Lecture 3 - Innovation

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Innovation and Market Structure

Why innovation is central in IO

Innovation is the **dynamic** margin of competition: firms try to change the game by shifting **costs** and **demand**.

Why IO cares

- Innovation changes **prices, mark-ups, and welfare** today
- Innovation changes **market structure** tomorrow (entry/exit, dominance, concentration)
- Policy trade-off: **static efficiency** (low prices) vs **dynamic efficiency** (strong incentives)

Types of innovation (and what we model today)

Process innovation (this lecture's workhorse case)

- Lowers marginal (or average) cost, e.g. a better production method
- Think: a shift from c_0 to $c_1 < c_0$

Product innovation

- Raises willingness to pay, expands demand, or creates new varieties
- Often analysed with differentiated products and quality ladders (later in the course)

Stages (high level): Research $\rightarrow$ Development $\rightarrow$ Adoption

Learning objectives

- Compute the **private value** of a process innovation under different market structures
- Define **drastic vs non-drastic** innovations and explain the **replacement effect** (Arrow)
- Understand why innovation can have **strategic value** when it affects **entry** and market structure
- See how models with **free entry + endogenous R&D** link innovation to **concentration** (Dasgupta–Stiglitz)

Today: roadmap

1. Benchmark model: value of a process innovation under **monopoly**, **perfect competition**, and the **social planner**
2. **Drastic vs non-drastic** innovations and the **replacement effect**
3. Innovation incentives in **oligopoly** and under **entry threat**
4. Seminal results on **concentration** and **R&D** (Dasgupta–Stiglitz)

Two-way relationship to keep in mind

Market structure $\rightarrow$ innovation

- Competition affects profits, appropriability, and the gain from becoming "better" than rivals

Innovation $\rightarrow$ market structure

- Cost/demand shifts affect entry, market shares, and concentration (and can create dominance)

Measuring incentives: willingness to pay (WTP)

- **Firm WTP**: the max lump-sum payment that leaves profits unchanged
  $\Rightarrow$ WTP $= \Delta\pi$
- **Planner WTP**: the max lump-sum payment that leaves welfare unchanged
  $\Rightarrow$ WTP $= \Delta W$

In what follows we compute WTP for: **Monopoly** (before/after), **perfect competition** (before; exclusive rights after), and the **social planner**.

Benchmarks: Value of a Process Innovation

Setup: linear demand + cost-reducing innovation

Inverse demand

$$P(Q) = A - Q$$

Technology

- Constant marginal cost c
- Process innovation reduces marginal cost from c_0 to c_1 with $c_1 < c_0 < A$

Goal

Compute the value of moving from c_0 to c_1 under different market structures.

Monopoly benchmark (exclusive access before and after)

Problem

$$\max_{Q}\ (A - Q - c)Q$$

Solution

$$Q^m(c) = \frac{A-c}{2}, \qquad P^m(c) = \frac{A+c}{2}, \qquad \pi^m(c) = \frac{(A-c)^2}{4}$$

WTP for the innovation

$$\Delta\pi^m = \pi^m(c_1) - \pi^m(c_0) = \frac{(A-c_1)^2 - (A-c_0)^2}{4}$$

Interpretation

$\Delta\pi^m$ is the monopolist's value of *exclusive* access to the lower

Perfect competition benchmark (innovation creates rents)

Before innovation (all firms at MC c_0):

- Competitive price: $P_0^{pc} = c_0$
- Firm profit: $\pi = 0$

After innovation (innovator has exclusive use / patent):

- **Drastic**: innovator behaves as a monopolist with cost c_1
- **Non-drastic**: innovator is constrained by the competitive fringe at cost c_0 (limit pricing)

Innovator profit / WTP

$$\Delta\pi^{pc} = \begin{cases} \pi^m(c_1) & \text{(drastic)} \\ (c_0 - c_1)(A - c_0) & \text{(non-drastic, } p = c_0\text{)} \end{cases}$$

Why the non-drastic formula? If the innovator sets $p = c_0$, quantity is $Q = A - c_0$, so profits are $(p - c_1)Q = (c_0 - c_1)(A - c_0)$.

Replacement effect: a one-line comparison (drastic case)

If the innovation is drastic and grants exclusive rights:

$$\Delta\pi^{pc} = \pi^m(c_1), \qquad \Delta\pi^m = \pi^m(c_1) - \pi^m(c_0)$$

So

$$\Delta\pi^{pc} - \Delta\pi^m = \pi^m(c_0) > 0$$

! Takeaway

Holding everything else fixed, an incumbent monopolist has **weaker** incentives to innovate than a competitive industry because it is “replacing” its own pre-innovation rents.

