Strategic Concealment in Innovation Races

WATE-FL

Yonggyun (YG) Kim

Florida State University

Francisco Poggi

University of Mannheim

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Introduction

Motivation: Patent or Secret?

- Consider firms racing for developing an innovative product
  - COVID vaccines, new software
- Innovation often involves **interim breakthroughs** (new technology)
  - mRNA technology, new algorithms

Option 1: Patent

- Disclose the new technology
- Secure exclusive rights
- Potentially license it to the rival.

Option 2: Keep Secret

- Conceal the new technology
- Protecting it via prior-use defense to maintain a strategic advantage.

- This decision shapes knowledge spillovers and the overall pace of innovation.

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Motivation: The Strategic Trade-off

- **Patenting Decision**
  - Pro: Licensing the new technology enables faster, more efficient joint development (maximizes social welfare).
  - Con: Disclosing the new technology allows the rival to **adjust its R&D strategy**, which improves the rival's outside option and weakens the patent holder's bargaining position.
- **Hold-up Problem**
  - It is socially optimal for the firm with the new technology to patent and license, but it refrains from doing so since it may give the rival increased outside option.

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Main Questions & Preview of Results

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  - How do the **form of the race** (e.g., stakes of winning) and the **intellectual property system** (e.g., prior-use defense) shape the choice to conceal?
  - What are the consequences for the social speed of innovation?
- **Preview of the Main Result**:
  - High stakes and strong prior-use defense induce firms to *conceal* their discovery of the new technology
  - As a result, this strategic concealment slows down the overall pace of innovation

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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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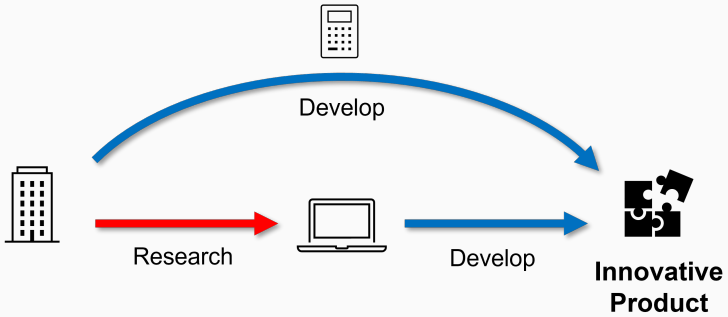
Model: Technology Illustrations

- Two paths toward the product development



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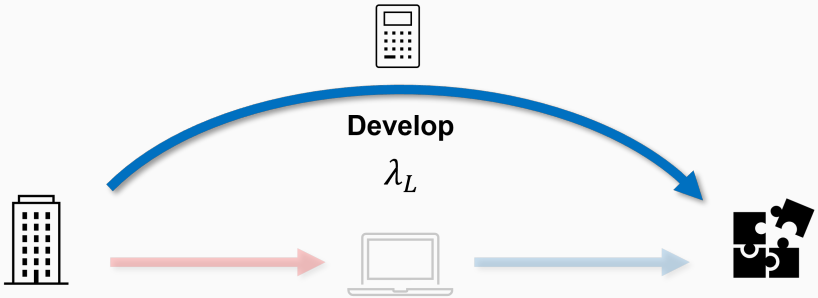

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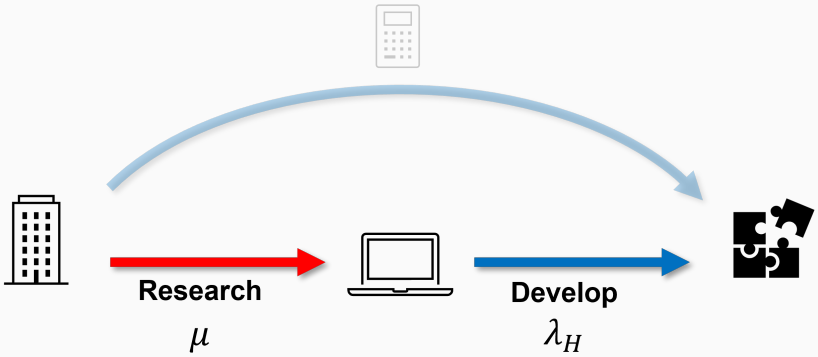

