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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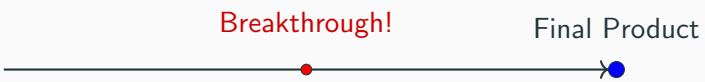

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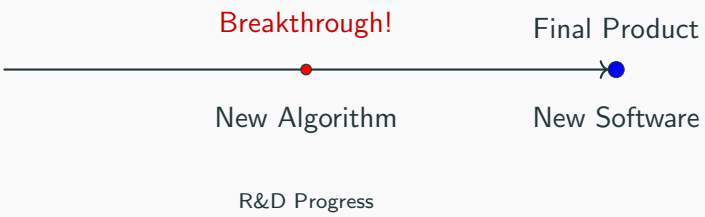

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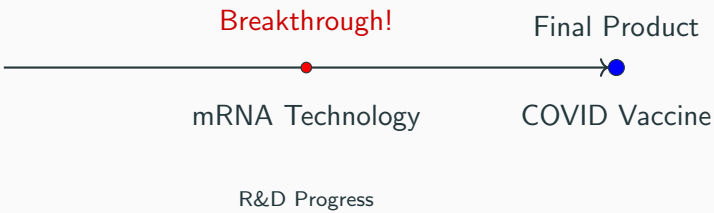

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Tradeoffs of Disclosure vs. Concealment

1. **Disclosure**
   - **IP Protection**: Patent
   - **Efficiency**: Enables knowledge spillover through licensing
     - Joint venture by Pfizer and BioNTech
   - **Information**: Rival observes breakthrough $\Rightarrow$ Strategic Adjustment
     - AstraZeneca and Johnson&Johnson using traditional method
2. **Concealment**
   - **IP Protection**: Prior-use defense $\Rightarrow$ vulnerable to Rival's independent discovery
     - β: prob. that the firm can keep using discovery when the rival applies for a patent
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Preview of Results

- To study this trade-off, we build a *continuous-time innovation race* model
  - Evolution of belief about rival's breakthrough
  - Timing of disclosure
- Concealment decision depends on
  - **Structure of final product market** (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

  $\Rightarrow$ strategic concealment *slows down* the overall pace of innovation

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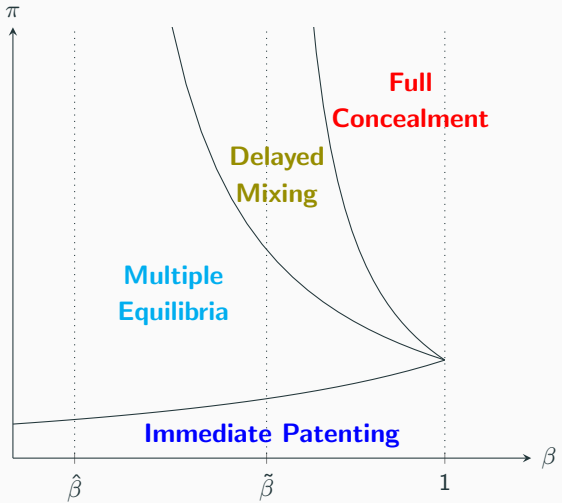
π
Full
Concealment
Delayed
Mixing
Multiple
Equilibria
Immediate Patenting
β
$\hat{\beta}$
$\tilde{\beta}$
1

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
  - Filing a patent is costly
  - Patent protection is limited (e.g., Denicolo, Franzoni '04)
  - Patent can be infringed (e.g., Anton, Yao '04)

- **This paper**: Strategic Advantage of Secrecy
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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
  - Development $(1 - \sigma_t^i)$
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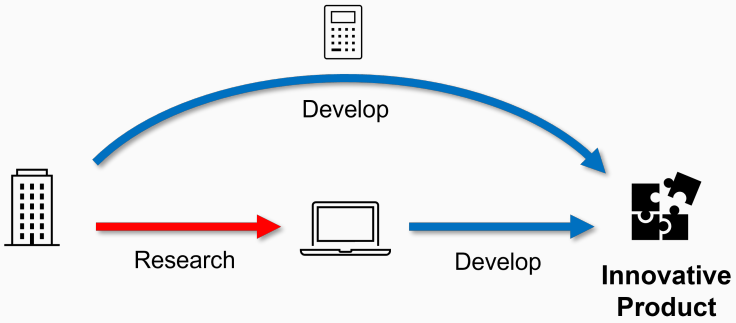
Model: Technology Illustrations