Empirical example: competition and innovation

Inverted-U evidence (QJE) Aghion et al. (2005) document an **inverted-U** relationship between product-market competition and innovation (patents/citations) in UK firms, consistent with "escape competition" incentives for neck-and-neck firms and a **replacement effect** for laggards.

Social planner: value of a cost reduction

Efficient output (price equals marginal cost)

$$Q^{sp}(c) = A - c$$

Total surplus (welfare):

$$W(c) = \int_0^{A-c} (A - Q - c)\, dQ = \frac{(A-c)^2}{2}$$

Max WTP for innovation (social planner):

$$\Delta W = W(c_1) - W(c_0) = \frac{(A-c_1)^2 - (A-c_0)^2}{2}$$

Interpretation

In this linear example, $\Delta W = 2\,\Delta\pi^m$: the planner values the output expansion that the monopolist does not internalise

Putting the benchmarks side-by-side

Environment	What the innovator captures	WTP / value
Monopoly (incumbent)	Incremental rents	$\Delta\pi^m = \pi^m(c_1) - \pi^m(c_0)$
Perfect competition (pre) + exclusive rights (post)	Mostly created rents	$\Delta\pi^{pc} = \pi^m(c_1)$ if drastic; otherwise limit pricing profit
Social planner	Full surplus gain	$\Delta W = W(c_1) - W(c_0)$

! Policy interpretation

Private incentives and social value need not align: ΔW **can exceed** $\Delta\pi$, but market power created by IPRs also generates static distortions. This is the basic patents trade-off.

Empirical example: private vs social returns

Welfare gains from product innovation (JPE)

Trajtenberg (1989) estimates consumer and producer surplus gains from quality improvements in computed tomography (CT) scanners, illustrating that the **social value** of innovation can greatly exceed the innovator's private returns. DOI: 10.1086/261611. (Trajtenberg 1989)

Quick numeric check (optional)

Take $A = 20$, $c_0 = 10$, $c_1 = 6$.

- Monopoly: $\pi^m(c_0) = 25$, $\pi^m(c_1) = 49$, so $\Delta\pi^m = 24$
- Planner: $W(c_0) = 50$, $W(c_1) = 98$, so $\Delta W = 48$ (twice the monopoly gain)

Discussion question

In what sense is this "too little" innovation from a welfare perspective? What policy instruments could close the gap?

Innovation with Rivals and Entry

Incentives to innovate in oligopoly

Takeaway

- Innovation incentives need not be monotone in "competition intensity"
- They depend on:
  - Number of firms (n)
  - Product differentiation
  - Mode of competition (price vs quantity)
  - Whether innovation is **protectable** (patents/lead time) and whether there are **spillovers**

Rule of thumb

More rivals reduces baseline profits (hurting incentives), but can increase the value of being the low-cost firm (helping incentives).

Impact of number of firms (Cournot intuition)

Linear Cournot with n firms: incentives can follow an **inverse-U** as n increases.

Two opposing effects as $n \uparrow$:

- **Competition effect**: profits for all firms fall (discourages innovation)
- **Competitive advantage effect**: cost advantage becomes more valuable when there are more inefficient rivals (encourages innovation)

Monopoly threatened by entry: setup

Incumbent monopoly faces potential entrant:

- Both can acquire innovation reducing MC from c_0 to $c_1 < c_0$
- Entrant can enter profitably **only if** it gets innovation
- Let $\pi^d(c_i, c_j)$ denote firm i's profit in the post-entry **duopoly** when costs are (c_i, c_j)

Payoffs:

- **If incumbent gets innovation**: entrant stays out
  - Incumbent: $\pi^m(c_1)$; Entrant: 0
- **If entrant gets innovation**: entrant enters
  - Incumbent: $\pi^d(c_0, c_1)$; Entrant: $\pi^d(c_1, c_0)$

> **Strategic value**
>
> Innovation can change market structure (monopoly vs duopoly), so incentives are not only about production efficiency.

Entry threat: pre-emption incentives (Gilbert and Newbery 1982)

Per-period value of innovation

$$V_I = \pi^m(c_1) - \pi^d(c_0, c_1)$$

$$V_E = \pi^d(c_1, c_0)$$

Incumbent has stronger incentives if

$$V_I > V_E \quad \Leftrightarrow \quad \pi^m(c_1) > \pi^d(c_1, c_0) + \pi^d(c_0, c_1)$$

Typically when products are close substitutes (entry is very harmful).

