Strategic Concealment in Innovation Races

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Introduction

Interim Breakthroughs in Innovation Races

- Firms race to develop a final product (e.g., new software, COVID vaccine)
- Innovation often involves **interim breakthroughs**

- **The Question:** Upon breakthrough, will the firm **disclose** or **conceal**?

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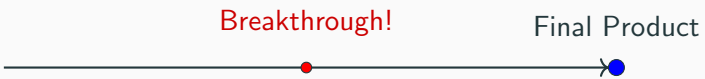

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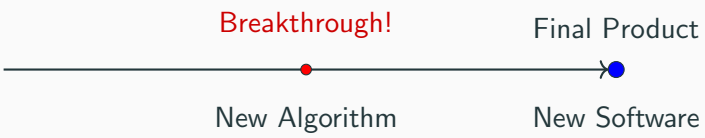

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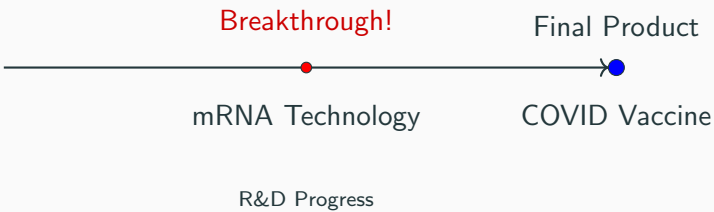

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Tradeoffs of Disclosure vs. Concealment

1. **Disclosure**
   - **IP Protection**: Patent
   - **Information**: Rival observes breakthrough $\Rightarrow$ Strategic Adjustment
     - AstraZeneca and Johnson&Johnson using traditional method
   - **Efficiency**: Enables knowledge spillover through licensing
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Preview of Results

- To study this trade-off, we build a *continuous-time innovation race* model
- Concealment decision depends on
  - **Form of the race** (stakes of winning the race)
  - **Intellectual property system** (the level of prior-use defense)

  $\Rightarrow$ the social speed of innovation?
- **Preview of the Main Result**:
  - **High** stakes and **strong** prior-use defense $\Rightarrow$ firms *conceal* their discovery

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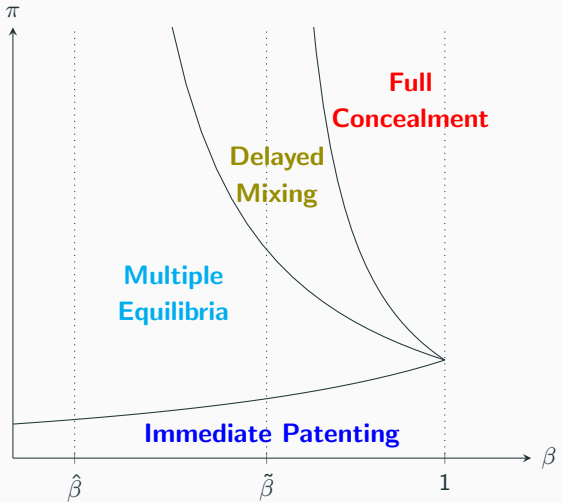
π
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Concealment
Delayed
Mixing
Multiple
Equilibria
Immediate Patenting
β
β̂
β̃
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Literature on Patent vs. Secrecy

- **Empirical Studies**
  - Many surveys indicate that companies regard secrecy as more effective than patents (Hall, Helmers, Rogers, Sena '14)

- **Theoretical Literature**: Structural Limitations of Patent
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Model

Model: Preliminaries

- Two risk-neutral firms $i \in \{A, B\}$ race to develop an innovative product
- Continuous and infinite time $t \in [0, \infty)$
- Two technologies to develop the product:
  - An **old** technology L
  - A **new** technology H (*not accessible at the beginning*)
- At t, each firm (w/o new technology) allocates a unit of resources to:
  - Research σ_t^i
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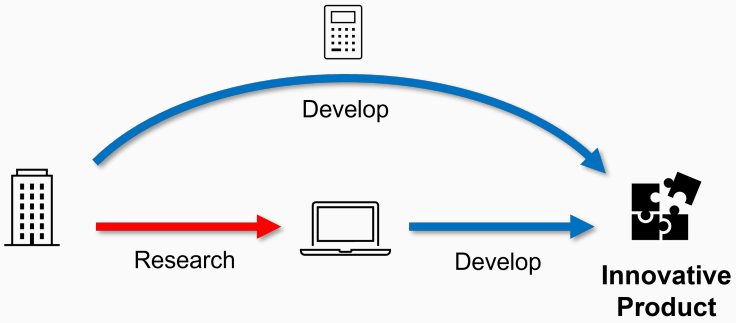
Model: Technology Illustrations

