Bargaining under Asymmetric Information

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BARGAINING UNDER ASYMMETRIC INFORMATION

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This paper investigates two-person bargaining under incomplete information where one player has strictly better information about the potential value of the transaction than the other. The implications of informational barriers to trade are explored, and optimal bargaining mechanisms are characterized.

1. INTRODUCTION

IN MANY COMMONLY ENCOUNTERED BARGAINING SETTINGS, one individual possesses better or worse information about the potential value of the transaction than the other. Examples range from the sale of a used automobile to a corporate acquisition via tender offer, where in each case the buyer is likely to be less well-informed than the seller. This paper examines optimal bargaining behavior for the informed and uninformed agents. It also emphasizes the tension between the opportunity for mutual gain and the impact of asymmetric information in bargaining situations. For instance, in the acquisition example, it may be common knowledge that the target firm would be worth more in the hands of the acquirer than under current management. Nonetheless, the presence of asymmetric information may preclude the attainment of a mutually beneficial sale. The acquirer should recognize that a given price offer is more likely to be accepted by an ailing firm than a healthy one. Thus, any offer it makes may be too high, since its very acceptance signals that the target is a (relatively) low value firm. In the extreme case, no mutually beneficial exchange may ever be possible, even though it is common knowledge that trading gains always exist.

The preceding discussion should suggest certain similarities between the issues raised in the present paper and in the market for "lemons" presented by Akerlof [**1**] in which the presence of "bad" quality items for sale may drive out "good" items. Despite the difference in setting—Akerlof examines a market model while we consider the classic bargaining case of bilateral monopoly—the common emphasis is on the importance of information differences for the economics of exchange. Our analysis will demonstrate that Akerlof's example of market failure can be viewed more generally as one instance of the limitations on resource allocation in settings of incomplete information.

Recent research in the area of competitive bidding is also related in spirit to ours. In a common model [**6**, **8**], potential buyers have different and independent sample evidence and bid for an item with a common but unknown value. Each buyer, in making his bid, must estimate the item's value conditional on his sample evidence and conditional on his winning the competition. In short, winning the bid is, in itself, informative of the item's unknown value (i.e., it

[1] The author is grateful to V. Crawford, R. Dorfman, R. Myerson, J. Pratt, J. Riley, W. Thomson, C. Wilson, and *Econometrica* referees for helpful comments. This study also owes a considerable debt to the work in [**5**].

means that the others' sample evidence was less favorable than one's own). If a buyer overlooks this fact, his bids will be too optimistic. Consequently, he will tend to win items that (consistent with the collective evidence) prove to be worth less on average than the price he paid for them—a phenomenon known as the "winner's curse." Our analysis suggests that this phenomenon and the caution, *Caveat Emptor*, far from being special to bidding situations, are of general importance.[2]

In what follows, we construct a bargaining model under asymmetric information in which an uninformed buyer faces an informed seller and derive the following results: (i) The uninformed buyer achieves his maximal attainable expected profit when he has the opportunity to make a first-and-final offer which the seller can reject or accept. (ii) Even if, in all circumstances, the good is worth more to the buyer than to the seller, the presence of asymmetric information may preclude a mutually beneficial sale. For an economic exchange to be possible, a necessary and sufficient condition is that the buyer can make a profitable first-and-final offer. (iii) The allocation mechanism which maximizes the seller's expected profit (and the collective profit of the parties) may or may not be implementable via a simple voluntary bargaining procedure. If implementation is possible, then the optimal mechanism has the seller making a first-and-final offer. If not, the mechanism requires the parties to enter into a "bargaining contract" based on mutually binding promises.