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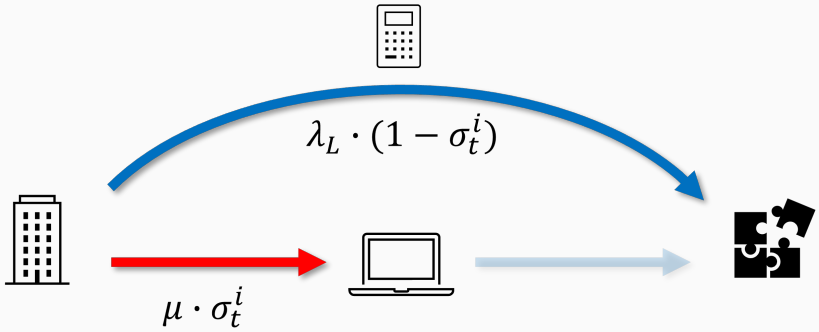

Partial Allocation

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: Information and Patenting

- Recall that a firm's resource allocation is unobservable to the rival
- Informational settings about intermediate breakthroughs
  - **Public progress**: a firm can observe whether its rival has discovered the new technology
  - **Private progress**: a firm cannot observe the rival's progress
- A firm with the new technology can apply for a patent and such patent application is observable to the rival.
  - The subgame following the patent application will be addressed later.

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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:

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

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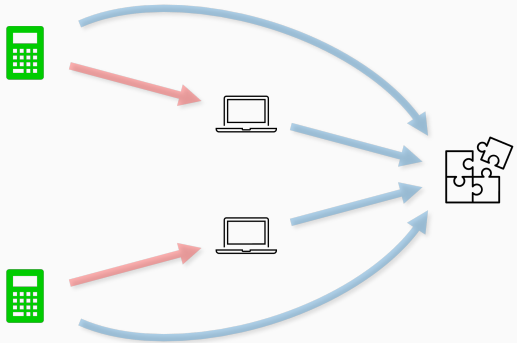
- Planner can control the resource allocations and observe research progress
- Planner's goal is to *max* joint profit $\Leftrightarrow$ *min* expected completion time
- **First-Best Case**: firms do research and the new technology is immediately shared



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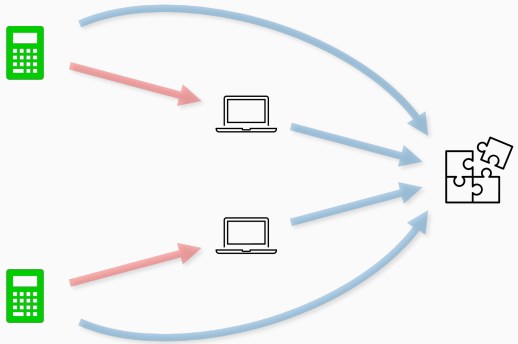

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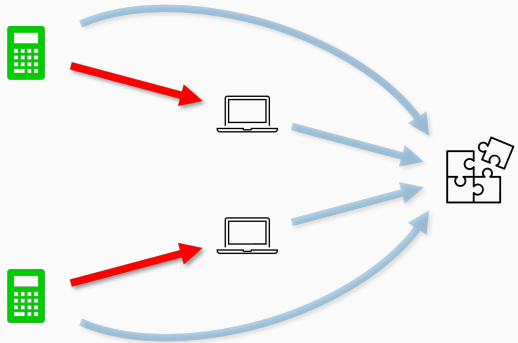

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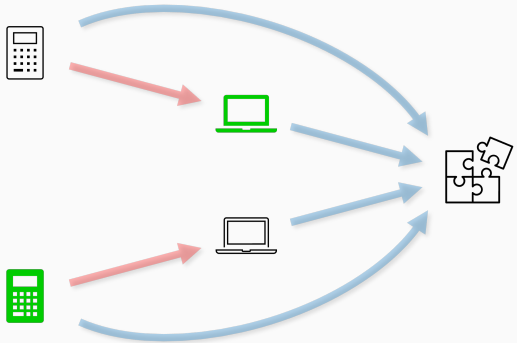

