Ec717a: Contract Design with Unforeseen Contingencies (Herweg-Schmidt 2018)

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Motivation

- Important element of complexity: *unforeseen contingencies*
- If something is unforeseen it cannot be described, hence cannot be written into a contract
- Then the contract cannot be *ex ante* complete; has to renegotiated as the future unfolds and players observe contingencies ex post
- Yet parties may be *ex ante* aware of the possibility of such contingencies, and worry about prospects of *ex post* holdup/opportunism

Motivation, contd.

- Yet it may be possible to write ex ante contracts in a way to cope with unforeseen contingencies
- Maskin-Tirole (RES, 1999) make the argument in a very abstract framework
- The underlying idea is that it may be possible to design contracts to cope with *payoff/pecuniary consequences* of unforeseen contingencies as they become evident, even if the physical contingencies themselves are unknown and hard to describe *ex ante*

Motivation, contd.

- Herweg-Schmidt (2018) provide a specific illustration of this, in a procurement setting

Motivation, contd.

- Herweg-Schmidt (2018) provide a specific illustration of this, in a procurement setting
- Show in this setting how procurement contracts can be designed to achieve efficient allocations in an informationally robust manner (a la Bergemann-Morris 2005, i.e. EPIC), despite the existence of unforeseen design flaws

The Herweg-Schmidt Procurement Setting

- Buyer B wants to procure a complex good from one of two sellers $i = 1, 2$ at date 0
- There exists a current design D_0 of the product (proposed by B)
- Seller i can produce D_0 at cost $c_i \in [\underline{c}, \bar{c}]$, which they privately observe; (c_1, c_2) have a joint atomless cdf (allow correlated costs)
- If the design D_0 has no flaws, generates a value v to B

Design Flaws

- However, design D_0 may have flaws that B is unaware of at $t = 0$
- **Consider first a scenario where possible design flaws can be foreseen and described in advance; later we will drop this assumption**
- Set of possible flaws: $\mathcal{F} \equiv \{f_1, \ldots, f_n\}$
- Set of actual flaws: F is some subset of $\mathcal{F}$, drawn with probability $G(F)$

Design Flaws, contd.

- Seller i has expertise to evaluate the design D_0; after examining it i becomes (privately) aware of some of the actual flaws $\hat{F}_i \subseteq F$; $Q(\hat{F}_1, \hat{F}_2)$ is probability of $(\hat{F}_1, \hat{F}_2)$
- So seller i is privately informed about both c_i and $\hat{F}_i$
- i can decide which of the flaws in $\hat{F}_i$ to disclose to B, and when to disclose ('early': date 1 before contract is assigned, or 'late': date 2 after it has been assigned)
- Once a flaw f_i is discovered, it can be fixed at the early stage (by either seller) at additional cost $\Delta c_k \geq 0$, and at cost $\Delta c_k + \Delta x_k$ (with $\Delta x_k \geq 0$) at the late stage

Incentives to Reveal and Fix Flaws

- If flaw f_i is not fixed, it reduces value to B by $\Delta v_k > \Delta c_k + \Delta x_k$ (so B will want all flaws to be fixed as soon as B becomes aware of them, early or late)
- P therefore prefers flaws to be identified, and fixed early (v is sufficiently large, that project is still worthwhile irrespective of flaws)

Incentives to Reveal and Fix Flaws, contd.

- On the other hand sellers may strategically want to report them later, after contract has been assigned
- Because this will give rise to a contract renegotiation, in which (if they have been assigned the contract) they would be able to appropriate (some given proportion α) of additional surplus $S_k^R \equiv \Delta v_k - \Delta c_k - \Delta x_k$ from B for all flaws k they disclose late

Timeline

- Stage 0: B announces D_0; F determined; i observes $(c_i, \hat{F}_i)$
- Stage 1 (early): i reports $\tilde{c}_i, \tilde{F}_i \subseteq \hat{F}_i$; contract assigned by B to some $i*$, and which of reported design flaws to be fixed at this stage
- Stage 2 (late): $i*$ reports some additional design flaws (from $\hat{F}_{i*} \setminus \tilde{F}_{i*}$); followed by renegotiation (resulting in additional surplus accruing to $i*$)

Some Underlying Assumptions

- *Partial Verifiability:* Sellers cannot fabricate flaws that do not actually exist (any reported flaw can be verified); so only scope for strategic manipulation is withholding information
- B cannot commit not to renegotiate *ex post*
- More generally, B cannot commit not to get identified flaws fixed immediately

What if Flaws are Unforeseen?