- Two paths toward the product development



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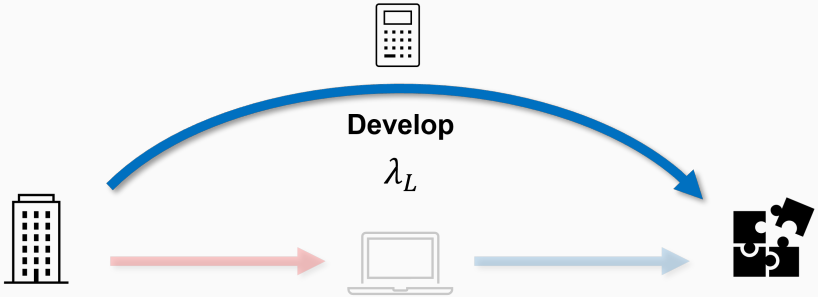
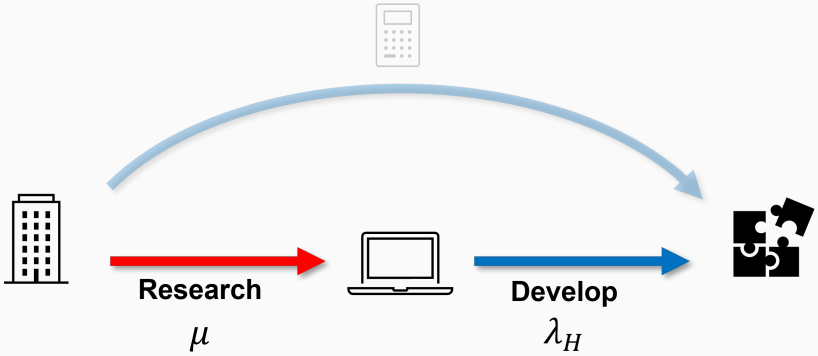


Old Technology

Direct-Development Path

Model: Technology Illustrations



New Technology

R&D Path

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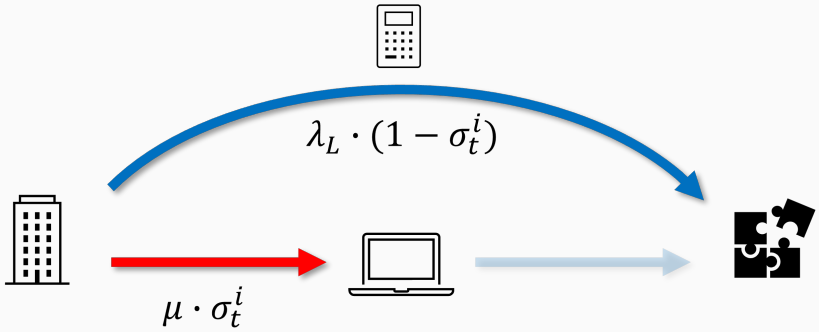

Partial Allocation

Model: Payoffs

- The first firm to successfully develop the innovative product receives Π
  - e.g., Π is a transitory monopoly profit
- The rival firm gets zero and the race stops
- Firms pay a flow cost c until the race stops
- Firms do not discount the future
- Thus, the final payoff of Firm i is:

$$\mathbb{1}_{\{i \text{ develop the product first}\}} \cdot \Pi - c \cdot T$$

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Model: Parametric Assumptions

1. Developing with the old technology is profitable:

$$\Pi > \frac{c}{\lambda_L} \quad \Longleftrightarrow \quad \pi := \frac{\lambda_L \Pi}{c} > 1. \tag{1}$$

   - π represents the stake of winning the race.

2. The research is a high-stakes trade-off:

$$\frac{1}{\lambda_H} < \frac{1}{\lambda_L} - \frac{1}{\mu} - \frac{1}{\lambda_H} < \frac{1}{\mu} \tag{2}$$

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- Recall that a firm's resource allocation is unobservable to the rival
- Informational settings
  - **Public progress**: Rival's breakthrough is observable
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- A firm with breakthrough can apply for a patent.
  - Patent application is observable to the rival
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   - Planner controls the resource allocations & technology transfer
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   - Private progress

