

Bargaining Before or After Communication?

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Abstract

We ask how bargainers' incentives to communicate about more efficient widget designs depend on whether they negotiate price prior to, or after, fixing the traded design. We find three effects: (1) Since communication reveals information about preferences, bargainers with little power prefer to remain quiet prior to bargaining. (2) Later bargaining gives communicators a chance to share in joint gains from more efficient trades. (3) The revealed preference information enhances the efficiency of the bargaining process. The comparison might help explain why some contracts have more features left incomplete and throw some light on the nature of the employment relationship.

I. INTRODUCTION

Most reasonable people would agree that bargaining is costly and by implication that rational agents can be expected to take steps to avoid or minimize these costs. It has, however, proven difficult to build a satisfactory theory of bargaining avoidance. The challenges include modeling the costs of bargaining, accounting for its advantages, and comparing to alternative trading institutions. We will here take a small step in this direction. In particular, we look at a context in which identification of efficient trades requires communication and ask whether bargaining should take place before or after this communication. The question is of obvious theoretical interest, but could also be mapped into recent theories of the firm (Bajari and Tadelis, [2001]; Bolton and Rajan, [2001]; Tadelis, [2002]; Wernerfelt, [1997]) by identifying “bargaining before communication” with employment relationships and “bargaining after communication” with arms length contracts.

The costs of bargaining after communication are that the players may withhold certain types of information. We will call this the “bargaining power effect”. The essential idea is that communication carries a signal about a player’s preferences and therefore reduces his expected share of gains from trade. Consistent with this argument Busse, Silva-Risso, and Zettelmeyer [2006], and Scott-Morton, Zettelmeyer and Silva-Risso [2005] show that better-informed bargainers get bigger shares of surplus, while Simester and Knez [2002] show that firms take steps to restrict communication between employees and outside trading partners.

The costs of bargaining prior to communication are twofold. One straightforward problem is that the terms of trade can not be changed to reflect the content communicated. Players will thus only communicate information that is beneficial to them under the agreed upon terms of trade. With bargaining after communication, one would expect agreement on terms under which the players share the gains from trade. We will call this the “incentive transfer effect”. A more subtle effect follows from the fact that communication reveals information about preferences. This implies that ex ante bargaining is based on less information such that the bargaining process itself may be less efficient. We call this the “bargaining efficiency effect”.

Summarizing, we identify three effects of the order of bargaining and communication. Bargaining after communication is

- (1) unattractive, because senders prefer opponents with bargaining power to know as little about their preferences as possible (the bargaining power effect),
- (2) attractive, because the ability to negotiate for a share of the gains from a trade can give a player incentives to help implement it (the incentive transfer effect), and
- (3) attractive, because the revealed information contributes to the efficiency of the bargaining process (the bargaining efficiency effect).

The relative magnitudes of these effects depend, among other things, on the extent to which communication reveals preferences, the gains from communication, and the players’ relative bargaining power. Our purpose is to identify circumstances under which bargaining should and should not precede communication.

With an eye to applications to the theory of the firm, we make our argument in the context of a bilateral monopoly. The seller can always design a “low quality” widget, but

there is some chance that the he also discovers the design for a “high quality” version. The seller offers a specific design to the buyer, and the parties will trade that or nothing. In the “Ex Ante Bargaining” game form, the players negotiate a price before the seller selects the design, while the sequence is reversed in the “Ex Post Bargaining” game form. If the seller finds the high quality design, it is more valuable for the buyer, but may or may not be more costly to produce. So if the price is agreed upon ex ante, the seller may not offer it (communicate about it) if it is more expensive for him, even though this may be inefficient. However, ex post bargaining may help the seller by allowing him to appropriate part of the incremental value; particularly if he has bargaining power. This then gives him incentives to communicate even if the high quality design is unattractive on a strict cost-basis. However, the argument is complicated by the fact that the buyer can use the seller’s communication-decision to make inferences about his costs of the two designs. If he proposes the high quality design, it must be cheap to make, and if he does not, the low quality design must be cheap. Because the seller finds the high quality design with probability less than one, the buyer learns more if the seller offers that: He will only offer the high quality design if it is cheap, but may offer the low quality design if it is cheap or if he failed to find the high quality design. To the extent that the buyer has bargaining power, this reduces the seller’s incentives to communicate.

While the comparison of ex ante versus ex post bargaining is our main focus, it is obviously important that we can restrict attention to these two game forms. This suggests a couple of questions. First, why don’t the players negotiate a pair of prices? In the game form with ex ante bargaining, we rule this out by assuming that specific designs only are contractible after being described by the seller (in the context of making an offer). Ex ante contracts can only specify that the widget is “working”, so the seller will always deliver the design that is cheapest for him. In the game form with ex post bargaining, the players are under some time-pressure, such that the seller can describe at most a single design, thus making it impossible to negotiate over more than one. Secondly, how about the possibility of renegotiation of ex ante bargains? Since the ex ante contract is assumed to be binding, neither player can demand renegotiation without the consent of the other. In particular, the buyer can not insist on a lower price upon being offered the low quality design. It is, however, possible that the seller could demand a higher price after offering the high quality design, implicitly threatening to deliver low quality instead. To rule this out, we show that anticipated renegotiation may be unattractive for the seller. If renegotiation is observable, we can then sketch an argument according to which a renegotiating seller would incur sufficiently severe reputational penalties to make it unattractive to do so.