2. THE MODEL

Consider a setting of bilateral monopoly in which a single risk-neutral seller faces a single risk-neutral buyer. At issue is the potential exchange of the good from seller to buyer. The seller knows his own monetary value for the good v and also the buyer's value w, while the buyer is uncertain about these values. (The distinction between the informed and uninformed players—not the buyer and seller labels themselves—is all that is crucial for our analysis.) The function $w = w(v)$ defines the relation between player values, and $f(v)$ denotes the continuous probability density function of v over the interval $[a, c]$. Finally, the functions $w(v)$ and $f(v)$ are common knowledge among the players.[3]

A key assumption of the model is that the seller's information concerning v is nontransferable—that is, it is impossible for the buyer to verify independently this information. (For instance, even the transfer of all accounting records could not provide an acquirer information on a par with current management's.) Furthermore, if the active participation of the seller is necessary in the information transfer, the problem of moral hazard immediately arises, since the seller's

[2] Recently, Myerson and Satterthwaite [5] and Riley and Zeckhauser [7] have examined bargaining problems in which buyer and seller hold independent values.

[3] No restrictions are placed on the function $w(v)$, a priori. A relatively strong assumption (used in the examples) is that $w(v) \geq v$, for all v. An alternative assumption is that w be increasing in v.

incentive will be to transmit a value of v most favorable to its own bargaining position. The model also precludes making the terms of agreements contingent on the realized values v and w, either because these may never ultimately be observable or because such a contingent contract may be prohibitively costly. (Of course, some contingent sales agreements are commercially feasible—product warranties and money-back guarantees being two examples.)

BARGAINING EQUILIBRIA: The parties may bargain by any means they deem appropriate. Whatever the ground rules of the negotiation process, we require the outcome of the associated bargaining game to be a Nash or Bayesian equilibrium —that is, when each side plays its equilibrium strategy, neither can increase its expected profit by unilaterally deviating. Our main task is to investigate the welfare implications of such bargaining equilibria. It is well-known (see [**2** and **4**]) that any bargaining procedure under incomplete information can be recast as a direct revelation game (DRG). In the present case only the seller holds private information. Thus, in the revelation game the seller reports his value of v and this report directly determines the bargaining outcome. Since the players are risk neutral, the equilibrium outcome of the DRG can be summarized by two entries: (i) $p(v)$, the probability that the good is transferred from seller to buyer, and (ii) $t(v)$, the transfer payment from the buyer to the seller. Furthermore, in order to implement the intended equilibrium outcome, the appropriate direct revelation game must be designed to give the seller the proper incentive to report his *true* value. The seller's expected profit in the DRG is

$$(1) \qquad \pi_s(v,x) = t(x) - p(x)v,$$

when he holds value v and reports value x. This profit is simply the difference between the monetary payment he receives and the expected value he forgoes when he gives up the good. (In this formulation, a payment occurs whether or not the good is traded.) Then the DRG must be designed so that

$$(2) \qquad \pi_s(v,v) \geq \pi_s(v,x),$$

for all possible offers x and all values of v. The seller maximizes his expected profit by reporting his true value v. Applying this condition when the seller holds value v and considers reporting v' or vice versa, one obtains the following inequalities:

$$(3) \qquad (v'-v)p(v') \leq \pi_s(v,v) - \pi_s(v',v') \leq (v'-v)p(v).$$

If $v' > v$, then $p(v') \leq p(v)$ so that the first implication of (3) is that

(4) $\qquad p(v)$ is nonincreasing in v.

A second implication of (3) is that

$$(5) \qquad d\pi_s(v)/dv = -p(v)$$

almost everywhere, after letting v' approach v in the limit. (Here and henceforth, we denote the seller's expected profit simply as $\pi_s(v)$, omitting the second argument on the understanding that (2) holds.)