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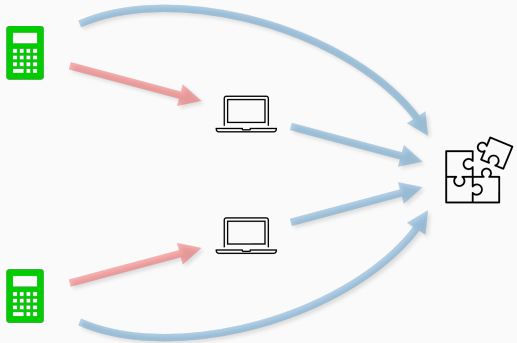

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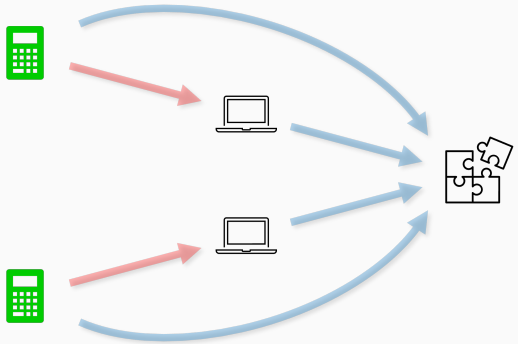

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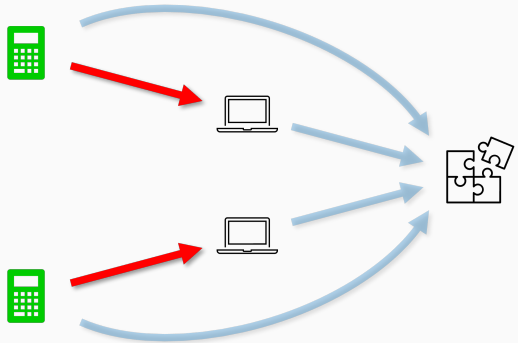

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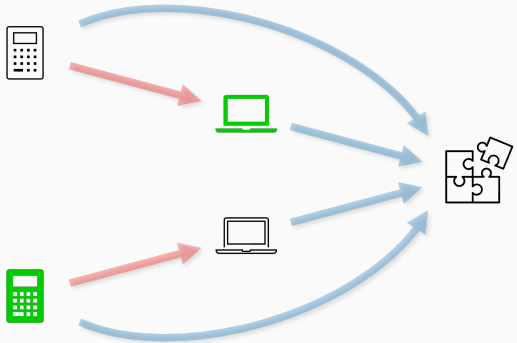

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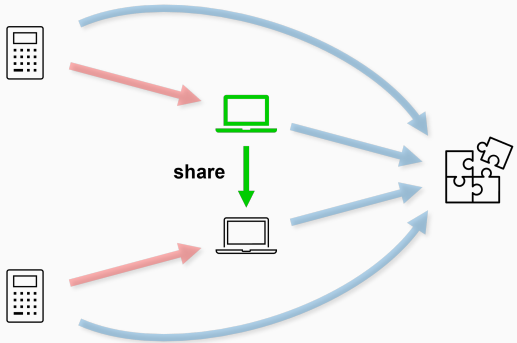

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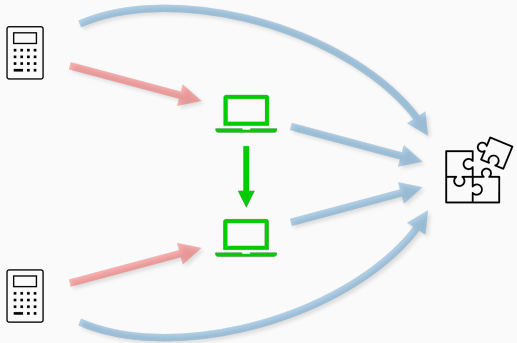

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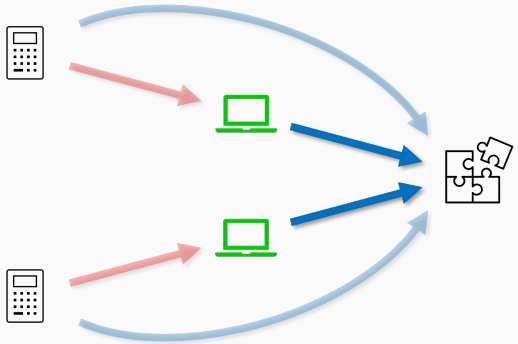
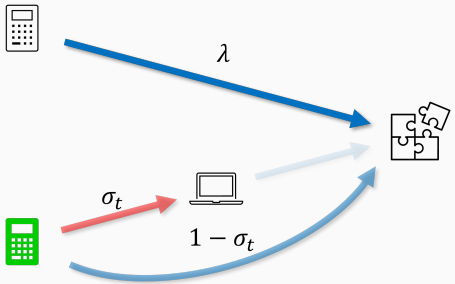


Benchmarks: Non-patentable Technology

Benchmark 1: Constant Development Rate

- We focus on cases without patenting decisions
- Suppose that Firm j develops the product at a constant rate λ



Proposition 1

Suppose that Firm j's development rate is λ:

(a) if $\lambda < \lambda_\star$, Firm i researches (R&D path);

(b) if $\lambda > \lambda_\star$, Firm i develops with the old technology (Direct-Development path).