After discussing some related literature in Section II, we present the core argument in Section III, looking at a model in which the buyer has bargaining power. The analysis shows that Ex Post Bargaining is better when design differences are larger and communication is less revealing, while Ex Ante Bargaining is better when design differences are smaller and communication is more revealing. We show in Section IV that more communication also can be implemented by reallocation of bargaining power to the buyer. However, we argue that this alternative instrument is likely to be quite blunt. More sophisticated contracts, an application to the theory of the firm, and empirical evidence is discussed in Section V. We end with a brief conclusion in Section VI.

II. RELATED LITERATURE

The most closely related paper is by Gertner [1999], who also is concerned with withholding of information. He compares a game form with a neutral arbitrator (“a firm”) and an asymmetric game form in which one party has control (“a market”). So information is sent to a neutral party in one, but an adversary in the other. Ergo, less information is sent in the latter case. In the present paper, information is always sent to an adversary, but either after or before bargaining. Depending on parameter values, we find that there may be more communication before or after bargaining. On the other hand both papers predict that concerns about bargaining power *ceteris paribus* will hamper communication.

Our effects are known from other contexts, but we here interpret them differently and in many cases reverse the direction of the argument. The bargaining power effect is a cost of *ex post* bargaining (renegotiation) and as such fits into a large literature on the appropriate allocation of bargaining power. Most work in the area is concerned with hold up problems, but Farrell and Gibbons [1995] look at the incentives to communicate. They invoke intuition similar to ours and show that intermediate allocations of bargaining power are necessary to give both parties incentives. The present analysis is different because we are varying the game form - comparing *ex ante* and *ex post* bargaining – while holding bargaining power fixed. In fact, our version of the bargaining power effect is more closely related to the idea that offering a contract reveals information about the offerer as in Aghion and Bolton [1987] and Hermalin and Katz [1993]. Another way to limit the harm done by the possibility of *ex post* bargaining is to commit against it and a number of other papers have shown how such a commitment can be sustained by a commitment not to acquire certain pieces of information (Cremer, [1995], Dewatripont and Maskin, [1995]; Spier, [1992]). The bargaining power effect studied in this paper makes the causality go the other way: A commitment not to bargain *ex post* influences the amount of information revealed.

The incentive transfer effect plays a role in models in which incentive systems may cause agents not to reveal information that is of value to their principals (Dewatripont and Tirole, [1999]; Rotemberg and Saloner, [1993]). These arguments are variants of the hold-up problem. If only one player has search costs, *ex post* bargaining can be bad, because it may prevent a player from getting enough expected surplus to warrant the specific investment. In the present paper we highlight the opposite case in which it may be efficient to spread the surplus in *ex post* bargaining, rather than concentrate it in *ex ante* bargaining. This then provides a possible rationale for contractual incompleteness. Finally, the bargaining efficiency effect is exploited in a lot of signaling and screening games in which revelation of a player’s type allows implementation of previously impossible trades (Akerlof, [1970]; Rothschild and Stiglitz, [1976]; Spence, [1973]; and more recently Creane and Davidson, [2006]).

III. BASIC MODEL

A seller and a buyer may trade a widget. The seller can design a “low quality” widget for sure, and finds an additional, “high quality” design with probability $\alpha < 1$. The buyer values the former design at 1 (one) and the latter at $h > 1$. The seller incurs costs c_l for the low quality design and c_h for the high quality design. These costs are privately known, but i.i.d. draws from a C^2 distribution F over $[0, 1]$. The nature and feasibility of

the designs is the private information of the seller. However, he may offer one of the designs to the buyer, and the offer is assumed to involve significant description, such that the players can contract on a specific design once an offer has been made. We assume that it takes time to adequately describe a design and that the players are under some time-pressure *ex interim*, such that the seller therefore can make at most one offer. Prior to an offer, a contract can only specify that the widget “works”, a property shared by both designs.

Because she can invert the seller’s equilibrium strategy, the buyer may get information about the relative magnitudes of c_l and c_h from the quality of the design offered by the seller. In particular, if the seller offers a high quality design, the buyer will be able to conclude that c_h is low relative to c_l . Since it is possible that the seller can not produce the high quality design ($a < 1$), the buyer learns less if the seller offers low quality, because it leaves open the possibility that c_l is “high”.

We model the bargaining game by assuming that one of the players has all the bargaining power and makes a take-it-or-leave-it (TIOLI) offer. In this Section, we assume that the buyer makes the offer. This negotiation mechanism is clearly arbitrary and in general less than second best. However, it is very simple to work with, and it has the property that bargaining is more efficient when players have better information, such that we can isolate the bargaining efficiency effect. Our assumptions imply that the players bargain over a single price in either game form. Under *Ex Ante Bargaining*, it is not possible to contract on a specific design, and under *Ex Post Bargaining*, time-pressure means that the seller can describe at most one design. We have thus ruled out design-contingent prices. We will address the possibility of renegotiation in the final Subsection.