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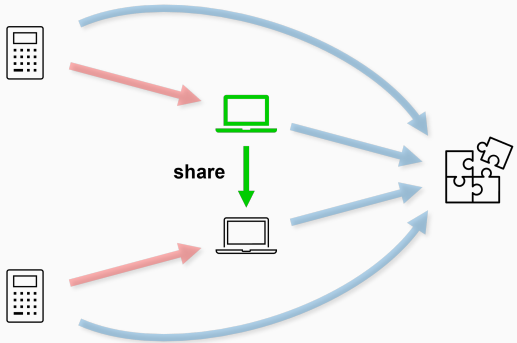

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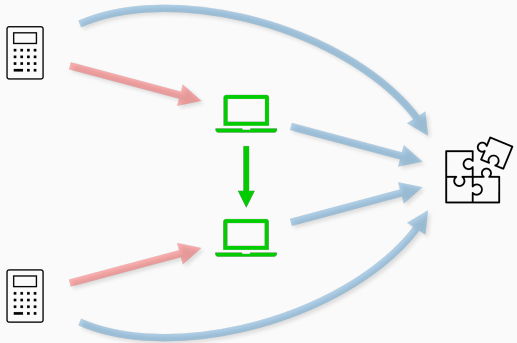

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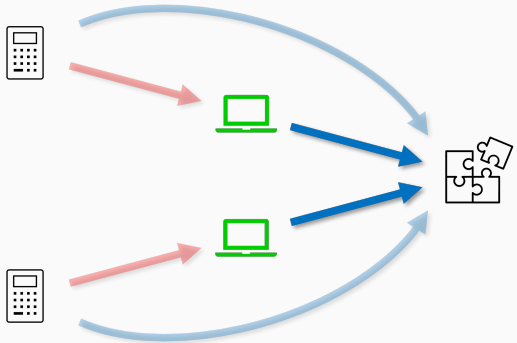

Benchmarks: Non-patentable Technology

Benchmark 1: Constant Development Rate

- As benchmarks, we focus on resource allocation strategies without patenting decisions

- Suppose that Firm j develops the product at a constant rate λ

▸ Illustration

Proposition 1

Suppose that Firm j's development rate is λ:

(a) if $\lambda < \lambda_\star$, Firm i conducts research;

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

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Fall-Back Strategy

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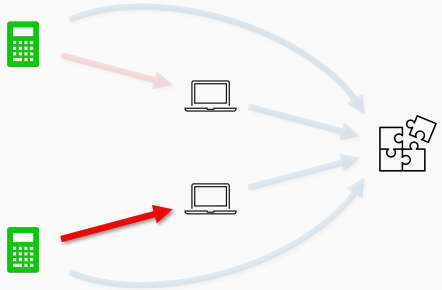

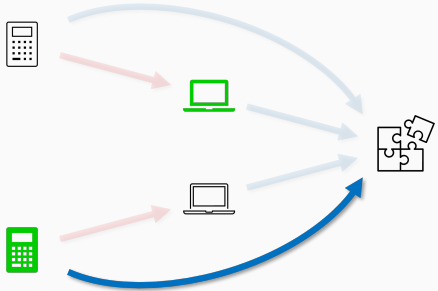

Benchmark 2: Public Research Progress

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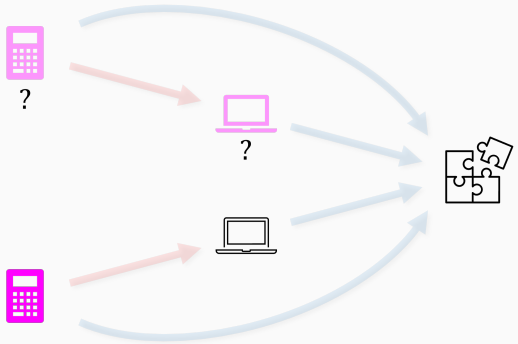
Proposition 2

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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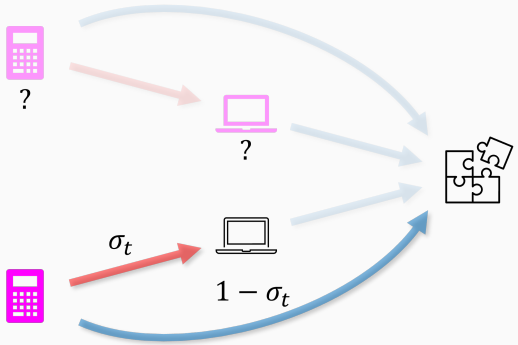