Recall that we assume

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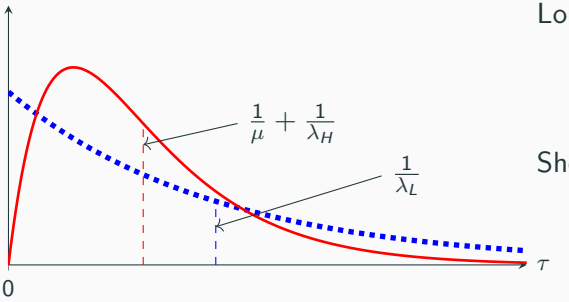

Long Run:

- Expected completion time:
  R&D $\succ$ Direct-Development

Short Run:

- Prob. of completion in the near future:
  R&D $\prec$ Direct-Development

Fall-Back Strategy

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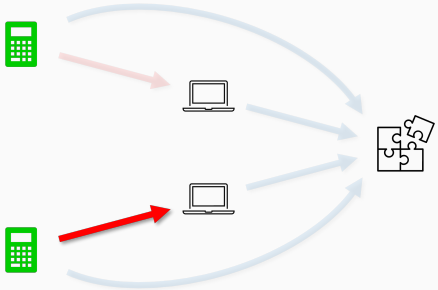

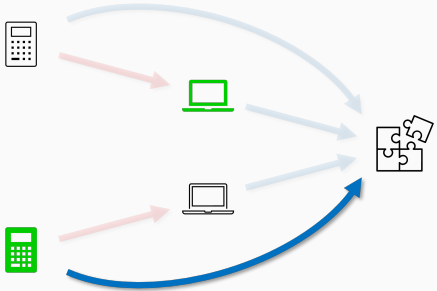

Benchmark 2: Public Research Progress

Fall-Back Strategy

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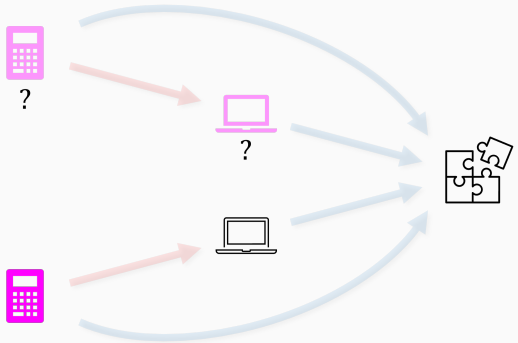
Proposition 2

Suppose that research progress is public information, the new technology is not patentable, and Assumptions (1) and (2) hold.

Then, the **fall-back strategy** is the symmetric Nash equilibrium with the shortest expected duration (SDSNE).

Benchmark 3: Private Research Progress

- When progress is private, firms cannot condition strategies to the rival's progress



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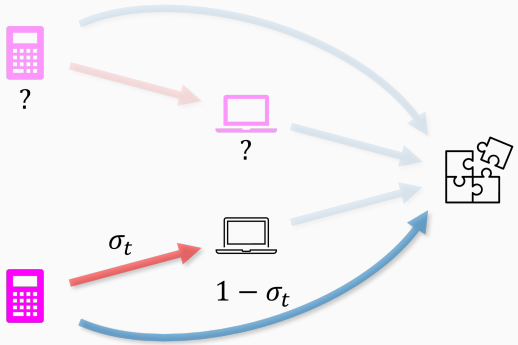

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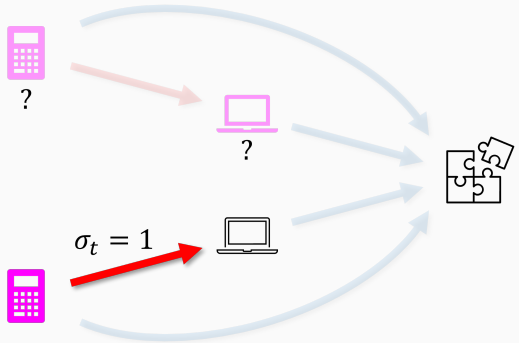

Research Strategy

Benchmark 3: Private Research Progress

Proposition 3

Suppose that research progress is private information, the new technology is not patentable, and Assumptions (1) and (2) hold.