To give the seller an incentive to participate in the bargaining mechanism, the direct revelation game must provide him a nonnegative expected profit for any value v he might hold, $\pi_s(v) \geq 0$, for all v. Since $\pi_s(v)$ is nonincreasing, the equivalent constraint is

$$\pi_s(c) = t(c) - cp(c) \geq 0. \tag{6}$$

In evaluating bargaining performance under imperfect information, it is natural to focus on the parties' expected profits.[4] The sum of the players' expected profits is

$$\pi_s + \pi_b = \int_a^c [w(v) - v]\, p(v) f(v)\, dv. \tag{7}$$

The seller's expected profit is

$$\pi_s = \int_a^c \pi_s(v) f(v)\, dv = \pi_s(c) - \int_a^c F(v)\, d\pi_s(v) \tag{8}$$

$$= \pi_s(c) + \int_a^c p(v) F(v)\, dv,$$

after an integration by parts and a substitution using (5). The buyer's expected profit is

$$\pi_b = \int_a^c [w(v) - v - F(v)/f(v)]\, p(v) f(v)\, dv - \pi_s(c), \tag{9}$$

after using (7) and (8). Finally, if the buyer is to have an incentive to participate in the bargaining, it must be the case that

$$\pi_b \geq 0. \tag{10}$$

3. OPTIMAL BARGAINS

First, consider the problem of designing a direct revelation bargaining mechanism—a specification of probability function $p(\cdot)$ and associated transfer function $t(\cdot)$—to maximize the uniformed buyer's expected profit. The relevant constraints are (4), (6), and (10), and the buyer's expected profit is given in (9). From this last expression, it is apparent that (6) must hold as a strict equality.

[4]By employing ex ante expected profit as the welfare criterion, we are focusing on average expected returns taken over all seller types. This measure is most appropriate for the uninformed buyer but less so for the seller who will usually know his type at the time the mechanism is implemented. In this case, one may wish to adopt the weaker criterion of interim efficiency developed in [3] and focus on the seller's conditional profit $\pi_s(v)$.

For convenience, define $H(v) = w(v) - v - F(v)/f(v)$ in (9). Because the buyer's profit is linear in $p(\cdot)$, the optimal probability function (required to be nonincreasing) can always be described by a step function of the form

$$p(v) = \begin{cases} 1, & a \leq v \leq b^*, \\ 0, & \text{otherwise,} \end{cases}$$

for some $b^* \in [a, c]$. In short, $p(\cdot)$ contains a single positive step. The proof is by contradiction. If this were not the case, then the buyer's expected profit could be increased by the following modification: over any subinterval V such that $0 < p(v) < 1$ for all $v \in V$, increase $p(v)$ if $\int_V H(v)f(v)\,dv > 0$ and decrease $p(v)$ if $\int_V H(v)f(v)\,dv < 0$ in each case subject to the constraint that $p(v)$ be nonincreasing. Such improvements are exhausted only when $p(v)$ takes solely the values 0 and 1.

Along the positive step, the probability of an agreement is constant. So too is the seller's expected receipt $t(v)$ by (3) and (1). With this observation, we can describe a particularly simple bargaining procedure which implements $p(\cdot)$ and $t(\cdot)$. The buyer makes a first-and-final price offer b^*. The seller accepts this offer (and so the good changes hands) if and only if $v \leq b^*$. This implements precisely the desired probability function at the constant price $t(v) = b^*$, for $v \leq b^*$.

Thus, the buyer must choose a first and final price offer b to maximize $\int_a^b H(v)f(v)\,dv$, or equivalently

$$\int_a^b [w(v) - b] f(v)\,dv = E[w - b \mid v \leq b] F(b).$$

This last expression indicates that, in determining his optimal offer, the buyer must estimate his expected profit conditional on his offer being accepted by the seller. In particular, the buyer's proper value estimate is

$$E[w \mid v \leq b] = \int_a^b [w(v)f(v)/F(b)]\,dv,$$

which measures his expected value for the good conditional on a sale.

With respect to the optimal offer b^*, three cases can be distinguished. First, b^* may occur at an interior maximum satisfying the first order condition $H(b^*) = 0$. (In the case of multiple roots, one must check to find the global maximum.) Second, the buyer's optimal offer may occur at the corner solution $b^* = c$. Here the buyer makes a maximal price offer which is always accepted by the seller. A final case occurs when $b^* = a$. A sale is never made since the buyer's expected profit in (9) is negative for any $b^* > a$—that is, the buyer faces a negative profit from any offer which might be accepted by the seller.