- Two paths toward the product development



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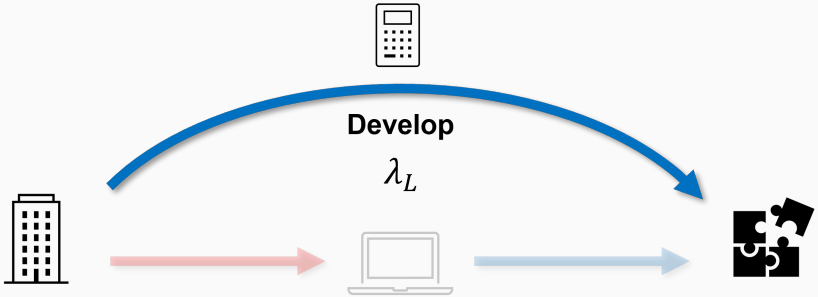
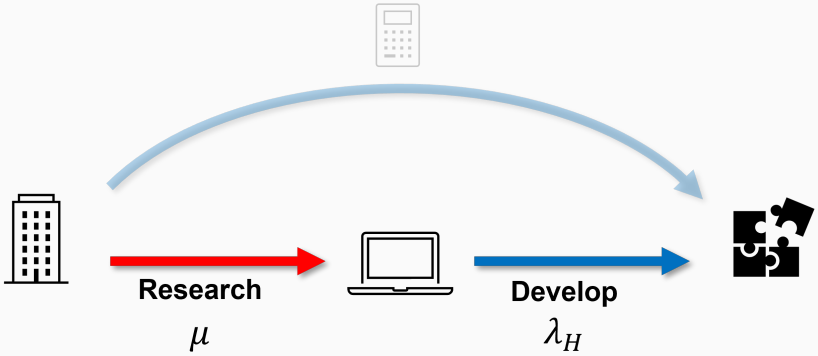


Old Technology

Direct-Development Path

Model: Technology Illustrations



New Technology

R&D Path

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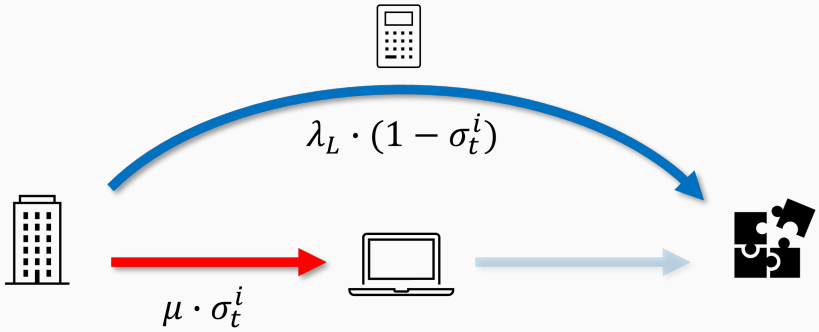

Partial Allocation

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:

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

where T is the time at which the race stops

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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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   - The new technology is much superior
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Roadmap

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2. **Benchmarks**: Non-patentable technology
   - Public progress: Rival's breakthrough is observable
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3. **Main Analysis**: Patentable technology
   - Policy implication

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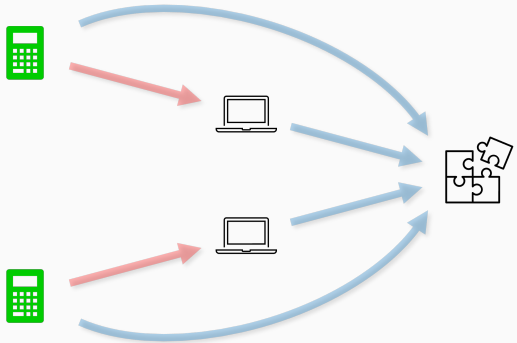
- **First-Best Case**: firms research and the new technology is immediately licensed



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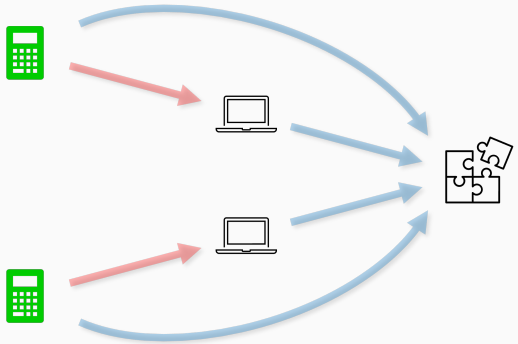