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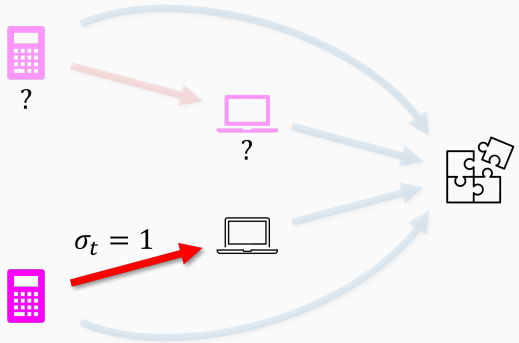

Research Strategy

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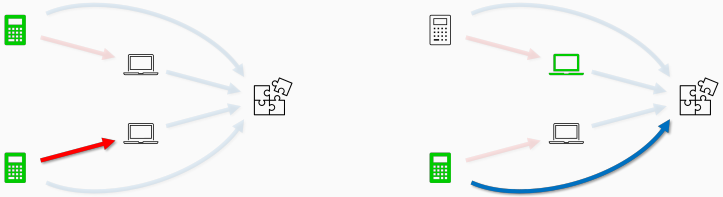
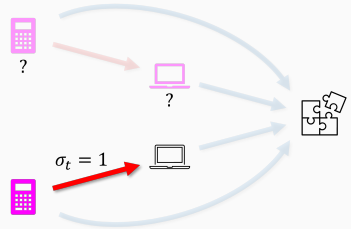
Strategic Adjustments

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



- Such reaction is not feasible when progress is private information



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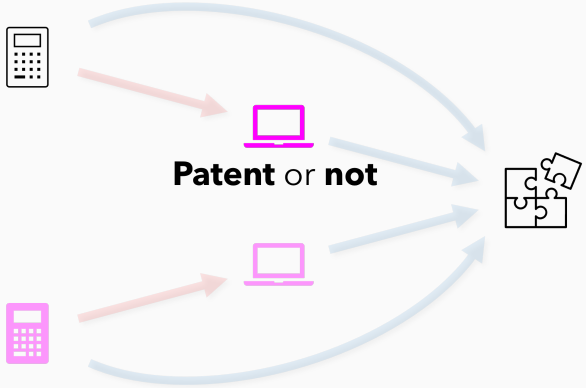

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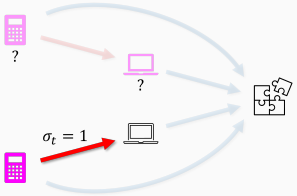

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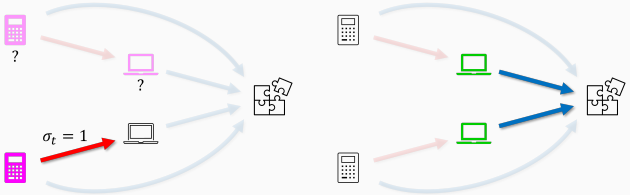

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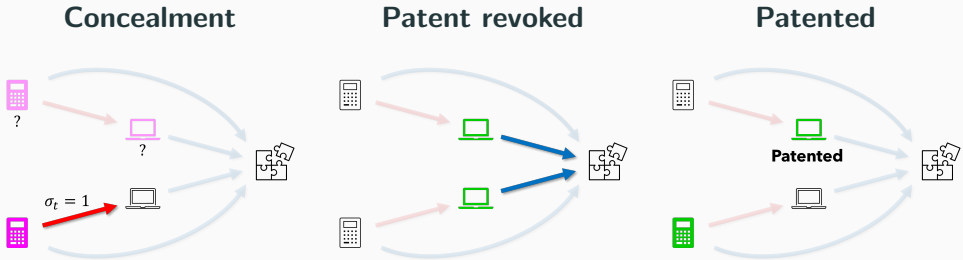

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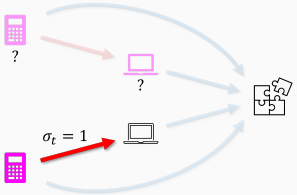

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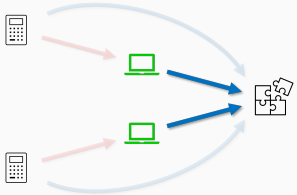