Given the situation described above, we will compare two game forms. In the “*Ex Ante Bargaining*” game form, the players make decisions about the design in light of an already agreed upon price. Conversely, price is negotiated after the design is chosen in the “*Ex Post Bargaining*” game form. It is clearly possible to look at a number of other game forms. In particular, one could imagine a game form with some intermediate degree of commitment (Aghion and Tirole, 1997; Rogoff, 1985) to an *ex ante* negotiated contract. However, as a first cut, we will focus on a comparative analysis of the two extreme cases with full and no commitment. We will confine attention to pure strategy equilibria.

The *Ex Ante Bargaining* game form is defined by the following six stages:

1. The players write a contract, which says that the seller, if the buyer wants him to, will deliver a working design to the buyer in return for a payment of w_A . The players negotiate w_A according to the bargaining mechanism described above. If negotiations fail, the game ends with (seller, buyer) payoffs (0, 0).
2. The seller learns whether or not he can produce the high quality design.
3. The seller learns his costs for the low quality design, and if he can produce it, those for the high quality design as well.
4. The seller offers a design to the buyer.
5. The buyer may ask him to deliver the offered design. Otherwise, the game ends with total (seller, buyer) payoffs (0, 0).

6. The seller delivers the design in question, and the (seller, buyer) payoffs are $(w_A - c_h, -w_A + h)$ when the high quality design is delivered, and $(w_A - c_l, -w_A + 1)$ when the low quality design is delivered.

The *Ex Post Bargaining* game form is identical except that bargaining takes place after the design has been determined. It is formally defined as follows:

1. The seller learns whether or not he can produce the high quality design.
2. The seller learns his costs for the low quality design, and if he can produce it, those for the high quality design as well.
3. The seller offers a design to the buyer.
4. The buyer may ask to buy the offered design. If she does not ask for any design, the game ends with total (seller, buyer) payoffs $(0, 0)$.
5. The players write a contract specifying that the seller will get a price in return for delivering the offered design. They negotiate the price according to the bargaining mechanism described above. If negotiations fail, there are no further payoffs and the game ends with total (seller, buyer) payoffs $(0, 0)$.
6. The seller delivers the design in question, and (seller, buyer) payoffs are $(w_H - c_h, -w_H + h)$ when the high quality design is delivered, and $(w_L - c_l, -w_L + 1)$ when the low quality design is delivered.

The first best calls for the high quality design to be chosen when $h - c_h > 1 - c_l$ and for all bargains to succeed. However, both game forms will have trouble inducing the seller to propose the high quality design in sufficiently many cases, and both will suffer some failed bargains. Since the Ex Ante Bargaining game form is easier to analyze, we look at that first.

The Ex Ante Bargaining Game Form.

With ex ante bargaining, communication and choice can not influence bargaining, so the equilibrium is relatively simple. Analyzing from the back, we first assume that the price is less than 1. In this case, the buyer will always want the high quality design because she values it more than the low quality design or the price. The seller will propose the high quality design whenever $c_h < c_l$ and he will agree to the contract if the price is larger than the smaller of the two costs. If $F_2 = 2 \int_0^w \int_w^1 dF dF$ is the cdf of the smaller of two draws from F , the buyer's best TIOLI offer below 1 will be

$$\begin{aligned} w_A &= \text{Argmax}[a(h/2 + 1/2 - w)\text{Prob}(\text{Min}\{c_l, c_h\} < w) + (1 - a)(1 - w)\text{Prob}(c_l < w)] \\ &= \text{Argmax}[a(h/2 + 1/2 - w)F_2(w) + (1 - a)(1 - w)F(w)] \end{aligned} \quad (1)$$

Since this is independent of the realized costs, the seller offers the high quality design iff he can produce it and $c_h < c_l$. The probability of this is $a/2$.

If the price exceeds 1, the seller will always take the offer, the buyer will only want to trade for the high quality design, and the seller will propose it if possible. So by setting the price slightly above 1 ($w_A = 1^+$), the buyer can commit herself to refusing any trade for the low quality design and thus induce the seller to propose the high quality design with probability a . Since this guarantees her close to $a(h - 1)$ in expected payoff, she will prefer it if

$$a(h - 1) > a(h/2 + 1/2 - w_A)F_2(w_A) + (1 - a)(1 - w_A)F(w_A), \quad (2)$$

where w_A is defined by (1). After using the envelope theorem and doing a bit of algebra, we can see that (2) is more likely to hold for larger values of h and a . This makes intuitive sense. When h and a are large, the high quality design promises large expected payoffs and the buyer is willing to pay extra and forgo the low quality design for the chance to cash in on the high quality version. We can summarize this in

Result A: *The Ex Ante Bargaining game form has a unique equilibrium and the seller offers the high quality design with probability a or $a/2$ depending on whether or not (2) is satisfied.*

The Ex Post Bargaining Game Form.

The game form with ex post bargaining is in general much more complicated. The seller's decision about whether or not to offer the high quality design depends on $(c_l, c_h) \in [0, 1]^2$, and the buyer's TIOLI offers in turn depends on the posterior cost distributions induced by the equilibrium offer strategy. Fortunately, the following Lemma greatly simplifies the analysis.