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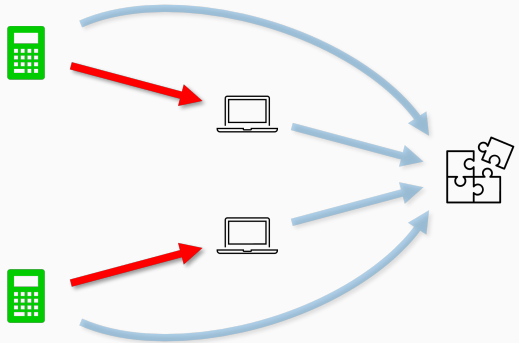

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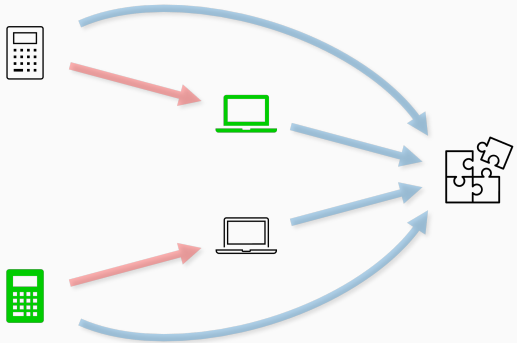

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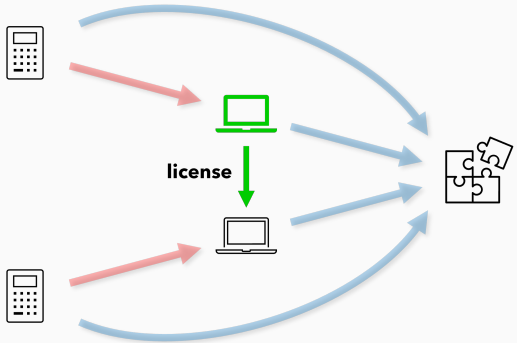

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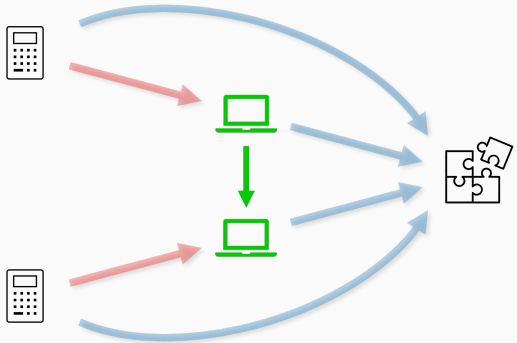

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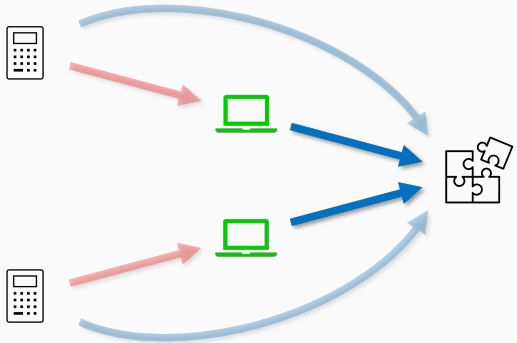
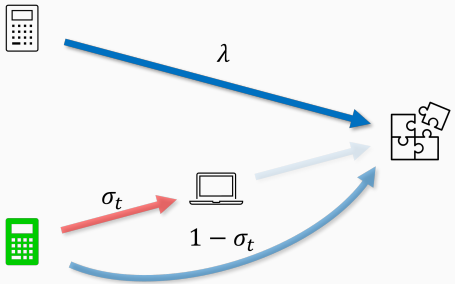


Benchmarks: Non-patentable Technology

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

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

$$\iff \qquad \mu < \lambda_\star := \mu\lambda_H\left(\frac{1}{\lambda_L} - \frac{1}{\mu} - \frac{1}{\lambda_H}\right) < \lambda_H$$