These results are summed up in the following proposition.[5]

[5] Riley and Zeckhauser [7] prove a similar result under the assumption that buyer and seller values are independently generated.

PROPOSITION 1: (1) *Of all bargaining procedures, the buyer most prefers to make a first-and-final price offer which the seller can then accept or reject.* (2) *A mutually beneficial agreement is attainable with positive probability if and only if there exists a buyer price $b \in [a,c]$ such that the buyer's expected profit conditional on b being accepted is positive—that is, when*

$$\int_a^b [w(v) - b][f(v)/F(b)]\,dv \geq 0, \qquad \textit{for some } b.$$

(3) *Supposing that a mutually beneficial agreement is possible, then the buyer's optimal first-and-final offer b^* satisfies*: (i) $w(b^*) - b^* - F(b^*)/f(b^*) = 0$, *at an interior maximum, or* (ii) $b^* = c$, *at a corner solution.*

EXAMPLE 1: Suppose v is uniformly distributed on the interval [0, 1] and that $w = \Delta + kv$, where $\Delta, k \geq 0$. Then $H(b) = \Delta + (k-2)b$, implying that for $\Delta > 0$ there exists a profitable offer for the buyer. If $\Delta = 0$, then a nonnegative profit is available if and only if $k \geq 2$. If this condition is satisfied, the buyer's optimal offer is $b^* = 1$ and an agreement is always reached. If $k < 2$, on the other hand, the buyer earns a negative profit on average for any offer $b > 0$. Consider the case where $w = 1.5v$ (the example presented by Akerlof in a market setting). If he offers b, the buyer acquires on average an item that he judges is worth $b/2$ to the seller. (This follows since the seller accepts only if $v \leq b$ and v is uniformly distributed.) In turn, the average good acquired is worth $1.5b/2 = .75b$ to the buyer. Thus, on average the buyer acquires an item worth some 25 per cent less than the offer price. Though the good is always worth more to the buyer than to the seller, under asymmetric information a mutually beneficial sale is impossible.

THE SELLER'S OPTIMAL MECHANISM: First, note that the problems of maximizing the seller's profit and the group profit (in each case subject to (4) and (10)) are one and the same as long as (10) is binding. Thus, the results concerning the seller's optimal mechanism apply equally to the optimal group mechanism. It was previously shown that the buyer's optimal mechanism can be implemented by a first-and-final offer. The optimal seller mechanism, on the other hand, may or *may not* be achievable by means of such a simple bargain. In outlining this result, we begin with a lemma.

LEMMA: *Both the expected profit of the seller and the expected profit of the players collectively are maximized under a bargaining mechanism in which the probability function contains at most two positive steps. Specifically, $p(\cdot)$ is of the form*

$$p(v) = \begin{cases} 1 & \textit{for} \quad a \leq v < s^*, \\ p & \textit{for} \quad s^* \leq v \leq s^{**}, \\ 0 & \textit{for} \quad s^{**} < v \leq c, \end{cases}$$

where $0 \leq p \leq 1$ and $a \leq s^* \leq s^{**} \leq c$.

In the case that $s^* = s^{**}$, the seller's optimal mechanism is single-stepped and (like the buyer's optimal mechanism) can be implemented as a simple bargain. The seller makes a first and final offer s^* when he holds $v \leq s^*$, which the buyer always accepts. For $v > s^*$, whatever offer (greater than s^*) that the seller might make is rejected by the buyer. On average, the buyer earns zero profit (whether or not he accepts s^*), while the seller earns a positive profit when he holds $v < s^*$, a zero profit otherwise. Therefore, we have the following result.