- **Real situation:** B does not know what the set of possible flaws is, or what their payoff consequences might be (and certainly cannot ascribe probabilities to possible sets of flaws)
- However, they assume that *once a flaw is disclosed, an impartial third party arbitrator can verify it, and evaluate the payoff and repair consequences* $(\Delta v_k, \Delta c_k, \Delta x_k)$
- They can specify a contract that describes decisions (eg contract assignment, product design, contract payments) as a function of what is disclosed and verified by the arbitrator (even though players do not have a prior over flaws or their consequences)

What if Flaws are Unforeseen? contd.

- For expository purposes:
  - initially suppose these contingencies are foreseen
  - derive optimal contract with foreseen contingencies
  - show later that there is a way to implement this contract with an indirect mechanism even when the contingencies are unforeseen

1. Consequences of Second Price Sealed Bid Auction

- Suppose B uses a sealed bid second price auction (each seller submit bids as well as report of a flaw; B alters design to require a fix of the reported flaw, assigns contract to seller bidding less and offers it the bid of the other seller)
- If the flaw was unreported, the assigned seller can report it later, and earn additional surplus from resulting renegotiation
- Unique PBE, where both sellers have a dominant strategy to report a flaw late rather than early (besides bidding own true cost, less expected renegotiation surplus at later stage)

1. Consequences of Second Price Sealed Bid Auction (contd.)

- Three sources of inefficiency:
  - Late Disclosure/Fix of Flaws
  - Inefficient Production (higher cost seller obtains signal of flaw, other seller does not; former wins because of bidding lower owing to anticipated renegotiation surplus)
  - Inefficient Design (flaw noticed only by losing seller, is not reported or fixed)

2. Designing an Efficient Mechanism, with Foreseen Contingencies

- Seek a mechanism with the following properties:
  - *Efficient Design (ED):* all flows observed by (both) sellers should be fixed early
  - *Efficient Production (EP):* Seller with lower cost c_i should be assigned the contract
  - *Ex Post Participation Constraints (EPPC):* Both sellers should want to participate ex post
  - *Ex Post Incentive Compatibility (EPIC):* Incentive to report truthfully, ex post

2. Efficient Mechanism, with Foreseen Contingencies

Proposition

There exists a direct revelation mechanism satisfying ED, EP, EPPC and EPIC, in which: (i) each seller reports a bid and design flaws simultaneously at the early stage; (ii) all flaws reported early are fixed; (iii) the lowest bidder wins the auction (iv) and is paid the sum of: (a) the bid of the other seller, (b) the cost of fixing all the reported flaws, and (c) share of renegotiation surplus that the seller would have won had she not reported the flaws that she did report at the early stage (and given the flaws reported by the other seller).

Main Idea: Separate the rewards for early report of flaws, and for submitting a low bid.

3. Implementing the Efficient Mechanism when Contingencies (Flaws) are Unforeseen

- Stage 1: B publicizes D_0, and invites all potential sellers to inspect it and report possible design flaws in sealed envelopes
- Stage 2: Arbitrator opens the envelopes, evaluates all reported flaws, and their associated $\Delta v_k, \Delta c_k, \Delta x_k$; gives reward to each seller i equalling share of renegotiation surplus that i would have earned had she been assigned the contract, and revealed these flaws later (given flaws reported by others)

3. Implementing the Efficient Mechanism when Contingencies (Flaws) are Unforeseen, contd.

- Stage 3: Buyer redesigns the product, fixing all revealed and verified flaws; then invites sealed bids in a second price auction
- Stage 4: Lowest bidder wins, and is paid second lowest bid. If she reveals any new flaws now, contract is renegotiated.
- Easy to verify this replicates the efficient mechanism in all respects, as (unforeseen) contingencies unfold, are reported and verified by the arbitrator

Conclusion

- Under some reasonable circumstances, possible to specify a simple mechanism that implements efficient outcomes despite important contingencies being unforeseen at the time of writing the contract
- Contract is incomplete in the strict sense, allows renegotiation (but which does not actually happen), and nevertheless achieves full efficiency
- It is informationally robust: requires no priors, or common knowledge regarding possible flaws and their payoff consequences
- Requires some assumptions nevertheless: (counter-factual) renegotiation surplus and division; independent verification of flaws by arbitrator