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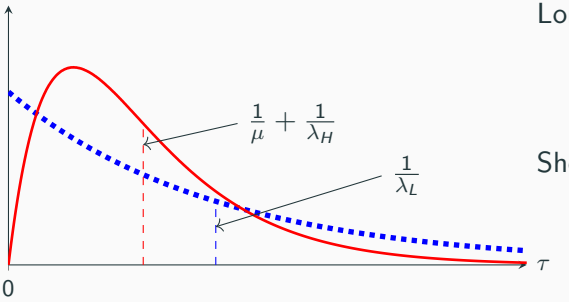


Long Run:

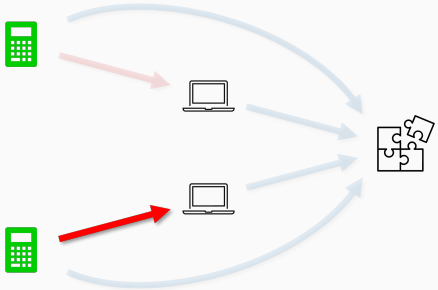
- Expected completion time:
  R&D $\succ$ Direct-Development

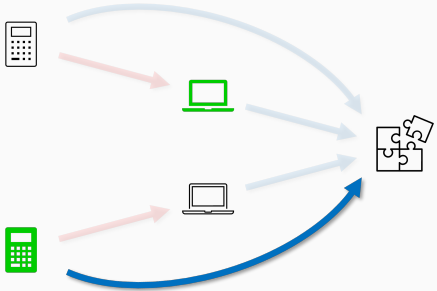
Short Run:

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

Fall-Back Strategy

1. Research if the rival does not possess the new technology;
2. Switch to developing with the old technology once the rival discovers





Benchmark 2: Public Research Progress

Fall-Back Strategy

1. Research if the rival does not possess the new technology;
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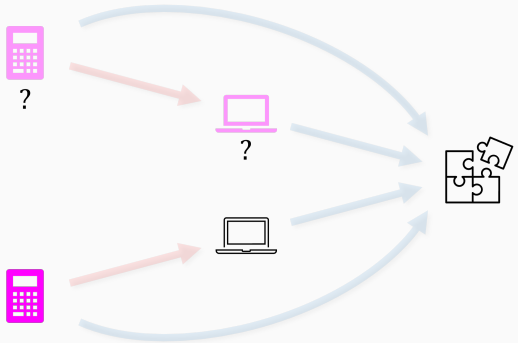
Proposition 2

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



Strategy: $\sigma : \mathbb{R}_+ \to [0, 1]$

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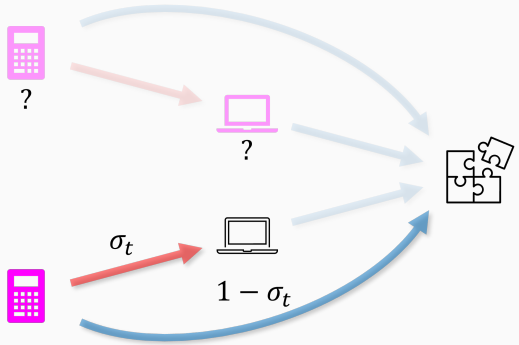

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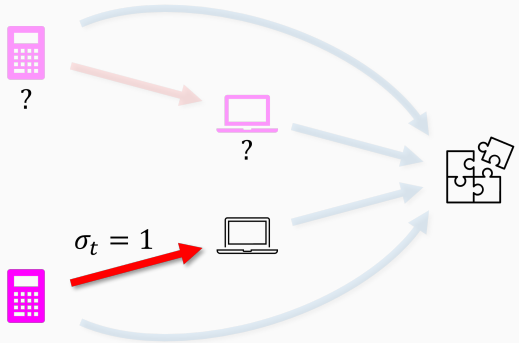

Research Strategy

Benchmark 3: Private Research Progress

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

$$\dot{p}_t = \underbrace{\mu \cdot \sigma_t \cdot (1 - p_t)}_{\text{Duration effect}} - \underbrace{\{\lambda_H - (1 - \sigma_t)\lambda_L\} \cdot p_t \cdot (1 - p_t)}_{\text{Still in the race effect}}$$