PROPOSITION 2: *If the probability function of the lemma is single-stepped, the seller maximizes his expected profit (and the group expected profit) by making a first-and-final offer s^* when he holds $v \leq s^*$ and no offer otherwise. The offer s^* is the highest price such that $\pi_b \geq 0$.*

An obvious implication of Propositions 1 and 2 is that the seller's first-and-final offer is always greater than the buyer's. For instance, in Example 1 with $w(v) = \Delta + v$, the seller's optimal strategy is a first-and-final offer $s^* = 2\Delta$, whereas the buyer's optimal offer is Δ. By contrast, in the following example, the seller's optimal mechanism is described by a double-stepped probability function.

EXAMPLE 2: Suppose v is uniformly distributed on [0, 1] and that

$$w(v) - v = \begin{cases} .2, & \text{for } 0 \leq v < .4, \\ 2v - .6, & \text{for } .4 \leq v \leq .6, \\ v, & \text{for } .6 < v \leq 1.0, \end{cases} \qquad \text{so that}$$

$$H(v) = \begin{cases} .2 - v, & \text{for } 0 \leq v < .4, \\ v - .6, & \text{for } .4 \leq v \leq .6, \\ 0, & \text{for } .6 < v \leq 1. \end{cases}$$

By construction, the buyer's comparative advantage for the item $w(v) - v$, is continuous, always positive, and increases sharply for v in the interval [.4, .6] and continues to increase thereafter.

For this example, the optimal seller mechanism can be found by simple inspection. First, it is easy to check that the seller's best single-stepped mechanism has $p(v) = 1$, for $v \in [0, .4]$ and $p(v) = 0$ elsewhere. The step ends at $v = .4$ where the constraint, $\pi_b \geq 0$, becomes strictly binding. However, this step function can be improved upon. By shifting probability mass from the interval [.2, .4] to the interval [.6, 1.0], it is possible to increase the group expected profit in (7) and so the seller's expected profit while maintaining binding constraint (10). Indeed, since the potential trading gains, $w(v) - v$, rise steeply with v and since both (7) and (9) are linear in $p(\cdot)$, as much probability weight as possible, subject to constraints (4) and (10), should be transferred to the upper interval. Such a shift results in $p(v) = 1$, for $v \in [0, .2]$ and $p(v) = .5$ for $v \in (.2, 1]$. This latter probability cannot be increased above .5 without violating the buyer's individual rationality constraint. Under this double-stepped function, the seller and group expected profits come to .26; the corresponding profit quantities are only .08 under the single-step function.

It remains to construct the necessary transfer payment function $t(\cdot)$ to accompany $p(\cdot)$. Since the steps of the transfer function mirror those of the probability function we have

$$t(v)=\begin{cases} t_1 & \text{for } 0\le v\le .2,\\ t_2 & \text{for } .2<v\le 1.0.\end{cases}$$

The boundary condition $\pi_s(c)=0$ at the upper support $c=1.0$ immediately implies that $t_2=.5$. Equivalently, the contingent payment in the event of a sale is $T_2=1.0$. The value of t_1 is determined so that a seller holding $v=.2$ is indifferent between a sure sale at t_1 or a sale at T_2 with probability .5. In the former case, his profit is $t_1-.2$; in the latter, his profit is $.5-.5(.2)=.4$. Together, these imply $t_1=.6$. Since a sale occurs with probability one, the contingent payment T_1 equals .6 as well. As a final check, we can calculate the buyer's expected profit.

$$\begin{aligned}\pi_b &= (.2)(.3-.6)+(.8)\big[.5(1.15)-.5\big]\\ &= -.06+.06=0.\end{aligned}$$

The first term lists the buyer's expected profit at a transfer price $T_1=.6$ when $v\in[0,.2]$, while the second term lists the buyer profit at transfer price $T_2=1.0$ when $v\in(.2,1.0]$.

We have shown by construction that the seller's optimal mechanism may be double-stepped. Furthermore, it is easy to modify Example 2 to support $p(v)=0$ for sufficiently large v (by making $w(v)-v$ turn down drastically over this interval). Thus, it remains to show that there can be at most one step such that $0<p<1$.