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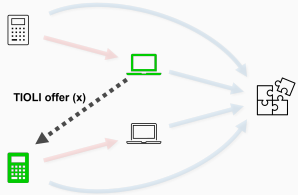

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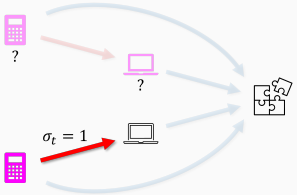

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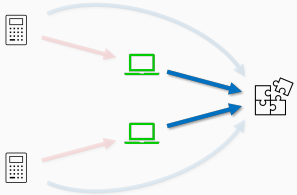
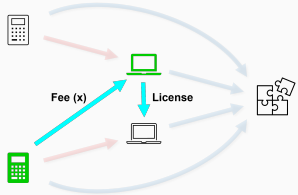


Patented



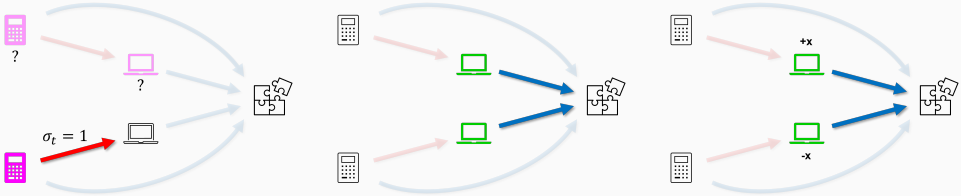
Patent vs. Concealment

- Now we consider firms' patenting decisions.

▸ Illustration

- Possible Scenarios

Concealment **Patent revoked** **Patented**



Patent vs. Concealment: Equilibrium

- When a firm discovers the new technology at τ, the patenting strategy is $G(t|\tau)$, the probability that the firm files a patent by t
- **Immediate Patenting**: $G(\tau|\tau) = 1$
- **Mixed Patenting**: $\exists\ T > 0$ and $\eta > 0$ such that

$$G(t|\tau) = \begin{cases} 0, & \text{if } \tau < t < T, \\ 1 - e^{-\eta(t-T)}, & \text{if } \tau < T \leq t, \\ 1 - e^{-\eta(t-\tau)}, & \text{if } T \leq \tau \leq t, \end{cases}$$

- **Concealment**: $G(t|\tau) = 0$ for all $t > \tau$

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- **Immediate Patenting**: $G(\tau|\tau) = 1$
  - The first to discover the new technology immediately patents & licenses
  - The first-best outcome is implemented
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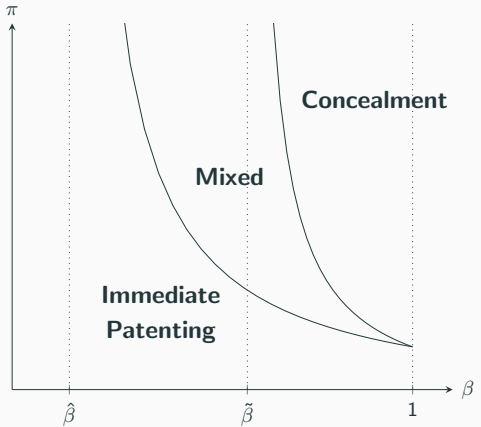
Theorem

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

The SDSNE is characterized as in the following figure.



Patent vs. Concealment: Intuition

- Why does β matter?
  - Higher β increases the incentive to conceal the new technology as the concealed technology is more likely to be protected.
- Why does π matter?
  - Patent $\rightarrow$ information revealed $\rightarrow$ rival's outside option changes
    $\rightarrow$ license fee is determined given that the rival is developing w/ old tech.
  - When π is high, a firm wants the rival *squander* its time in research

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Patent vs. Concealment: Takeaways

- Firms' patenting decisions crucially depend on the stake of winning the race (π) and the prior-use defense level (β)
  - When β is low or π is *small*, the new technology is patented and licensed (Outcome is equivalent to the **First-Best** outcome)
  - When β is high and π is *high*, firms conceal their discoveries (Outcome is equivalent to the **Private progress** benchmark)
- **Implications**
  - The first-best outcome can be achieved by lowering either π or β (e.g., imposing tax in the innovative product market; shifting the patent system from 'first-to-invent' (high prior-use defense) to 'first-to-file' (no prior-use defense))
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Related Literature and Conclusion