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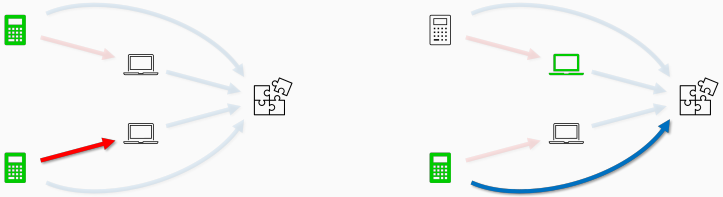
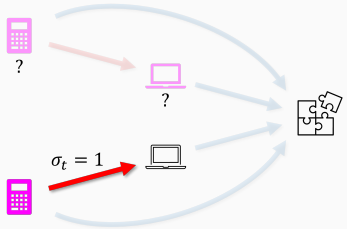
Strategic Adjustments

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



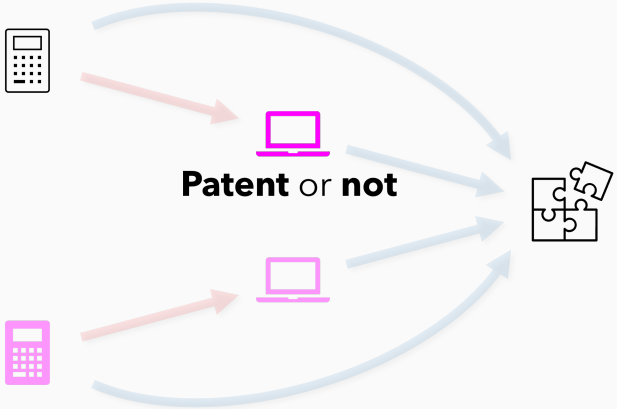
- Such reaction is not feasible when progress is private information



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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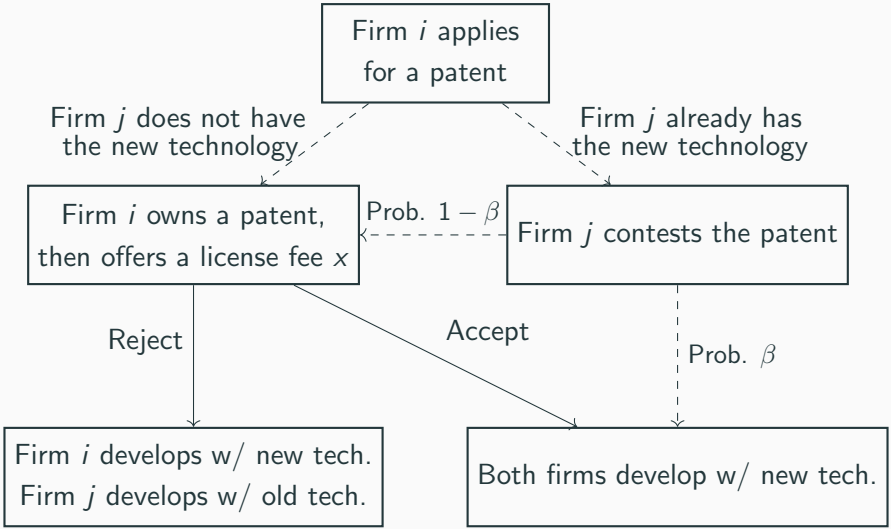
Firm i applies for a patent
Firm j does not have the new technology
Firm j already has the new technology
Firm i owns a patent, then offers a license fee x
Prob. $1-\beta$
Firm j contests the patent
Reject
Accept
Prob. β
Firm i develops w/ new tech.
Firm j develops w/ old tech.
Both firms develop w/ 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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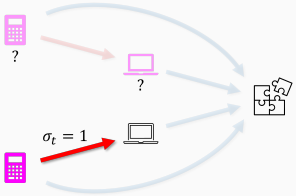

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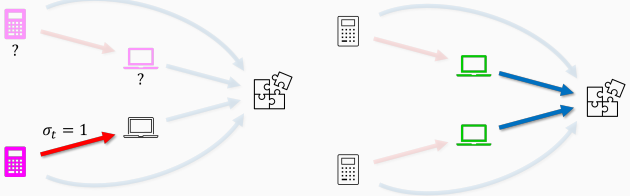

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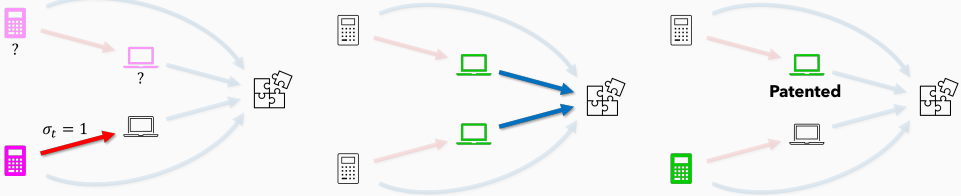

