Optimal Procurement and Investment in New Technologies under Uncertainty

Malin Arve (Mannheim) and Gijsbert Zwart (Groningen)

Tirole Symposium, The Hague, 9 December 2014

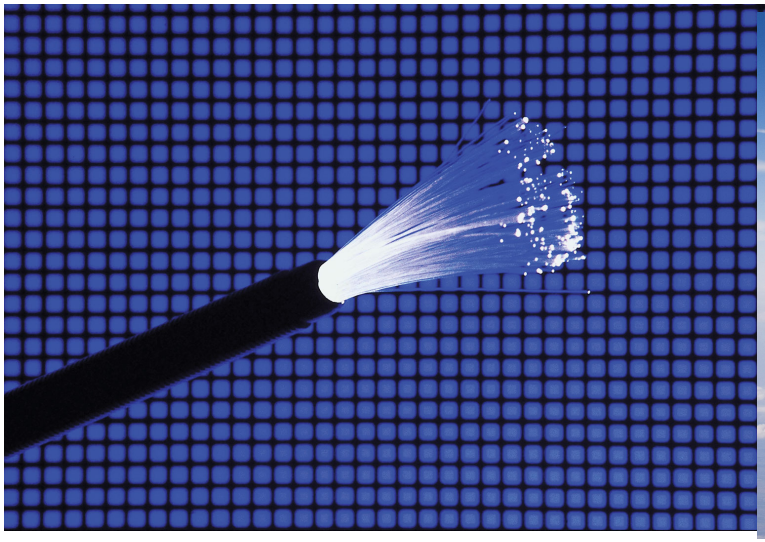
Introduction

Dynamic asymmetric information

Solution

Conclusion

The problem: when to invest?





Procurement: choice among multiple technologies with uncertain costs

- costs still evolving
- postpone decision waiting for more information
- get firms to reveal evolution of costs

Example: pre-commmercial procurement

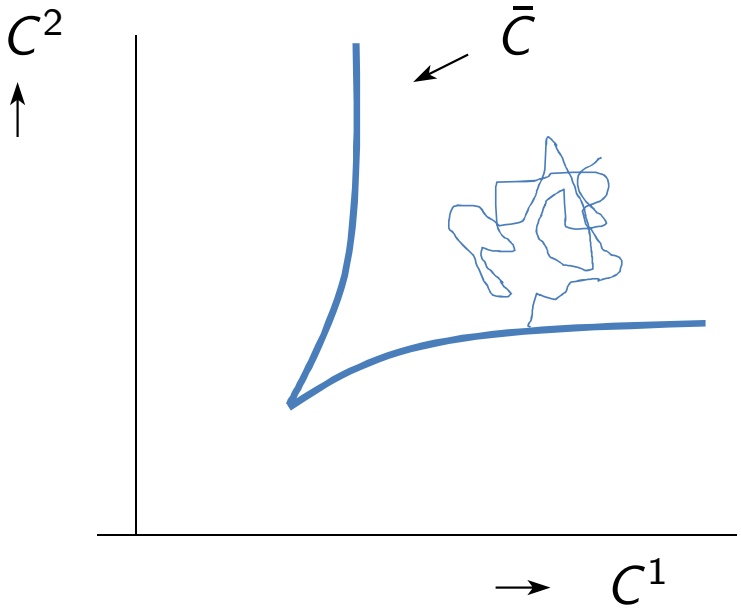
- auction in which multiple firms keep on interacting
- until information gets favourable: invest
- or unfavourable: costs get out of control

The problem

In general

- Value of the buy is stochastic
- The agents (sellers) observe their stochastic evolution, the principal (buyer) does not
- Principal wants to design a mechanism to elicit that continuously evolving information
- and use it to determine the optimal timing of the buy
  - plus choice from which seller to buy

Symmetric information: real option

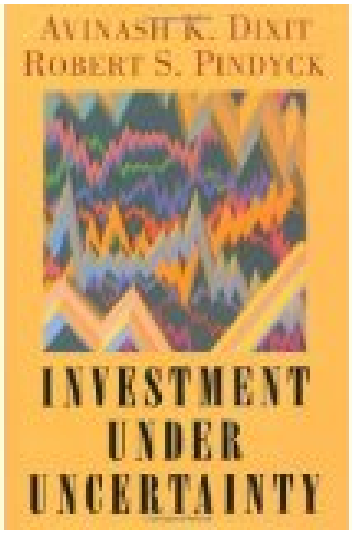


$$dC^i = \underbrace{\mu^i C^i dt}_{\text{growth rate } \mu} + \underbrace{\sigma C^i dz^i}_{\text{uncertain fluctuations}}$$