Lemma: *In any equilibrium, there exists a $q \hat{I} [-1, 1]$, such that the seller's equilibrium strategy is to offer the high quality design iff $c_h - c_l < q$.*

Proof: Let w_H and w_L be the buyer's TIOLI offers for the high and low quality designs, respectively. Since the buyer's offers reflect only her beliefs about the seller's offer strategy and do not change with the actual strategy, it is a dominant strategy for the seller to offer the high quality design iff he can produce it and $c_h - c_l < w_H - w_L$. **QED**

We can solve the game backwards under the assumption that the seller's offer strategy is completely characterized by the parameter $q \hat{I} [-1, 1]$. To find the buyer's TIOLI offers in stage 5, we look for the posterior cost distributions as functions of q . There are two possible histories up to stage 5.

History L: The seller offered the low quality design. This leaves open two cases. One is that the seller did not find the high quality design, and the other is that he found it but has chosen not to offer it. To construct the posterior distribution of c_l , we start by finding the posteriors conditional on each of these cases. The former case is easy: If the seller did not offer the high quality design because he did not find it, the probability that $c_l < w$ is just $F(w)$. This is illustrated in Figure 1 below for the special case in which F is uniform.

1 - ?

- ?

Since the buyer can not know whether or not the seller found the new design, she will make her TIOLI offer based on the unconditional posterior. We can find the posterior probabilities that the seller did not find the high quality design as

$$b(q) \equiv (1 - a) / [1 - a + a(\int_0^{1+q} \int_0^{x-q} dF dF(x) + \int_{1+q}^1 dF)] \text{ for } q < 0, \text{ and}$$

$$\equiv (1 - a) / [1 - a + a(\int_0^1 \int_0^{x-q} dF dF(x))] \text{ for } q > 0.$$

Given this, the posterior distribution of c_l is

$$F_L(w|q) \propto b(q)F(w) + [1 - b(q)] \int_0^w \int_{x+q}^1 dF dF(x) / \int_0^1 \int_{x+q}^1 dF dF(x) \text{ for } q > 0 \text{ and } w < 1 - q,$$

$$\propto b(q)F(w) + [1 - b(q)] \int_0^w dF / [\int_0^{-q} dF + \int_{-q}^1 \int_{x+q}^1 dF dF(x)] \text{ for } q < 0 \text{ and } w < -q,$$

and

$$\propto b(q)F(w) + [1 - b(q)] [\int_0^{-q} dF + \int_{-q}^w \int_{x+q}^1 dF dF(x)] / [\int_0^{-q} dF + \int_{-q}^1 \int_{x+q}^1 dF dF(x)] \text{ for}$$

$$q < 0 \text{ and } w > -q.$$

So we can find the buyer's TIOLI offer after History L as

$$w_L(q) \equiv \text{Argmax}(1 - w)F_L(w|q). \quad (3)$$

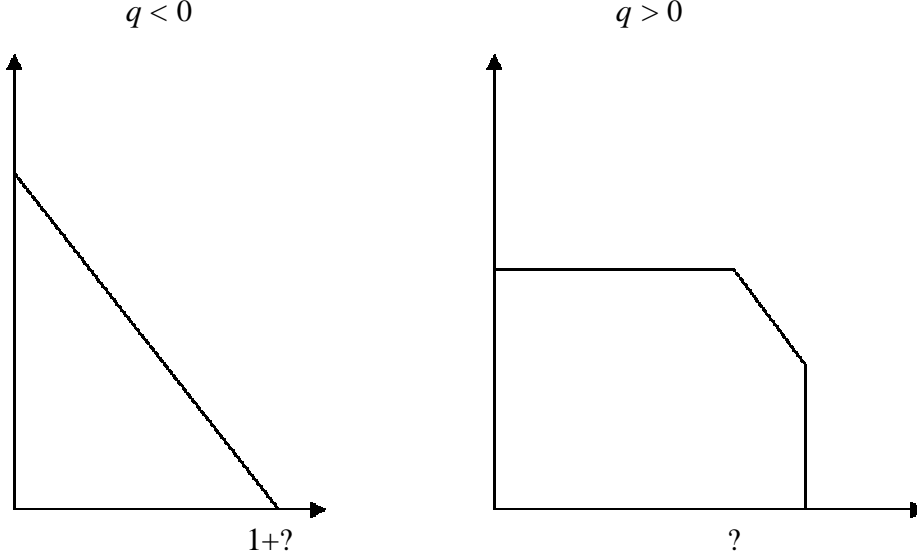
We can use standard tools to derive several properties of the buyer's expected payoff and his offer. Note first that both are continuous functions of a , that b is decreasing in a , and that the distributions $\int_0^w \int_{x+q}^1 dF dF(x) / \int_0^1 \int_{x+q}^1 dF dF(x)$, $\int_0^w dF / [\int_0^{-q} dF + \int_{-q}^1 \int_{x+q}^1 dF dF(x)]$, and $[\int_0^{-q} dF + \int_{-q}^w \int_{x+q}^1 dF dF(x)] / [\int_0^{-q} dF + \int_{-q}^1 \int_{x+q}^1 dF dF(x)]$, all dominate $F(w)$ on $[0, 1]$. So we can appeal to the implicit function theorem to first conclude that the buyer's expected payoff is an increasing function of a , and then (after some algebra) that w_L is weakly decreasing in a . Neither result is surprising, because larger values of a increases the likelihood that the buyer is facing a more favorable cost-distribution.