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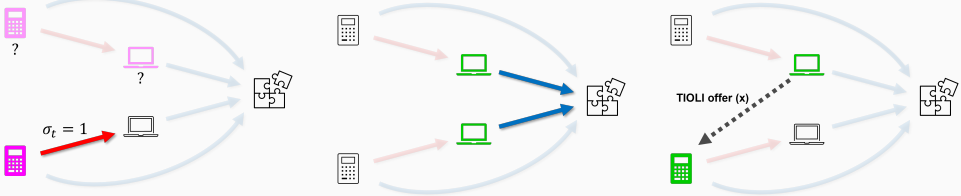

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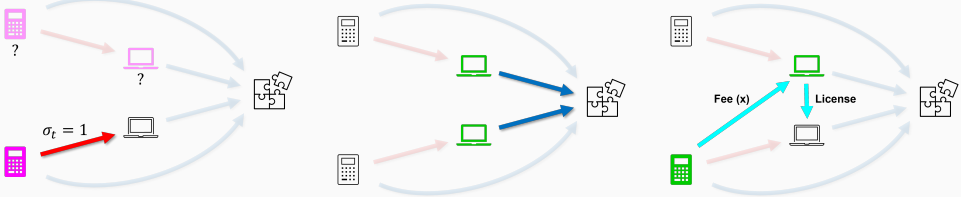

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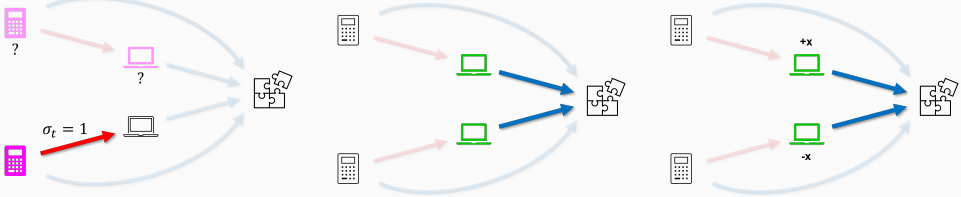
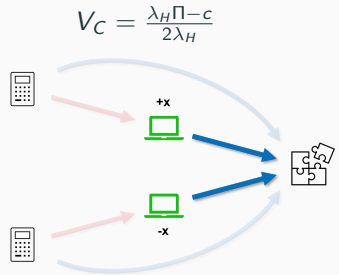


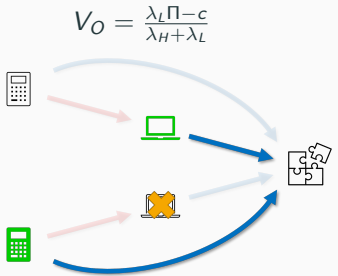
Patent vs. Concealment: Equilibrium License Fee

Proposition 4

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

$$V_C - x^* = V_O$$





Patent vs. Concealment: Equilibrium License Fee

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

$$\rho := \frac{x^*}{V_C} = 1 - \frac{V_O}{V_C}$$

- **Observation**: ρ is decreasing in $\pi := \frac{\lambda_L \Pi}{c}$

- **Intuition**: as π increases, pivoting to the direct-development becomes more appealing, i.e., $\frac{V_O}{V_C}$ is increasing.

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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 $0 \leq \tau \leq t < T_1$;

(ii) **Mixing Phase**: the firm engages in *partial patenting* between T_1 and T_2: $0 < G_\tau(t) \leq 1$ for all $\tau < t$ and $T_1 \leq t < T_2$, and if $T_2 < \infty$, by the end of this phase, the firm patents with certainty: $G_\tau(T_2) = 1$ for all $\tau < T_2$;

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Patent vs. Concealment: Gradual Patenting

Theorem 1

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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- **Heuristic argument**: if a patenting phase is followed by a silent phase, find a profitable deviation by swapping them (Silence first, Patent later).
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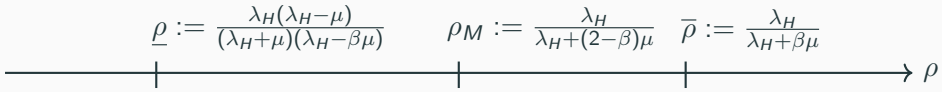
Immediate Phase