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When p_t is the belief that the firm has made a breakthrough by time t,

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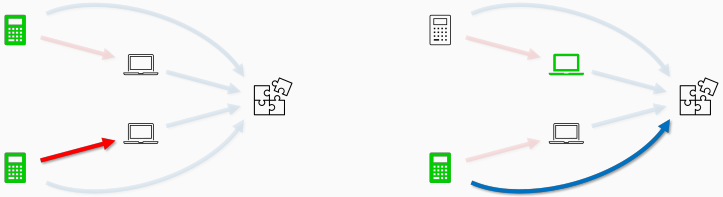
and under the research strategy ($\sigma_t = 1 \ \forall \ t \geq 0$),

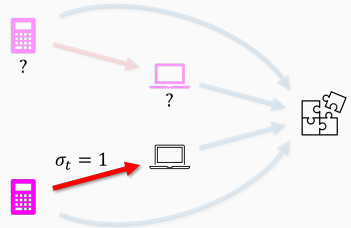
$$\lim_{t \to \infty} p_t = \frac{\mu}{\lambda_H}$$

Strategic Adjustments

- Firm B strategically reacts to Firm A's progress:



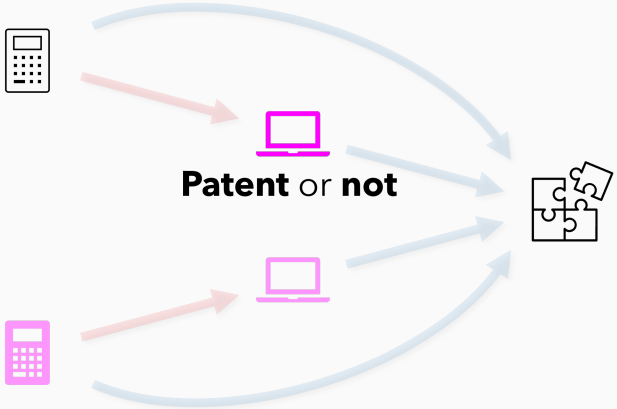
- Such reaction is not feasible when progress is private information



Patentable Technology

Patent vs. Concealment

Now we consider firms' patenting decisions.



Patent vs. Concealment

- We focus on the *private progress* case
  - A firm observes the rival's discovery only through patenting decision
- We focus on the *symmetric equilibrium* where both firms *research* until they discover the new technology or the rival patents
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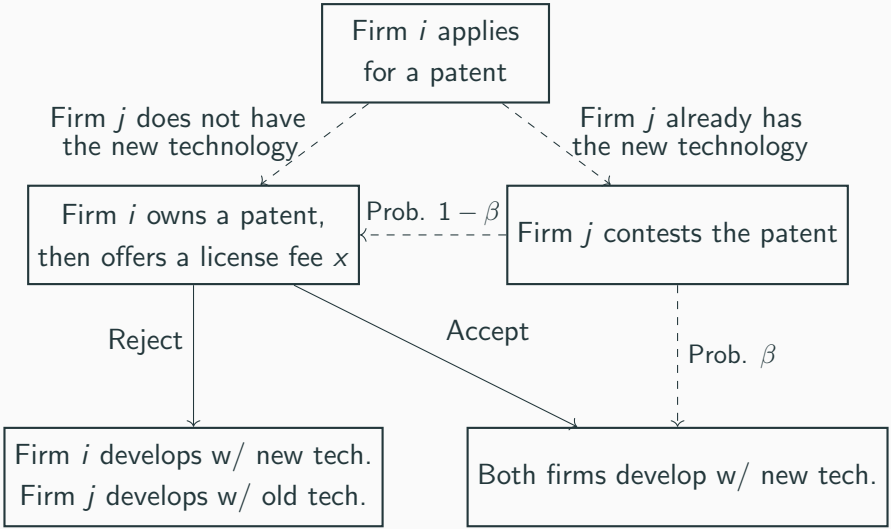
Firm i applies for a patent
Firm j does not have the new technology
Firm j already has the new technology
Firm i owns a patent, then offers a license fee x
Prob. $1-\beta$
Firm j contests the patent
Reject
Accept
Prob. β
Firm i develops w/ new tech.
Firm j develops w/ old tech.
Both firms develop w/ new tech.

