p_1(x)$, and assume that it is monotonically increasing. So, $z(p)$

reflects the "type" who places bid p in the fully-separating equilibrium. Suppose Owner 2 places a bid p_2. If $x < z(p_2)$ then $p_1(x) < p_2$ so Owner 2 wins the auction and purchases Owner 1's stake. If $x > z(p_2)$ then $p_1(x) > p_2$ so Owner 1 wins the auction and Owner 2 sells his stake to Owner 1 for price $p_1(x)$. Owner 2's payoff is given by:

$$\int_{x_L}^{z(p_2)} (x + a - p_2) dF(x) + \int_{z(p_2)}^{x_H} p_1(x) dF(x).$$

Differentiating this expression and setting it equal to zero gives the following differential equation:

$$z'(p_2)[z(p_2) + a - 2p_2] - z(p_2) + x_L = 0.$$

$z(p) = 3p - \frac{x_L}{2} - \frac{3a}{2}$ is a solution, and inverting this expression we have the expression for $p_1(x)$ in the proposition. So we have demonstrated that if Owner 1 bids $p_1(x)$, then Owner 2 is indifferent over the prices in the range $[p_1(x_L), p_1(x_H)]$ and is therefore willing to randomize.

We will now calculate Owner 2's expected payoff. Since Owner 2 is indifferent over the range of offers, we can calculate his payoff for offer $p_2 = p_1(x_L)$. At this low price, Owner 2 would lose the auction for all values of x, and his payoff would be

$$\int_{x_L}^{x_H} p_1(x) dF(x) = \int_{x_L}^{x_H} \left(\tfrac{x+a}{2} - \tfrac{x-x_L}{6} \right) dF(x).$$

Rearranging terms gives the expression in the proposition. ■

[Supplementary Material (Not For Publication).]

SAMPLE INSTRUCTIONS - SHOTGUN MECHANISM WITH INFORMED OFFEROR.

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

STAGE 1

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 **reveals this information ONLY to Player 1**. **Player 2** will **NOT** know the initial value of the business assets until the end of the round.

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

   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**.

- The business partnership will be dissolved. Then, the value of the business assets **will increase by 200 tokens.**

PLAYER 1'S OFFER

2) **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 **any price greater than or equal to 0** (no decimals).

PLAYER 2'S RESPONSE

3) 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**

ROUND PAYOFF

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.

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