Patent vs. Concealment: Equilibrium

Theorem 2

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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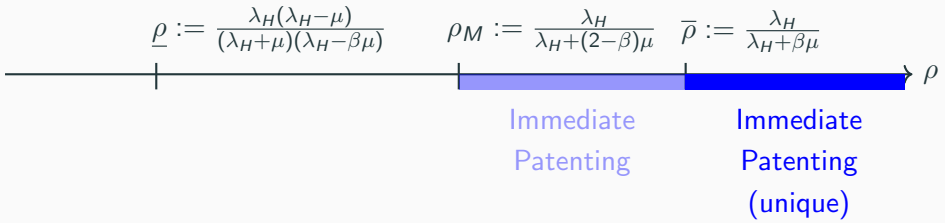

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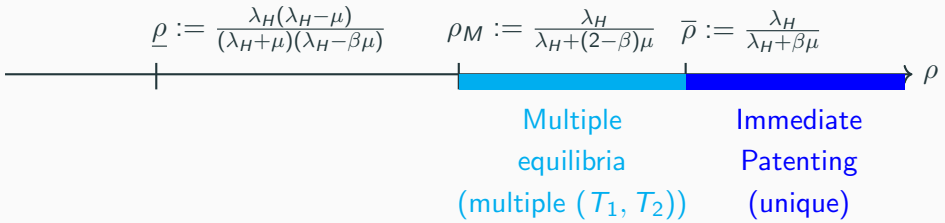

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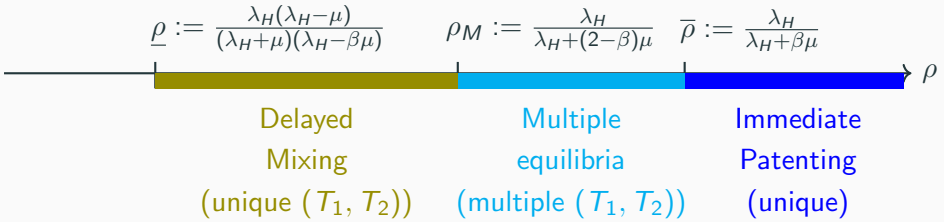

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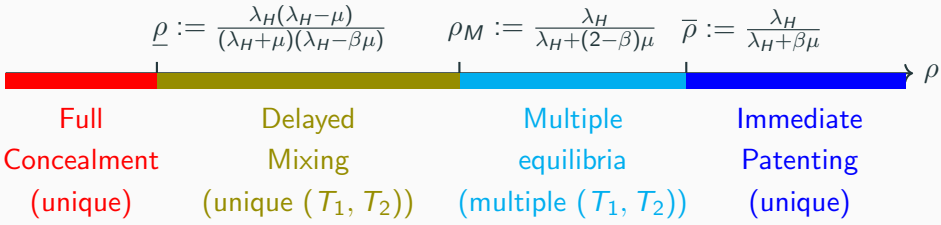

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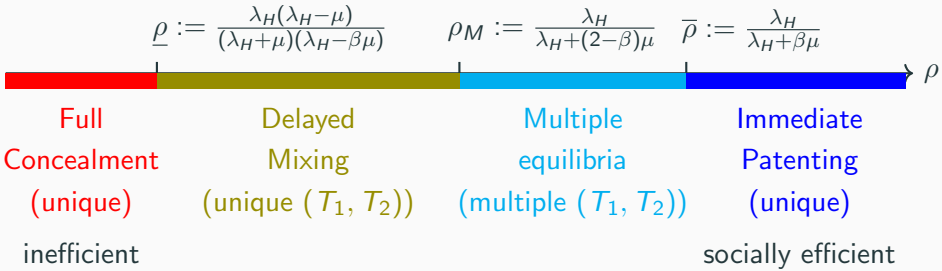