Patent vs. Concealment

- β captures the strength of prior-use defense
- Possible Scenarios

Concealment **Patent revoked** (βp_t) **Patented** $(1 - \beta p_t)$

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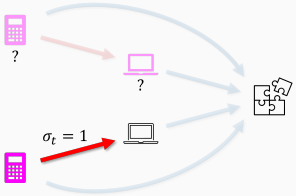

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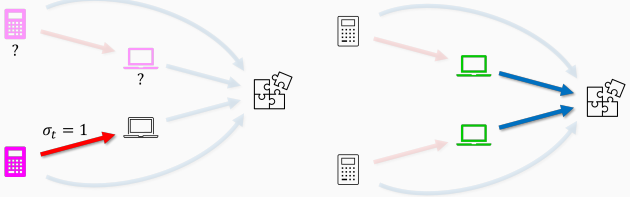

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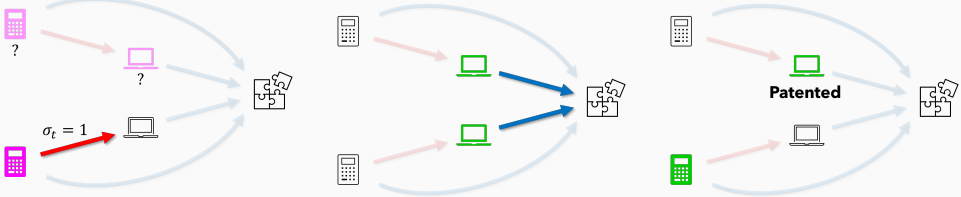

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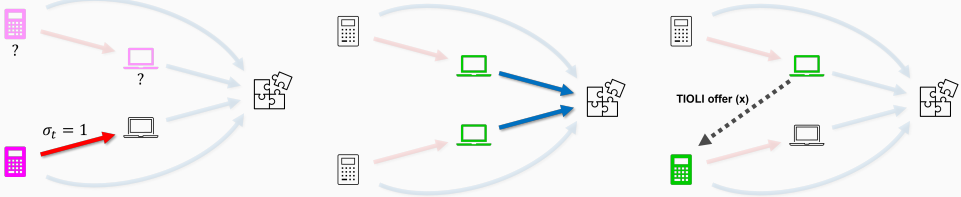

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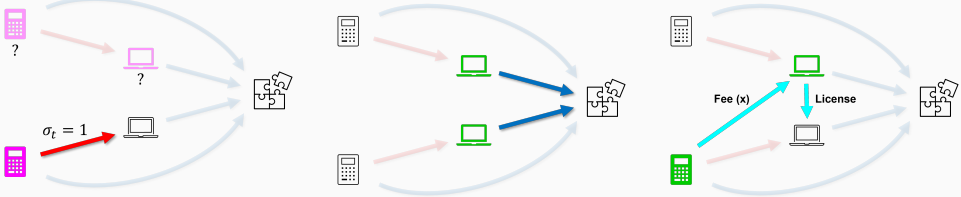

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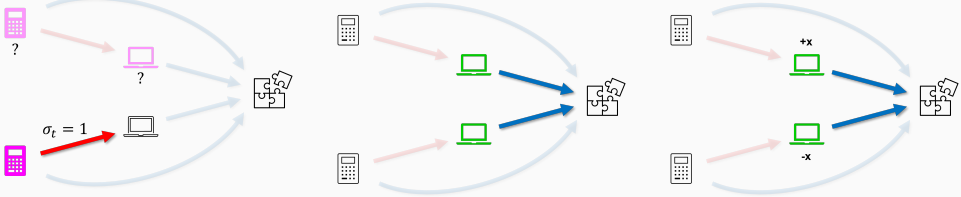
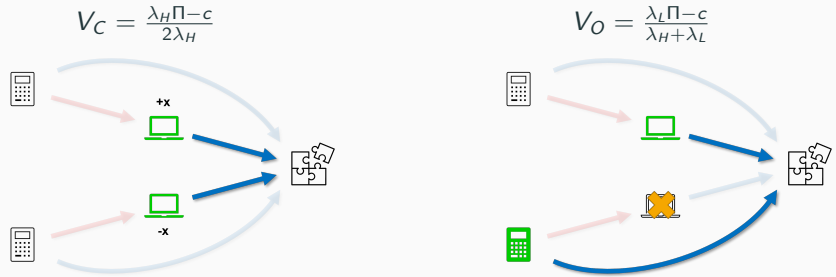