The effects of q are more complicated. The buyer's expected payoff and his offer are both continuous functions of q , but it affects (3) in two different ways. Reflecting the fact that $b(q)$ is increasing, higher values of q increase the posterior probability that the seller had no choice, implying that the buyer more likely faces the unattractive (uniform) cost distribution. Facing a less attractive cost distribution will lower the buyer's expected payoff and increase w_L . However, if the seller had a choice and decided against offering the high quality design, the distribution faced by the buyer is more attractive for higher values of q . Facing a more attractive cost distribution will increase the buyer's expected payoff and lower w_L . Bayes' rule tells us that the former force, which we will call the bargaining power effect, dominates for small a , while the latter force dominates for large a . So when a is close to zero, the buyer's expected payoff are decreasing in q , while w_L is increasing in q . Conversely, the buyer's expected payoff are increasing in q , while w_L is decreasing in q when a is close to one.

History H: The seller offered the high quality design. If $q < 0$, the posterior probability that $c_h < w$ is $\int_0^w \int_{x-q}^1 dF dF(x) / \int_0^{1+q} \int_{x-q}^1 dF dF(x)$ for $w < 1 + q$. If $q > 0$, it is $\int_0^w dF / [\int_0^{-q} dF + \int_{-q}^1 \int_{x-q}^1 dF dF(x)]$ for $c_h < ?$, and $[\int_0^{-q} dF + \int_{-q}^w \int_{x-q}^1 dF dF(x)] / [\int_0^{-q} dF + \int_{-q}^1 \int_{x-q}^1 dF dF(x)]$ for $c_h > ?$. The densities are illustrated in Figure 3 below for the case in which F is uniform.

Figure 3

Conditional posterior densities of c_h if seller offered the new design ($F=U$)



If we denote this distribution by F_H , the buyer's TIOLI offer will be

$$w_H(q) = \text{Argmax}(h - w)F_H(w|q). \quad (4)$$

The buyer's expected payoffs and his offer are once again continuous functions of q . As q increases, the density becomes less favorable, implying that the buyer's expected payoffs are decreasing in q , while w_H is increasing in q .

The seller will offer the high quality design iff $w_H(q) - c_h > w_L(q) - c_l$. According to the Lemma, an equilibrium is defined by a q^* satisfying

$$q^* \hat{I} \{w_H(q^*) - w_L(q^*), 1\}. \quad (5)$$

It is tedious, but trivial, to go through all the different cases of (3) and (4) to establish that $w_H(q) - w_L(q)$ is continuous. The same two equations tell us that $w_H(-1) = 0$, $w_L(-1) = 1 - F/F' < 1$, $w_H(1) = \text{Min}\{1, h - F/F'\}$, and $w_L(1) = 1 - F/F'$. If $h < 2$, the existence of a solution to $q = w_H(q) - w_L(q)$ then follows from the continuity of $w_H(q) - w_L(q)$, $w_H(-1) - w_L(-1) = F/F' - 1 > -1$, and $w_H(1) - w_L(1) = h - 1 < 1$. If $h = 2$, then $q^* = 1$. The equilibrium features negative values of q^* ($w_H < w_L$) in cases where the high quality design only is offered when it is extremely cheap to make.

We can summarize the above analysis in:

Result P: *The Ex Post Bargaining game form has at least one equilibrium. Any equilibrium is characterized by a $q^* \hat{I} [-1, 1]$ and the seller offers the high quality design if he finds it and iff $c_h - c_l < q^*$. The probability of this is increasing in q^* , a , and h . Furthermore, q^* is negative when h and a are small and $q^* = 1$ when h is large.*

The result combines at least two interesting effects. First, the seller is more likely to offer the high quality design for large values of h due to the “incentive transfer” effect. Because the buyer wants to be sure that her offer is accepted, she will bid more and thus transfer some of the incentives to the seller. Secondly, if a is small, the “bargaining power” effect may cause the seller to offer the low quality design even if $c_h < c_l$. This allows him to extract a better price by hiding behind the $1 - a$ probability that he did not find the high quality design. We get $q^* > 0$ and a greater tendency to offer the high quality design when the incentive transfer effect overwhelms the bargaining power effect.

Comparison

It is difficult to make a global comparison with the two game forms, but we can characterize the seller’s relative propensity to offer the high quality design in different regions of the parameter space. If h and a are very large, condition (2) will hold for Ex Ante Bargaining and $q^*=1$ for Ex Post Bargaining, such that sellers in both game forms will offer the new design with probability a (whenever possible). However, the choice of game form makes a difference for less extreme parameter values. (i) If h is large, the seller will offer the high quality design with probability a with Ex Post Bargaining and $a/2$ with Ex Ante Bargaining. (ii) If h is small, the probability is less than $a/2$ with Ex Post Bargaining and $a/2$ with Ex Ante Bargaining.¹ (iii) If a is small, the seller will offer the high quality product with probability $a/2$ with Ex Ante Bargaining, but with probability less than $a/2$ with Ex Post Bargaining (iv) If a is high, the probability is still $a/2$ with Ex Ante Bargaining, but more than $a/2$ with Ex Post Bargaining The comparison shows that Ex Post Bargaining is better when design differences are larger and communication reveals less information, while Ex Ante Bargaining is better when design differences are smaller and communication reveals more information. We can intuitively understand this as a result of the tradeoff between the incentive transfer effect and the bargaining power effect.