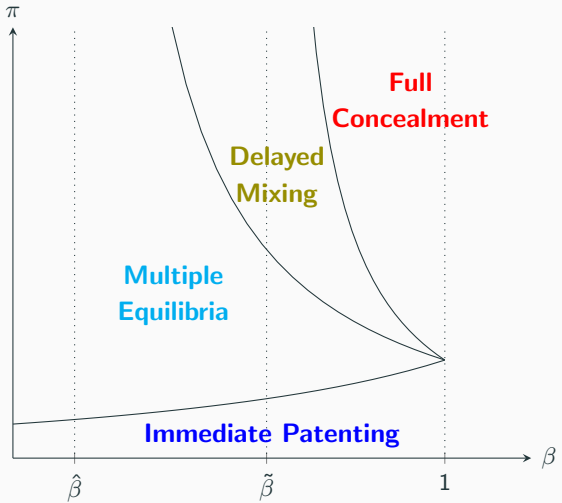
π
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Delayed
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β
$\hat{\beta}$
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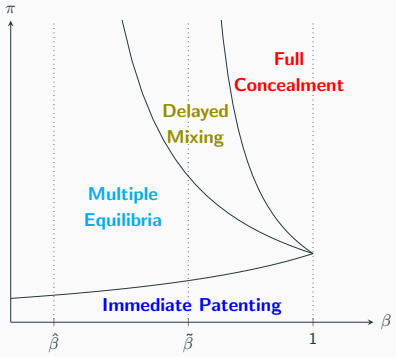
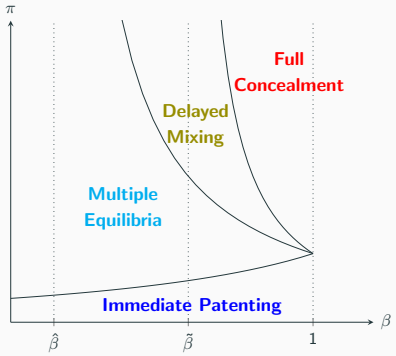
1

Patent vs. Concealment: Policy Implication



- No knowledge spillover under high π & β
  $\Rightarrow$ social speed of innovation $\downarrow$
- $\pi \downarrow \Rightarrow$ Efficiency $\uparrow$
  - Lower π makes licensing more attractive (e.g., tax in the final product market)
  - **Caveat**: too low $\pi \Rightarrow$ no race
- Two-fold effect of β
  - $\beta \downarrow \Rightarrow$ Concealment $\downarrow$ (High π)
  - $\beta \downarrow \Rightarrow$ sensitivity to rival's strategy $\uparrow$
    $\Rightarrow$ coordination issue $\Rightarrow$ multiplicity

Patent vs. Concealment: Policy Implication



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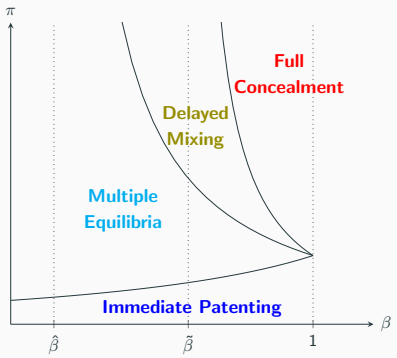

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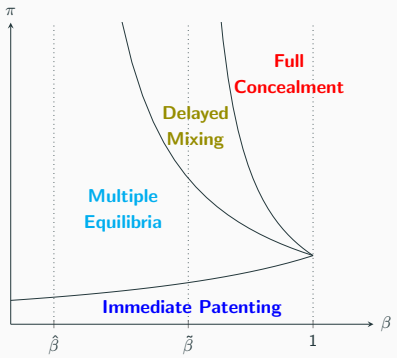
  - **Caveat**: too low $\pi \Rightarrow$ no race
- Two-fold effect of β
  - $\beta \downarrow \;\Rightarrow$ Concealment $\downarrow$ (High π)
  - $\beta \downarrow \;\Rightarrow$ sensitivity to rival's strategy $\uparrow$
    $\Rightarrow$ coordination issue $\Rightarrow$ multiplicity

Patent vs. Concealment: Policy Implication



- No knowledge spillover under high π & β
  $\Rightarrow$ social speed of innovation $\downarrow$
- $\pi \downarrow \;\Rightarrow$ Efficiency $\uparrow$
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  - Under non-patentable technology, we characterize the equilibrium under private or public progress
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    Stake of winning the race (π) & Prior-use defense level (β) $\uparrow$ $\Rightarrow$ Concealment $\uparrow$
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    - $\pi \downarrow$ $\Rightarrow$ concealment $\downarrow$ / race may not be initiated
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Thank you!