The proof is by contradiction. Suppose that the optimal mechanism has two such steps p_2 and p_3 (over the intervals V_2 and V_3) where $0<p_3<p_2<1$. Now let us define $g_j=\int_{V_j}[w(v)-v]f(v)\,dv$ and $h_j=\int_{V_j}H(v)f(v)\,dv$ for $j=2,3$. It must be the case that each h_j is negative; otherwise increasing p^j would increase π_s without violating binding constraint (10). Consider a small increase δ_3 in step 3. To maintain (10) binding, step 2 must change by $\delta_2=-(h_3/h_2)$ with the result that π_s changes by $[g_3-g_2h_3/h_2]\delta_3$. If the bracketed term is positive, δ_3 should be increased until the double step is leveled into a single positive step. If it is negative, step 3 should be leveled to zero. If the term happens to be zero, it is nonetheless true that a single step is optimal (though not uniquely so). This concludes the proof of the lemma.

When $p(\cdot)$ is single-stepped, a player's optimal mechanism can be implemented by a first-and-final offer. This is not true in the case of a double-stepped function which calls for a dual-price, stochastic bargain. This raises the question whether one can identify a simple bargaining procedure which implements the double-stepped mechanism. Toward this end, it is convenient to define a class of *simple* bargaining procedures as follows.

(i) Each side makes a price offer or perhaps a series of price offers. These can be simultaneous or sequential. An offer once made remains outstanding and cannot be withdrawn.

(ii) If at any time during the bargaining the buyer's highest price offer T_b exceeds the seller's lowest offer T_s, an agreement is reached at transfer price T according to a predetermined function of T_b and T_s and such that $T_s \leq T \leq T_b$.

Any bargaining procedure based on offers and counter offers (i.e. haggling) belongs to this class as does a first-and-final offer (where T depends only on the offerer's price). We are now ready to present a final proposition.

PROPOSITION 3: *An optimal mechanism for which $p(\cdot)$ is double-stepped cannot be implemented by a simple bargaining procedure.*

DEMONSTRATION: The proof is by contradiction. Suppose that there is a simple bargain G which insures that the good is sold at price T_1 with certainty for $v \in V_1$ (the lower interval) and sold with probability p^* at price T_2 for $v \in V_2$ (the upper interval), where $T_2 > T_1$. (Note that it must be the case that $T_2 = \hat{v}$, where $\hat{v}$ is the upper support of V_2, since at this "worst" value the seller should make a zero profit.) Sales at price T_2 can be supported if and only if one or both parties employ randomized strategies. We shall show that such randomization is not an equilibrium strategy for either player. First, consider the buyer's strategy. If G is to implement $p(\cdot)$, then the buyer must offer $T_b \geq T_2$ with probability greater or equal to p^* when $v \in V_2$. In fact, any such offer must exactly equal T_2 and must be made with exactly probability p^*. If the buyer offered $T_b > T_2$ with positive probability, a seller holding $v = \hat{v}$ could offer T_s such that $\hat{v} < T_s \leq T_b$ and earn a positive profit, contradicting the optimality requirement that $\pi_s(\hat{v}) = 0$. Similarly, if the buyer's probability exceeds p^*, a seller holding $v \in V_2$ could profit by offering $T_s = T_2$ with probability one. This would imply $p(\cdot) \geqslant p^*$ on the interval—a contradiction.

Supposing the seller holds $v \in V_2$ and the buyer offers $T_b = T_2$ with probability p^* (by the above argument), then if G is to implement $p(\cdot)$, the seller must offer $T_s = T_2$ with certainty. But if this is the case, the buyer will have an incentive to deviate from the prescribed strategy. Since he earns a positive profit from sales at T_2 for $v \in V_2$, he can increase his expected profit (above zero) by increasing the frequency which he offers $T_b = T_2$ to a level above p^*—a contradiction. In short, neither side has an incentive to employ the mixed strategy necessary to support the probability step for which $0 < p(v) < 1$.