Renegotiation

Since neither game form gives the first best for all parameter values, it is tempting to look for alternatives in which prices can be appropriately aligned with qualities. We have ruled out design contingent prices in both game forms. Two-price versions of Ex Ante Bargaining are not feasible, because contracts at that point can not distinguish between high and low quality, and two-price versions of Ex Post Bargaining are not possible because the players have limited time ex interim, such that it is impossible for the seller to communicate more than a single design.

We will here look in some detail at another possibility: That the players ex post renegotiate the price set by Ex Ante Bargaining. There are two scenarios. If the seller offered a low quality design, the buyer may want to renegotiate, but the seller will not agree to a lower price since he can insist on the original contract. If the seller has offered a high quality design, he can threaten to supply the low quality design unless the buyer agrees to up the price. In a game form with this possibility, the initial bargain will be for

¹ Ex Post Bargaining may be more efficient in some cases when $q^* < 0$ because the buyer makes her TIOLI offer with better information. However, the Ex Ante Bargaining game form will be more efficient for sufficiently small values of h .

the low quality design only, since a different high quality price will be set later. So we are effectively back to a two-price situation. We will now briefly analyze this *Renegotiation Game Form* defined by the following seven stages:

1. The players write a contract, which says that the seller, if the buyer wants him to, will deliver a working design to the buyer in return for a payment of w_l . The players negotiate w_l according to the same TIOLI bargaining mechanism as in the two other game forms. If negotiations fail, the game ends with (seller, buyer) payoffs $(0, 0)$.
2. The seller learns whether or not he can produce the high quality design.
3. The seller learns his costs for the low quality design, and if he can produce it, those for the high quality design as well.
4. If the seller can produce the high quality design, he offers it to the buyer together with a request to renegotiate the price to w_h . Otherwise he offers the low quality design.
5. If the high quality design was offered, the players negotiate w_H according to the TIOLI bargaining mechanism. If these negotiations fail, the original contract is still in force.
6. The buyer may ask the seller to deliver the contracted upon design. Otherwise, the game ends with total (seller, buyer) payoffs $(0, 0)$.
7. The seller delivers the design in question, and the (seller, buyer) payoffs are $(w_h - c_h, -w_h + h)$ when the high quality design is delivered, and $(w_l - c_l, -w_l + 1)$ when the low quality design is delivered.

We solve from the back, starting with stage 5. To keep the analysis as transparent as possible, we look at the simple case in which F is uniform. If w_l is the price from the ex ante contract, the buyer's TIOLI offer for the high quality design will be

$$\begin{aligned}
 w_h &= \text{Argmax}\{ \text{Prob}(w - c_h > \text{Max}\{0, w_l - c_l\})(h - w) + \text{Prob}(w_l - c_l > \text{Max}\{0, w - c_h\})(1 - w_l) \} \\
 &= \text{Argmax}\{ (h - w)[w_l(w - w_l/2) + (1 - w_l)w] + (1 - w_l)w_l(1 - w + w_l/2) \} \\
 &= [3w_l^2/2 + h - w_l]/2 \tag{6}
 \end{aligned}$$

In stage 1, if the buyer was myopic, her TIOLI offer for the low quality design would be $\text{Argmax}[\text{Prob}(w - c_l > 0)(1 - w)] = 1/2$. However, a rational buyer will bid less since the bid with probability a will compete with her own later bid for the high quality design. After substituting $w_h(w_l)$ into (7) and adding the possibility that the new design is not found, we get

$$\begin{aligned}
 w_l &= \text{Argmax}\{ (h/2 - 3w/4 + w/2)[w(3w^2/4 + h/2 - w) + (1 - w)(3w^2/4 + h/2 - w/2)] \\
 &+ (1 - w)w(1 - 3w^2/4 - h/2 + w) + w(1 - w)(1 - a)/a \} \\
 &= \text{Argmax}\{ 9w^4 - 20w^3 - 4[1 + h + 4(1 - a)/a]w^2 + 8[2 - h + 2(1 - a)/a]w + 4h^2 \} \tag{7}
 \end{aligned}$$

By the implicit function theorem, we see that w_l is decreasing in h and a . This makes intuitive sense. If the high quality design is very valuable to the buyer, she wants to reduce the risk that the seller prefers to trade the low quality version, and this concern has more weight the more likely it is that the high quality design will be offered. In fact, if $h = 2$, we see from (6) and (7) that $w_l \rightarrow 0^+$ and $w_h \rightarrow 1^-$ as $a \rightarrow 1^-$.

Since it is difficult to perform a global comparison of the Renegotiation game form and the Ex Ante Bargaining game form, we will look at the above-mentioned special case in which $h = 2$ and $a \rightarrow 1^-$. Since (2) holds, the TIOLI offer under Ex Ante

Bargaining will be I^+ , and both game forms will implement trades for the high quality design only. The seller's expected costs are $\frac{1}{2}$ and his payoffs are $1^- - 1/2$ and $1^+ - 1/2$. Since the latter is larger (recall that everything is continuous), the seller prefers the Ex Ante Bargaining game form. So at least in some areas of the parameter space, the seller wants the buyer to assume that he will make no attempt to renegotiate an ex ante negotiated price.