Literature on Patent vs. Secrecy

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

- **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
  - By concealing research progress, firms can hinder their rivals from adjusting R&D strategies

Conclusion

- We study firms' strategic incentives to conceal their interim technology
  - We introduce an innovation race model with multiple paths
  - We characterize the equilibrium behaviors of firms when their research progress is public or private information
  - We study firms' patenting behavior: Under a strong prior-use defense,
    Prize of winning the race $\uparrow \Rightarrow$ Incentives to conceal $\uparrow \Rightarrow$ Socially inefficient

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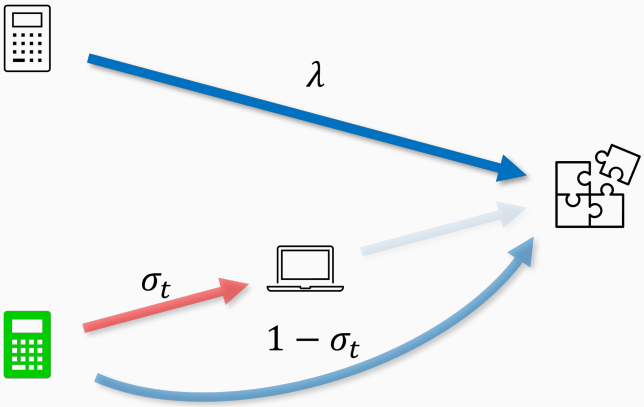
Thank you!

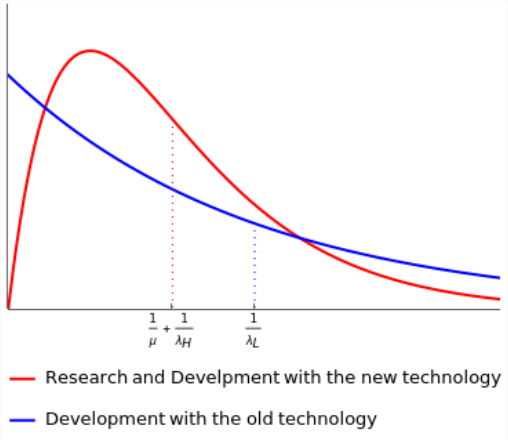
Appendix

Benchmark: Constant Development Rate



Go Back

Comparison between two paths



PDF of the completion time without race

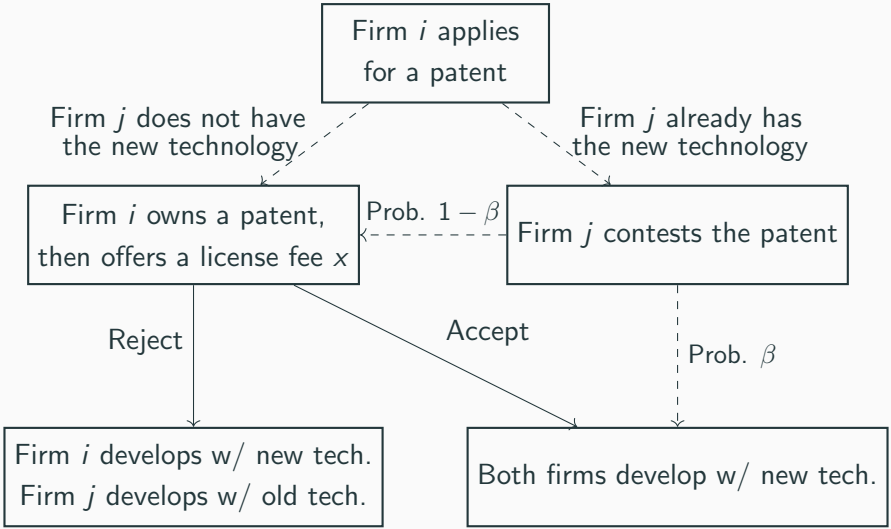
Long Run:

- By comparing the expected completion time:
  Research $\succ$ Development

Short Run:

- By comparing the prob. of completion in the near future:
  Research $\prec$ Development

▸ Go back



Model Patenting