Bargaining with Endogenous Information
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We examine the effect of endogenous private information on bilateral buyer-seller bargaining.

Imagine a consulting firm pitching a project to a potential customer. While the deliverables may be clear, the firm may not know exactly how costly they will be to complete; similarly, the buyer may not know exactly how much benefit they will get. Prior to negotiations, both sides may choose to invest time and resources in sharpening their estimate. In the current paper, we study how each side's bargaining power in the negotiations over price interacts with the incentives to invest ex-ante in information. (In future work, we will simultaneously endogenize the bargaining protocol (including the two sides' bargaining power) and information.)

1 Model

A single seller has one unit of an indivisible good for which there is a single potential buyer. The seller has noisy private information about the cost of selling the object (or his value from keeping it), and the buyer has noisy private information about his benefit from buying it. Importantly, we assume independent private values – each party cares about the other side's information only through its influence on the bargaining outcome, so there is no adverse selection problem. For a simple tractable model, we imagine that the buyer observes a signal which may be the exact benefit he will get from the object or may be identically-distributed noise; a more-informed buyer observes the informative signal with higher probability. Likewise the seller.

after observing their signals, the buyer and seller will negotiate via the following protocol. One of the two will be randomly selected to make a take-it-or-leave-it offer; the other will then accept or reject it, the game ends, and payoffs are realized. Each party's probability of being the one who gets to make the offer can be thought of as that party's bargaining power.

2 Results So Far – Comparative Statics

We start out by considering the effect of each party's information precision on equilibrium bargaining outcomes. Assume that the precision of each party's information is common knowledge. Analyzing a parameterized example, we find a number of interesting comparative statics:

1. When you have most of the bargaining power, better information always increases your expected payoff. But when you don't, there is a region where incrementally more precise information decreases your expected payoff.
    - This is because increasing the precision of your own signal has two effects: a direct effect and a strategic effect.
    - The direct effect is that, holding fixed your opponent's bidding behavior, better information causes you to make better decisions and earn greater payoffs.

- The strategic effect is that an increase in your own informedness makes your opponent bid more aggressively (lower bid, or higher ask) in the event that he is the one recognized to make the offer.
- Unless the latter happens with a sufficiently low probability, there is a level of information such that the latter effect dominates.

2. Information has decreasing returns when you have very little, then increasing returns once you have a bit. Except that when you have nearly all of the bargaining power, information always has increasing returns.

    - The direct effect described above not only always increases your expected payoff, but has increasing returns: when your opponent's bidding behavior is fixed, your expected payoff is convex in the precision of your own information.
    - When your bargaining power is sufficiently great, the strategic effect is minimal, and this dominates throughout.
    - However, the rest of the time, the strategic effect causes expected payoffs to be concave at low levels of information.

3. A better-informed opponent increases your expected payoff, unless you have a lot of information and little bargaining power.

    - When you have all the bargaining power, a better-informed opponent increases your payoff, as there is no adverse selection problem and you can benefit from bidding more aggressively.
    - Even when you do not have much (or any) bargaining power, a better-informed opponent generally increases your payoff, by increasing the variance of his bids.
    - If you are a buyer with private value v_b, facing a seller who demands price s, your payoff is $\max(v_b, s)$; since this is convex, variance in his bids, in expectation, helps you.
    - However, because bid functions need not be linear, a mean-preserving spread in your opponent's valuations need not lead to a mean-preserving spread in the prices he offers. In the example we study, your payoff is decreasing in your opponent's information precision when he has most of the bargaining power, but you have significantly more-precise information than he.

4. Your and your opponent's information are strategic substitutes, except when you have very little information.

    - This one is somewhat surprising: a better-informed opponent generally reduces the value of your own information.
    - It helps to recall that with private values, there is no adverse selection – we expect this result could change with interdependent values
    - The best intuition we can offer: the more information your opponent has, the less direct the link between your own valuation and whether or not trade occurs, which dilutes the incremental value of information

5. More bargaining power always increases your expected payoff.
    - This is unsurprising, although once we endogenize information acquisition, it will no longer always be true
6. Bargaining power is most valuable when you have either much more or much less information than your opponent, and least valuable when you are comparably well-informed.
7. Bargaining power and information are strategic complements, except when you have much less information relative to your opponent.
8. Bargaining power and opponent information are complements when you're comparably informed or at an informational disadvantage, but substitutes when you're at an informational advantage.
9. It's efficient to unite knowledge and control.
    - That is, when one player has more precise information than the other, joint payoffs (or expected gains from trade) are always increasing in that player's bargaining power.