We can use this fact to sketch a justification for the commitment inherent in the Ex Ante Bargaining game form. In particular, we will assume that the seller expects to do future business with other buyers, that these buyers can observe any attempt at renegotiation, and that the future trades may be in the relevant areas of the parameter space. The argument would then proceed along the lines that the seller will refrain from renegotiating in order to preserve his reputation for not doing so.

IV. THE SELLER HAS POWER

To see how the effects are driven by the allocation of bargaining power, we now look at the case in which the seller makes the TIOLI offer.

The Ex Ante Bargaining Game Form

Again analyzing from the back, we first assume that the price is less than or equal to 1. In this case, the buyer will always want the high quality design, the seller will offer it whenever $c_l > c_h$, and he will want to deliver if the price is larger than the smaller of the two costs. If the price exceeds 1, the buyer will only want to trade for the high quality design, the seller will always want to deliver, and the seller will propose it if possible. When the seller makes the TIOLI offer, call w_s , he will want to set it equal to 1 if

$$1 - (1 - a)E(c_l) - aE\text{Min}\{c_l, c_h\} > a(h - E(c_h)), \quad (8)$$

and otherwise equal to h . So $w_s = 1$ for small values of h and a . In such cases, the seller offer the high quality design iff he can produce it and $c_h < c_l$. For larger values of h and a , the seller sets $w_s = h$ and then offers the high quality design whenever he can make it. Simplifying (8) and summarizing, the probability of the seller offering the high quality design is $a/2$ or a depending on whether or not $h < (1 - \int_0^1 x dF)/a + 2 \int_0^1 x dF - \int_0^1 y dF_2$.

Compared to the case in which the buyer makes the TIOLI offer we find the same basic effect. When h and a are large, the high quality design promises a lot of expected surplus and the price is set to ensure that the probability of offering it is as large as possible. For smaller values of one or both of the parameters, the probability is again $a/2$.

The Ex Post Bargaining Game Form

Since the seller makes his TIOLI offer with complete information, it is obvious that he will charge 1 for the low quality design and h for the high quality design. This makes the analysis of the Ex Post Bargaining game form much easier. Note first that the Lemma continues to hold. Assuming that the buyer wants delivery whenever possible, the seller's expected payoffs from offering the high quality design are $h - c_h$, while they are $1 - c_l$ if he offers the low quality design. It is a dominant strategy for him to offer the high quality design iff he can produce it and $c_h - c_l < h - 1$. So $q^* = \text{Min}\{h - 1, 1\}$, and the

probability of the seller offering the high quality design is a if $h > 2$, while it is $a[F(h-1) + \frac{1}{h-1} \int_0^{x-h+1} dF dF(x)]$ for $h \in [1, 2]$.²

Comparing with the case in which the buyer makes the TIOLI offer we here see a somewhat different picture. The communication and offer strategies implement the first best and neither the bargaining power effect nor the incentive transfer effect plays any role. This is once again intuitively appealing, since all the bargaining power and therefore all surplus is given to the player who communicates. The distortions discussed in Section III appear because communication and power are misaligned.

The finding that communication can be induced by an appropriate allocation of bargaining power is consistent with Farrell and Gibbons [1995]. There are, however, many reasons to doubt the feasibility of this solution: (i) Bargaining power may not be a control variable, for example if it is tied to market position. (ii) Other forces, such as a desire to minimize hold up problems, may influence the optimal allocation of bargaining power. (iii) The parties may be communicating about several issues, suggesting different allocations of power. (iv) There may be uncertainty on both sides. For example, suppose that h equals R_h with probability λ and otherwise is one. In this case the seller's TIOLI offer will be R_h or 1, depending on the relative magnitudes of $\lambda(R_h - c_h)$ and $1 - c_h$. If the latter is larger, he will offer 1 and offer the high quality design with probability $\frac{1}{2}$ (iff $c_h < c_l$). So in this case nothing is accomplished by reallocating bargaining power.

There is no question that some communication problems can be solved by reallocation of bargaining power, but a change in game form is an alternative instrument. A significant advantage of "solution-by-game-form" is that it can be done on a feature by feature basis as a contract is designed. A disadvantage is that the solutions are likely to be imperfect.

V. DISCUSSION

In this Section, we generalize the Ex Ante Bargaining game form, argue that it has several properties in common with an employment contract, and review some empirical evidence with this in mind.

Aligning Incentives in the Ex Ante Bargaining Game Form

One way of thinking about the inefficiencies in the Ex Ante Bargaining game form is that the players' gains from adjustment are uncorrelated. The players could reduce the problems caused by the incentive transfer effect by increasing the correlation, thereby raising the efficiency of the commitment game form. As we saw in the Result A, if the seller has an idea that will increase the buyer's revenues, he will still not communicate it unless it reduces his own costs. However, he will be more cooperative if the contract gives him a different payment when the buyer has large gains. (This is of course just an example of the principle that an ex ante contract is more efficient if it is closer to being complete.)