! Interpretation

Here the incumbent may innovate **more** than an entrant because innovation does two things at once: it lowers cost *and* it

Empirical example: strategic incentives and market share

Pre-emptive innovation patterns (ReStud)

Blundell, Griffith, and Van Reenen (1999) find that higher market share and market value predict more patenting/innovations in UK manufacturing firms, consistent with **strategic** incentives (including pre-emptive innovation) in oligopolistic industries. DOI: 10.1111/1467-937X.00097. (Blundell et al. 1999)

Seminal Contributions

Why Dasgupta–Stiglitz matters (Dasgupta and Stiglitz 1980)

They model R&D as an **endogenous sunk cost**: firms spend on R&D to reduce marginal cost, and entry adjusts endogenously.

The punchline is a clean link between:

- **Demand conditions** (elasticity, market size)
- **Innovative opportunities** (how effective R&D is at lowering costs)
- **Equilibrium concentration** (how many firms survive under free entry)

Dasgupta–Stiglitz (1980): planner benchmark (Dasgupta and Stiglitz 1980)

Question: Does more firms imply more innovation?

Primitives:

- $U(Q)$ = gross social benefit
- $c = c(x)$ = constant marginal cost depending on R&D expenditure x
- Assumption: $c'(x) < 0$ (R&D reduces cost)

Social optimum:

$$\max_{x,Q} V(x,Q) = U(Q) - c(x)Q - x$$

First-order condition in x:

$$-c'(x)Q = 1$$

Interpretation:

Empirical example: market size and innovation

Pharmaceutical innovation responds to demand (QJE)

Acemoglu and Linn (2004) show that larger potential markets lead to more pharmaceutical innovation (new drugs/new molecular entities), consistent with models where the return to innovation rises with **scale**. DOI: 10.1162/0033553041502144. (Acemoglu and Linn 2004)

Dasgupta–Stiglitz (1980): symmetric oligopoly (Dasgupta and Stiglitz 1980)

Firm i's problem (symmetric firms):

$$\max_{x_i, q_i} \ \pi(x_i, q_i) = [P(q_i + q_{-i}) - c(x_i)]q_i - x_i$$

Symmetric equilibrium:

- $q_1^* = \cdots = q_N^* = Q^*/N$ and $x_1^* = \cdots = x_N^* = x^*$

First-order condition in q_i:

$$P(Q^*)\left(1 - \frac{1}{N\varepsilon}\right) = c(x^*)$$

where $\varepsilon = -\frac{\partial Q}{\partial P}\frac{P}{Q}$ is demand elasticity

Interpretation:

- The term $\left(1 - \frac{1}{N\varepsilon}\right)$ captures market power via the perceived

Free entry and concentration (Dasgupta and Stiglitz 1980)

Zero profit condition (free entry):

$$\pi = 0 \quad \Rightarrow \quad (P - c)\frac{Q^*}{N^*} - x^* = 0$$

Rearrange:

$$P - c = N^* \frac{x^*}{Q^*}$$

Define innovative potential:

$$\alpha = -\frac{dc(x)}{dx}\frac{x}{c}$$

Equilibrium concentration satisfies:

$$\frac{1}{N^*} = \frac{1}{\varepsilon} \cdot \frac{\alpha}{1 + \alpha}$$

Dasgupta (1986): key comparative statics (I) (Dasgupta 1986)

With $P(Q) = \sigma Q^{-\varepsilon}$ and $c(x) = \beta x^{-\alpha}$:

Dynamic vs static efficiency trade-off:

- $x^*(N+1) < x^*(N)$ (more firms $\rightarrow$ less R&D per firm)
- $Q^*(N+1) > Q^*(N)$ (more firms $\rightarrow$ higher output)

Research intensity:

- Often maximized at moderate concentration (Scherer-style inverse-U)

Interpretation:

- Market structure affects both static outcomes (Q) and dynamic investment incentives (x)

Dasgupta (1986): key comparative statics (II) (Dasgupta 1986)

Greater innovative opportunities associated with higher concentration:

$$\frac{\partial(1/N^*)}{\partial\alpha} > 0$$

Demand growth stimulates R&D:

$$\frac{\partial x^*}{\partial\sigma} > 0$$

Interpretation:

- Larger markets (higher σ) increase the return to cost reduction
- Stronger innovative opportunities (higher α) can support higher concentration in equilibrium

Summary

- Innovation value depends on the objective: $\Delta\pi$ **(private)** versus ΔW **(social)**
- Replacement effect: pre-innovation rents reduce the incumbent's incremental gain from innovation
- With entry threat, innovation can be worth more because it changes **market structure** (monopoly vs duopoly)
- In oligopoly, incentives reflect competing forces (competition effect vs competitive advantage effect)

Next week: patents and IPRs

- Patents as incentives: monopoly rights v dynamic efficiency
- Patent races and timing
- Disclosure, licensing, and welfare
- Horizontal and vertical innovation (brief)

References

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