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EC5230 - Industrial Organisation

Lecture 6 - Cooperative R&D

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Cooperative R&D

Cooperative R&D: overview

i Object of analysis

R&D cooperation when R&D creates spillovers ($\beta > 0$) or allows cost sharing (RJV).

- Baseline: each firm chooses R&D privately and internalises only its own costs/ benefits
- This lecture:
  - $\rightarrow$ R&D spillovers and the incentive to coordinate R&D
  - $\rightarrow$ Research joint ventures (RJVs) as cost-sharing arrangements
- Core question:
  - $\rightarrow$ When does cooperation increase welfare relative to non-cooperative R&D?

Multi-stage games: reminder

- Two-stage structure:
  1. Stage 1: choose x_i (R&D)
  2. Stage 2: choose q_i (product-market competition)

! Backward induction

Solve Stage 2 for $q_i^*(x)$, substitute into Stage 1 payoffs, then solve for x^*.

R&D spillovers (d’Aspremont–Jacquemin)

Spillovers model: primitives

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- Duopoly with inverse demand:

$$p(Q) = A - Q, \quad Q = q_1 + q_2$$

- Cost and spillovers:
  - → Marginal cost of firm i: $c_i = c - x_i - \beta x_j$ with $\beta \in (0, 1)$
  - → Feasibility: $x_i + \beta x_j \leq c$
- R&D cost:
  - → Firm i pays $\frac{x_i^2}{2}$
- Objects:
  - → Choice variables: x_i (stage 1), q_i (stage 2)
  - → Parameters: A, c, β

Spillovers model: primitives

Spillover parameter

$\beta \in (0, 1)$ measures how much of firm j's R&D reduces firm i's marginal cost.

Spillovers model: stage-2 profit

- Given (x_1, x_2), firm i chooses q_i to maximise:

$$\pi_i(q_i; q_j, x_i, x_j) = [A - (q_i + q_j) - c_i]q_i - \frac{x_i^2}{2}$$

- Interpretation:
  - $\rightarrow$ R&D shifts marginal cost; output competition determines how much cost reduction is monetised

Product-market equilibrium (Cournot): quantities

- Cournot–Nash equilibrium quantities (given x_1, x_2):

$$q_i^* = \frac{1}{3}\Big[\,(A-c) + (2-\beta)x_i + (2\beta-1)x_j\,\Big]$$

- Interpretation:
  - → Own R&D raises own output; rival R&D can raise or lower own output depending on spillover strength

i Strategic effect of spillovers

The term $(2\beta-1)x_j$ implies rival R&D can be output-increasing or output-reducing depending on whether β is above or below $\frac{1}{2}$.

R&D regimes

Regimes: definition

- We compare three institutional regimes:
- Game I:
  - $\rightarrow$ Non-cooperative R&D and non-cooperative output (Cournot)
- Game II:
  - $\rightarrow$ Cooperative R&D, non-cooperative output (Cournot)
- Game III:
  - $\rightarrow$ Cooperative R&D and cooperative output (joint profit maximisation)

Game I: stage-1 problem (non-cooperative R&D)

- Stage 1 objective for firm i:

$$\max_{x_i} \pi_i^*(x_i, x_j) = [q_i^*(x_i, x_j)]^2 - \frac{x_i^2}{2}$$

- Symmetric equilibrium ($x_1 = x_2 = x^*$):

$$x^* = \frac{(A-c)(2-\beta)}{4.5-(2-\beta)(1+\beta)}$$

- Interpretation:
  - $\rightarrow$ Each firm invests less when spillovers are high because part of the benefit accrues to the rival

Game II: stage-1 problem (cooperative R&D)

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- Firms choose (x_1, x_2) to maximise joint profit given Cournot output:

$$\max_{x_1, x_2} \hat{\pi} = \pi_1^* + \pi_2^*$$

- Symmetric solution ($x_1 = x_2 = \hat{x}$):

$$\hat{x} = \frac{(A - c)(1 + \beta)}{4.5 - (1 + \beta)^2}$$

- Interpretation:
  - $\rightarrow$ Internalising spillovers increases R&D relative to Game I (for intermediate β)

Game III: cooperative R&D and output

- With full cooperation, firms maximise joint profit over (q_1, q_2, x_1, x_2)
- Under symmetry ($x_1 = x_2 = x, q_1 = q_2$), aggregate output in stage 2 is:

$$\tilde{Q} = \frac{(A - c) + (1 + \beta)x}{2}$$

- Stage 1 chooses x to maximise joint profit; solution:

$$\tilde{x} = \frac{(A - c)(1 + \beta)}{4 - (1 + \beta)^2}$$

- Interpretation:
  - $\rightarrow$ Output coordination reduces product-market competition; R&D incentives differ because they are evaluated at monopoly output

Welfare

Welfare benchmark: social planner

Assume symmetry $x_1 = x_2 = x$.