Even if we maintain the assumption that it is impossible for the players to contract directly on the nature of the design itself, there are many other ways of inducing

² Compared to the Ex Ante Bargaining game form, we see that Ex Post Bargaining is better because the price can be adjusted to reflect the identity of the traded design.

correlation. To illustrate the general idea, we will look at a single example: the widgets come in “units,” the contract species a unit price, and the buyer may choose to use more units of the new design than of the old. Suppose that the buyer’s unit revenues are p_l and p_h for the old and new designs, respectively. If she buys the quantity $Q(p)$ and v is the unit input price, then $w = vQ$ may let the seller share some of the gains from adjustment without ex post bargaining. Specifically, the buyer’s gains from adjustment are $Q(p_h)(p_h - v) - Q(p_l)(p_l - v)$, while the seller’s gains are $Q(p_h)(v - c_h) - Q(p_l)(v - c_l)$. The ability to use such contracts allows the Ex Ante Bargaining game form to induce more communication.

Interpretation of the Ex Ante Bargaining Game Form as an Employment Contract

Like the seller in the Ex Ante Bargaining game form, employees agree to incompletely specified trades and only rarely ask to renegotiate their compensation as the details become clear. In contrast, and like the seller in the Ex Post Bargaining game form, independent contractors typically renegotiate prices as a result of “change orders”.

There are several possible explanations for these stylized facts. The “property rights” theory of the firm (Grossman and Hart, [1986]; Hart and Moore, [1990]; Hart, [1995]) defines the boss by asset ownership and explains the stylized facts by appeal to the power this confers to him. Employees’ attempts at renegotiation are bound to fail because they are powerless, while independent contractors have power and thus the ability to extract some rents from a change. In contrast, the “adjustment-cost” theory (Bajari and Tadelis, [2001]; Simester and Wernerfelt, [2005]; Tadelis, [2002]; Wernerfelt, [1997]; [2002]; [2004]) defines the employment relationship as an implicit contract in which the employee has agreed to refrain from renegotiation, retaining only the right to quit. It explains the efficiency of this institution by claiming that frequent renegotiation is costly. On the other hand, there are also various costs associated with an employment relationship and if these costs are larger than those of infrequent renegotiation, a market relationship may be more efficient. A central prediction of this theory is then that relationships needing more frequent adjustment are more likely to be organized inside the firm. (The difference between the work done by a secretary and that done by a homebuilder may illustrate this contrast.) In the present paper, we have added another force to the tradeoff by showing that the market may implement a different set of adjustments than those implemented in a firm.³ Phrased in these terms, our central finding is that the market is better when adjustments are large and reveal little information, while employment is better when adjustments are small and revealing.

No matter what the primary reasons for the existence of firms, they are clearly subject to the informational inefficiencies of the Ex Ante Bargaining game form. Employees have agreed to perform ex ante unspecified tasks under a fixed contract and thus can not expect any change in compensation as a result of their ideas. Conversely, arrangements with independent contractors suffer from the problems of the Ex Post Bargaining game form. By suggesting an alternative task, the contractor reveals information about costs and puts himself in a poorer bargaining position. As a result, we would expect certain kinds of information to be withheld in firms, and other kinds to be

³ Another attractive feature of the story is that it suggests that the more informed party should have more power, i. e. be the boss.

withheld in markets. Put differently, we would expect that firms and markets implement different sets of adjustments. So we can use firms and markets as examples of the Ex Ante and Ex Post Bargaining game forms and thereby throw empirical light on the model.

Empirical Evidence

It is not hard to find evidence consistent with the bargaining power effect. At an informal level, one often hears that firms “keep secrets”, to enhance their short-term negotiating positions or to protect long-term market power. More systematically, Simester and Knez [2001] study a company in which eighteen different parts are made both by employees and by independent suppliers. Consistent with the prediction that concerns for bargaining power lead to less communication between firms, they find that external suppliers give the company less information about delivery and production schedules and fewer design suggestions. They even report that the company restricts communication between its engineers and those of outside suppliers.

It is harder to find systematic evidence consistent with the incentive transfer effect. Most people know stories in which employees withhold information because its release would make their job harder – slipping deadlines and maintenance needs come to mind (Rotemberg, [2002]). The sociology literature documents individual cases in which employees make certain tasks seem harder than they really are (Roy, [1955]), and cases in which information is hidden from management (Crozier, [1964]). However, we have not been able to identify a large sample study of this phenomenon.

It may be possible to get some sense of the balance between the forces studied here by comparing incremental and radical new product development. When improvements are incremental, the new product’s revenues will be only marginally higher than those of the old product, and one could argue that Ex Ante Bargaining (a.k.a. integration) should be best. For more radical changes, the new product may command much higher revenues, and Ex Post Bargaining (a.k.a. the market) will be more efficient. This general prediction, that more radical innovations tend to occur between, rather than within firms, is in fact supported by literature in the area of innovation management (Freeman, [1991]; Hagedoorn, [1995]; Powell et al., [1996]).

VI. CONCLUSION

The paper has contributed to contract theory by showing that different types of information is communicated and withheld under ex ante versus ex post bargaining. In particular, when gains from trade are private information, concerns for bargaining power in ex post bargaining may cause players to withhold information. On the other hand, ex post bargaining may provide incentives for communication because it allows the players to share the resulting gains. On balance, we find that ex post bargaining is better when adjustments are large, while ex ante bargaining is better when adjustments are small.

On a more applied level, we have contributed to the literature on incomplete contracts by showing how the possibility of renegotiation influences information transfer between traders. This may help explain why some contracts have more features left up to renegotiation than others. Finally, because adjustments do not lead to renegotiation in employment contracts, the results also allow us to suggest that the information communicated in firms differ from that communicated in markets.

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