Patent vs. Concealment: Optimal License Fee

Proposition

When Firm A has obtained the patent, the optimal license fee, x^*, satisfies:

$$V_C - x^* = V_O$$



Patent vs. Concealment: Optimal License Fee

Observation

- $\rho := \dfrac{x^*}{V_C} = \dfrac{\lambda_H - \lambda_L}{\lambda_H + \lambda_L} \cdot \dfrac{\lambda_H \Pi + c}{\lambda_H \Pi - c}$ is decreasing in $\pi := \frac{\lambda_L \Pi}{c}$

- **Intuition**: the license fee includes the term related to the social cost saving, which is not proportional to π

- The equilibrium patenting strategy crucially **depends on** the licensing ratio ρ

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Patent vs. Concealment: Gradual Patenting

A patenting strategy $\{G_\tau\}_{\tau \geq 0}$ is called a **gradual patenting strategy** if there exist $0 \leq T_1 \leq T_2$ such that:

(i) **Silent Phase**: the firm *does not patent* before T_1: $G_\tau(t) = 0$ for all $0 \leq \tau \leq t < T_1$;

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In any symmetric equilibrium with research, the equilibrium patenting strategy takes a form of a gradual patenting strategy.

- **Full Concealment**: $T_1 = T_2 = \infty$
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Immediate Phase

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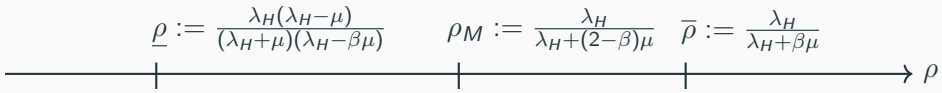
Suppose that firms' research progress is private information, the new technology is patentable, and parametric assumptions (1) and (2) hold.

The patenting strategy in the symmetric equilibrium with research depends on the licensing ratio ρ and is characterized as follows.



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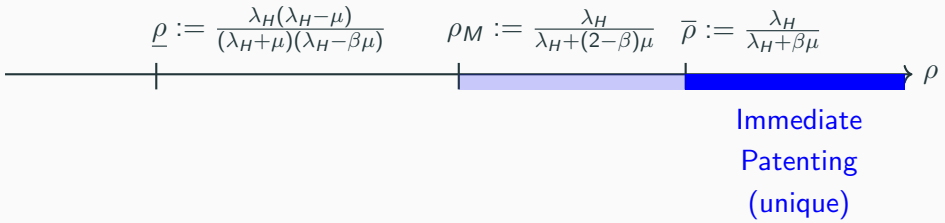

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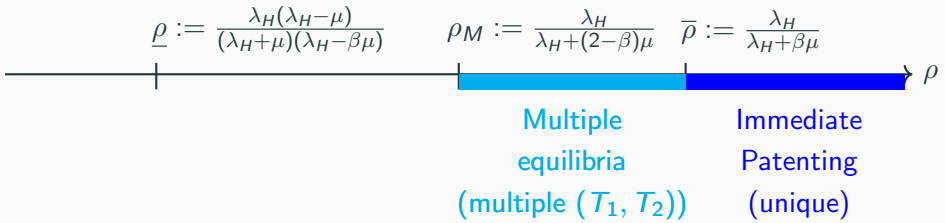

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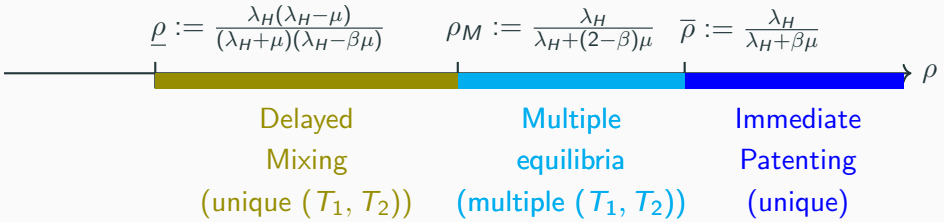

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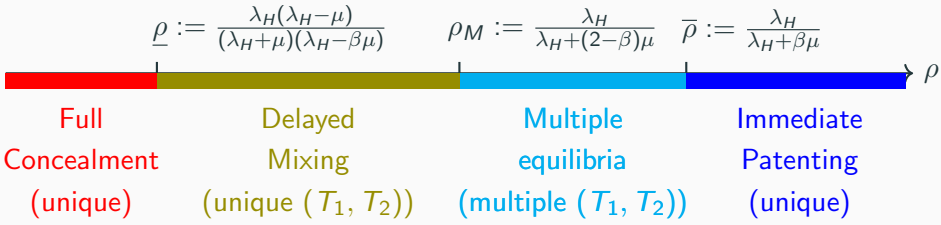