- Welfare function (as stated in the lecture):

$$W(Q) = V(Q) + R(Q) - [c - (1+\beta)x]Q - x^2$$

- Stage 2 FOC w.r.t. Q:

$$Q = A - c + (1+\beta)x$$

- Interpretation:
  - $\rightarrow$ Planner expands output to the efficient level given the cost reduction from total effective R&D

Social optimum: R&D and output

- Socially optimal R&D:

$$x^{**} = \frac{(A-c)(1+\beta)}{2-(1+\beta)^2}$$

- Socially optimal output:

$$Q^{**} = (A-c)\left[\frac{2}{2-(1+\beta)^2}\right]$$

- Interpretation:
  - $\longrightarrow$ Relative to market outcomes, the planner internalises both spillovers and the consumer-surplus gain from lower prices

Comparing regimes: R&D and output rankings

- R&D expenditure comparison (from the lecture):
  - $\rightarrow$ Large spillovers: $x^{**} > \tilde{x} > \hat{x} > x^*$
  - $\rightarrow$ Small spillovers: $x^{**} > \tilde{x} \geq x^* > \hat{x}$
- Output comparison (from the lecture):
  - $\rightarrow$ Large spillovers: $Q^{**} > \hat{Q} > Q^* > \tilde{Q}$
  - $\rightarrow$ Small spillovers: $Q^{**} > Q^* > \hat{Q} > \tilde{Q}$

! Reading the rankings

Higher x need not imply higher Q when cooperation also changes the intensity of product-market competition.

Research joint ventures (Combs)

RJV model: primitives

- Probability a single lab succeeds: p
- Product-market profits:
  - $\rightarrow$ Monopoly: π^m
  - $\rightarrow$ Duopoly: π^d
- Fixed cost of a lab: F
- Assumptions:
  - $\rightarrow$ If both succeed, firms compete in the product market (profits π^d each)
  - $\rightarrow$ If only one succeeds (non-cooperative setting), the innovator earns π^m

RJV: cost-sharing (single lab)

- Each cooperating firm's expected payoff:

$$V_C = p\pi^d - \frac{F}{2}$$

- Non-cooperating firm's expected payoff:

$$V_N = p(1-p)\pi^m + p^2\pi^d - F$$

- Cooperation condition:

$$V_C \geq V_N \quad \Leftrightarrow \quad \frac{F}{2} \geq p(1-p)(\pi^m - \pi^d)$$

- Interpretation:
  - $\rightarrow$ Cooperation is more attractive when the "winner-takes-all" component $p(1-p)$ is small

RJV: duplication (two labs)

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- If the RJV runs two labs (duplication), payoff of each cooperating firm:

$$\tilde{V}_C = 2p\pi^d - F$$

- Non-cooperating payoff remains V_N
- Cooperation condition:

$$\tilde{V}_C \geq \tilde{V}_N \quad \Leftrightarrow \quad p \geq \frac{\pi^m - 2\pi^d}{\pi^m - \pi^d} \equiv K$$

- Interpretation:
  - $\rightarrow$ With duplication, cooperation depends mainly on success probability p (not on F)

Summary and next week

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Summary

- Spillovers $\beta > 0$ create an externality in R&D, so non-cooperative R&D can be inefficiently low
- Cooperative R&D internalises spillovers and can increase R&D relative to non-cooperative choices
- Full cooperation may reduce product-market competition, affecting output and welfare
- RJVs trade off cost sharing against strategic effects from duplication and winning probabilities

Next week: assessment and feedback

- Online class test (timing and format)
- Tutorial: class test feedback and problem solving

Summary and next week

- Transition to subsequent lecture topics as scheduled

References

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