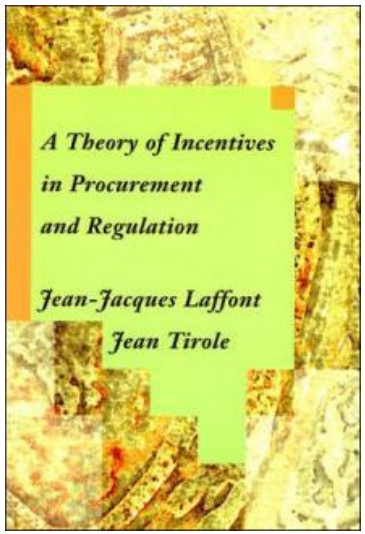
- Problem: find the optimal investment threshold

$$W(C_0^1, C_0^2) = \max_{\bar{C}} E\left[e^{-rT} \max\left(v^1 - \bar{C}^1, v^2 - \bar{C}^2\right) | C_0^1, C_0^2\right]$$

Our aim


AVINASH K. DIXIT
ROBERT S. PINDYCK
INVESTMENT
UNDER
UNCERTAINTY




A Theory of Incentives
in Procurement
and Regulation
Jean-Jacques Laffont
Jean Tirole

Dynamic asymmetric information

Principal never observes C^i, agents do

- process parameters (μ and σ) are known
- initial C_0^i from distribution $F^i(C_0^i)$

Principal's problem: get agents to reveal their costs processes C^i

Use that to make investment choices

- decide on optimal investment thresholds
- taking into account agency rents: distortions.

Solution strategy

Step 1: ex post incentive compatibility

given some threshold $\bar{C}$

- design payments so that agents will want to invest at that $\bar{C}$
- result: continuation value given threshold:

$$\frac{\partial V^i}{\partial C^i} = -E\left(e^{-rT}\frac{\bar{C}^i}{C^i} \mid C^i\right)$$

Step 2: ex ante incentive compatibility

reveal ex ante costs C_0^i by choosing threshold $\bar{C}$ plus upfront fee

- standard static mechanism design
- result:

$$\frac{d\Pi(C^i)}{dC^i} = \frac{\partial V^i}{\partial C^i}.$$

Solution strategy

Step 3: optimization

Find threshold line $\bar{C}(C^1, C^2)$ to maximize

$$W(C_0^1, C_0^2) = \max_{\bar{C}} E\left[e^{-rT} \max\left(v^1 - \alpha^1 \bar{C}^1, v^2 - \alpha^2 \bar{C}^2\right) | C_0^1, C_0^2\right]$$

with

$$\alpha^i = \left(1 + \frac{F(C_0^i)}{f(C_0^i)} \frac{1}{C_0^i}\right) \geq 1$$

Compare with first-best

$$W(C_0^1, C_0^2) = \max_{\bar{C}} E\left[e^{-rT} \max\left(v^1 - \bar{C}^1, v^2 - \bar{C}^2\right) | C_0^1, C_0^2\right]$$

Implementation

Vickrey-type payments

Ex post incentives principal and agent are aligned with fee upon investing:

$$\phi^{\text{invest}} = \frac{v^1}{\alpha^1}$$

and fee on dropping out (when investing in rival)

$$\phi^{\text{abort}} = \frac{v^2 - \alpha^2 \bar{C}^2}{\alpha^1}$$

with

$$\alpha^i = \left(1 + \frac{F(C_0^i)}{f(C_0^i)} \frac{1}{C_0^i}\right) \geq 1$$

(plus ex ante fee to ensure ex ante incentive compatibility)

Conclusions and extensions

Framework to combine real options with mechanism design

Pay opportunity costs (taking into account information rents) to induce firms to reveal good and bad outcomes

Outlook

- Other applications: regulation of investment (one firm case)
- Generalizations
  - Multistage investment
  - Commitment problems
  - Adding moral hazard: incentives to do cost-reducing effort