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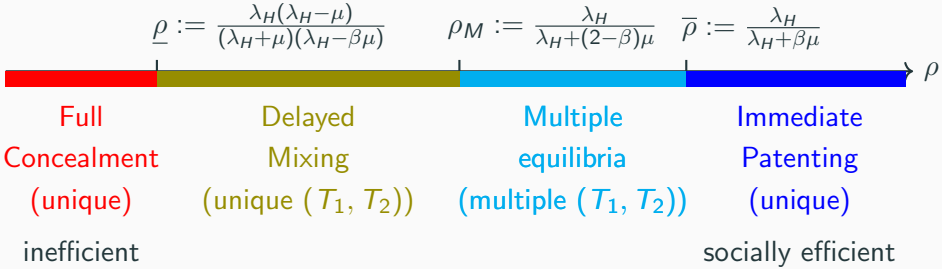

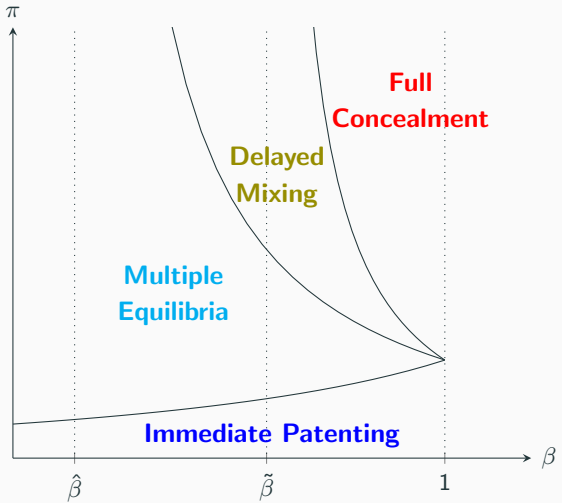
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β̂
β̃
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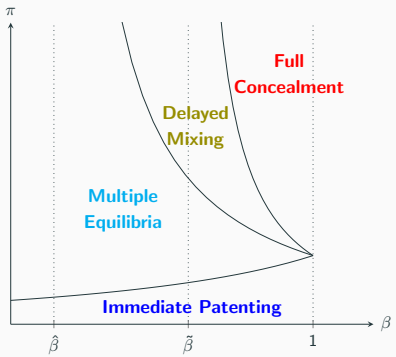
Patent vs. Concealment: Policy Implication



- No knowledge spillover under high π & β
  $\Rightarrow$ social speed of innovation $\downarrow$
- $\pi \downarrow \Rightarrow$ Efficiency $\uparrow$
  - Lowing π makes licensing more attractive (e.g., tax in the final product market)
  - **Caveat**: too low $\pi \Rightarrow$ firms exit
- Two-fold effect of β
  - $\beta \downarrow \Rightarrow$ Concealment $\downarrow$ (High π)
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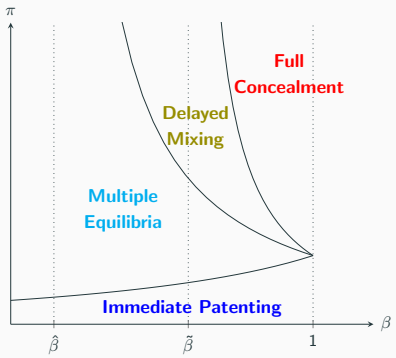
Patent vs. Concealment: Policy Implication



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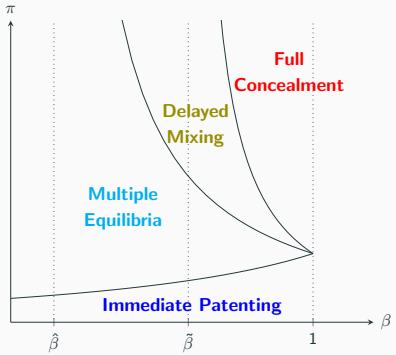

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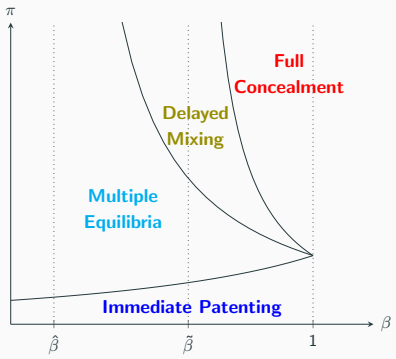

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