The circumstances in which double-stepped probability functions are optimal can be readily identified. Roughly speaking, a dual-price agreement offers advantages in circumstances when a single unconditional offer (for instance, a buyer or seller first-and-final offer) would miss much of the potential gains from trade. In Example 2 where the buyer's comparative advantage rises sharply with increases in v, neither of the unconditional price offers $T_s = .6$ or $T_s = 1.0$ is acceptable (i.e. individually rational) for the buyer. By contrast, the stated dual-price bargain is buyer-acceptable and captures the maximal portion of the potential gains from trade. Furthermore, though only the two extreme points of the expected profit frontier have been investigated, our results extend to points in between as well. Consider the problem of maximizing π_s subject to $\pi_b \geq k$ in Example 2. It is easy to check that the optimal probability function remains double-stepped as k increases until the buyer's maximum profit is attained. Specifically, the optimal mechanism is

$$p(v) = \begin{cases} 1, \\ .5 - 25k, \end{cases} \qquad t(v) = \begin{cases} .6 - 20k, & \text{for} \quad v \in [0, .2], \\ 1.0 & \text{for} \quad v \in (.2, 1.0]. \end{cases}$$

Note that in accordance with Proposition One, the mechanism becomes single-stepped at $k = .02$, the buyer's maximum profit.

The implementation of a double-stepped mechanism requires a kind of bargaining contract—a prior agreement concerning the means of determining whether or not a sale takes place and at what price. This bargaining contract is built on a number of binding promises. In Example 2, buyer and seller agree to forego sales fifty per cent of the time for $v \in (.2, 1.0]$, though on average both sides profit from such agreements. For $v \in [0, .2]$, the seller limits his price demand to $T_s = .6$ which the buyer agrees to accept, though this means he suffers a loss on average. It is precisely this requirement of binding promises that prevents an optimal dual price agreement from being implemented by a simple bargain.

4. CONCLUDING REMARKS

The presence of asymmetric information has important implications for individual bargaining behavior. In order to calculate correctly his payoff, the uninformed player must anticipate and draw the proper inferences from the behavior of his informed opponent. In turn, the informed player's objective is to attain a maximal profit while providing his uninformed counterpart an incentive to participate. The optimal bargaining strategy of the uninformed player is to make a first-and-final offer—a result which holds in a prescribed set of circumstances for the informed player as well.

The analysis also sheds light on the tension between the opportunity for mutual gain and the impact of asymmetric information in bargaining situations. Indeed, our results rebut the presumption of "property rights" proponents that bargaining offers a sufficient remedy in cases of market failure. The bargaining mechanism, like the market mechanism, is limited by informational constraints. The presence of asymmetric information may preclude the attainment of mutually beneficial agreements, even though profitable exchanges are known to be available ex post.

Finally, our investigation shows that even when mutually beneficial agreements are attainable, the familiar bargaining procedures used in every day practice may not be the best way of achieving them. In cases when an optimal bargaining procedure depends on a two-part pricing scheme, simple bargains are inadequate. This is a somewhat surprising result in view of the fact that simple bargains have a number of appealing properties. The exchange of price offers is relatively easy, purely voluntary, and not revealing (at least directly) of the players' proprietary information. Paradoxically, it is precisely the freedom to make unconstrained price offers that prevents simple bargaining procedures from being fully efficient—this due to the fact that certain desirable agreements cannot be supported as equilibria.

Overcoming this bargaining dilemma requires the use of a pact based on mutually binding promises—a mechanism which more closely resembles settlement by binding arbitration (either self-imposed or imposed by a third party) than an agreement reached by the free exchange of offers. Indeed, the transaction cost of implementing such a pact may be significant or even prohibitive. This may explain why arbitration is often viewed as a last resort in practice, though in principle it offers a first best solution.

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