All of these comparative statics were proven for a particular parameterized example; we expect that most of them will generalize when we consider other value distributions and signal structures.

3 Results So Far – Equilibrium Information Acquisition

Continuing to treat bargaining power as exogenously fixed (perhaps by the relative thinness of the two sides of the market), we next consider a two-stage game. In stage one, each player selects an information precision, paying a higher cost for more precise information. In stage two, their signals are realized, and they bargain via the protocol considered above. We have fully characterized equilibrium behavior in this game when one player has all of the bargaining power – that is, when it is known ex-ante which player will get to make a take-it-or-leave-it offer. For illustration, suppose that it is the seller:

1. When information acquisition is observable – that is, when each player's choice of information precision becomes common knowledge prior to bargaining:
    - There is a parameter range with two pure-strategy equilibria
        - In one equilibrium, the buyer acquires maximal information and the seller acquires none
        - In the other, the seller acquires maximal information and the buyer acquires a smaller amount
        - The two equilibria are not Pareto-ranked; each player prefers the equilibrium in which he is less informed
    - Setting aside the less efficient equilibrium from this region
        - The seller always acquires weakly more precise information than the buyer – usually strictly more, and by a significant margin

  - Both buyer and seller information decrease as the marginal cost of information increases
- There is a region where, when information costs are accounted for, the seller's ex-ante expected payoff is **lower** than the buyer's
  - Within this region, the unique equilibrium is for the seller to acquire much more information than the buyer
  - However, given the cost of this information, the buyer is better off ex-ante, despite the seller having all of the bargaining power ex-post

2. When information acquisition is unobservable – that is, when each player's choice of information precision is not publicized (but is correctly inferred in equilibrium):

   - The seller does not always acquire more information than the buyer
   - Buyer information acquisition is decreasing in the cost of information
   - Seller information is not. For intermediate cost levels – that is, on the region where neither "both players acquire maximal information" nor "neither player acquires any information" is an equilibrium – the seller's equilibrium level of information acquisition is *increasing* in its marginal cost
   - Buyer payoff is monotonically decreasing in the cost of information, but seller payoff is not

3. Finally, comparing the two:

   - At any cost level, the seller (the party with all the bargaining power) gets higher payoffs when information acquisition is unobservable than when it is observable; the buyer (the party with no bargaining power) gets higher payoffs when information acquisition is observable that when it is unobservable
   - (One way to state this: when equilibrium effects are accounted for, bargaining power and secrecy are complements)
   - Neither regime is uniformly more efficient, nor is the difference in efficiency monotonic: joint expected payoffs (ex-ante expected gains from trade, less information costs) are higher under unobservable information acquisition when the marginal cost of information is either quite high or quite low; and higher under observable information acquisition when they are in the middle.

So that's what we've got so far. We're in the process of extending the equilibrium results to the case where both parties have some bargaining power (that is, either is recognized to make the offer with positive probability). While our primary example assumes a linear structure on the cost of information, greatly simplifying things, we've done a robustness check that convex costs do not lead to qualitatively different results.

4 Next Steps

While these results are interesting, there is still a lot left to do. We do not yet know exactly which results will generalize to other value distributions and signal structures. We have not finished analyzing equilibrium information acquisition when both parties have some bargaining power. (Our our preliminary results suggest that the story will be qualitatively similar to what's discussed above, but with multiple equilibria being more prevalent and non-monotonicities more pronounced.) Our analysis so far has relied on linear information costs (although we've also analyzed a particular form of convex costs and found the results to be unchanged).

We are also considering the effect of using a different bargaining protocol in the second stage. (For example, we are analyzing the game when the second stage consists of the k-double auction, where trade occurs at a price which is a convex combination of the two players' bids. This analysis is complicated by extreme multiplicity of equilibria in the double auction, although in the example we analyze, we make a case for a particular focal equilibrium.)

Most importantly, we want to endogenize the bargaining protocol as well as information acquisition, by considering the problem of bilateral mechanism design when information is endogenous. In particular, when information is endogenous and acquired after a mechanism is chosen, what type of mechanism will maximize joint payoffs? Once information precision has been chosen, we know what the jointly optimal mechanism looks like; however, this mechanism may not lead to the efficient level of information acquisition, particularly when information acquisition is unobservable. There are a number of interesting questions in this direction, and we've begun working on this problem; we hope to have some preliminary results by the time we present the work this summer.