Strategic Concealment in Innovation Races

Yonggyun Kim and Francisco Poggi

May 5, 2023

Introduction

Consider two firms engaging in an innovation race.

- The first firm to have a breakthrough obtains a prize Π.
- Firms pay a flow cost c throughout the race.

- Breakthroughs for firm i arrive at constant rate λ_i.
- Firm A has a piece of knowledge that gives them an advantage: $\lambda_A > \lambda_B$.

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1. Reduce race duration.
2. Increase the chance that Firm B wins the race.

Overall, sharing knowledge would be more **efficient**.

Coase Theorem: There exists a price P such that

- Firm B is willing to pay to acquire the knowledge.
- Firm A is willing to accept to share the knowledge with Firm B.

$$P \in \left[\frac{(\lambda_A - \lambda_B)(\lambda_A \Pi - c)}{2\lambda_A(\lambda_A + \lambda_B)}, \frac{(\lambda_A - \lambda_B)(\lambda_A \Pi + c)}{2\lambda_A(\lambda_A + \lambda_B)}\right]$$

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What we do

Most times, knowledge has to be acquired and is private.

We study an innovation race with:

- Unobservable interim breakthroughs (knowledge).
- Firms directing R&D efforts in a flexible, dynamic way.

We characterize the equilibrium behavior of firms

- When they can patent and license interim breakthroughs,
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Results in a Nutshell

When interim breakthroughs are **public**, patents work:

- Induce firms to share their breakthroughs.
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When interim breakthroughs are **private**, patents might be ineffective.

- firms conceal interim breakthroughs (trade secrets).
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- Particularly problematic when stakes are high.

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Model

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Two firms $i \in \{A, B\}$ participate in a race.

Time is continuous and infinite $t \in [0, \infty)$.

Two technologies:

- An **incumbent** technology L.
- A **new** technology H (not available at first).

A firm allocates, at each point in time, a unit of resources to:

- **Research**: try to obtain the new technology.
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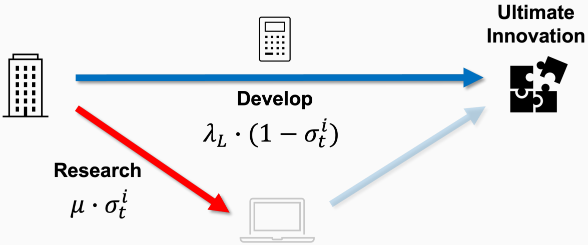
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Innovation
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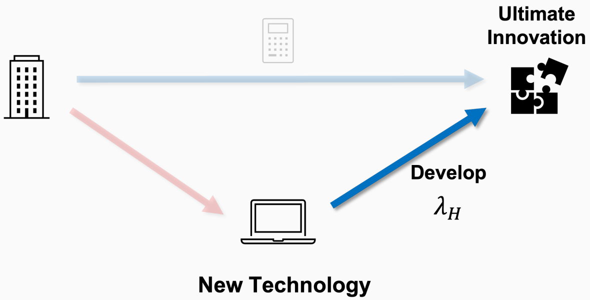

Payoffs

The race ends when one of the firms develops the innovation.

Payoff of firm i:

$$\Pi \cdot 1_{\{w=i\}} - c \cdot d$$

where

- $\Pi, c > 0.$
- $w \in \{A, B\}$ is the identity of the race winner,
- d is the duration of the race.

Assumption: Incumbent technology is profitable $\Pi > c/\lambda_L$

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- Successful development is public.
- Interim breakthrough (finding of the new technology). Three cases:

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Observable Interim Breakthroughs

Strategies

Proposition

For almost all parameters, there is a unique Markov equilibrium.

- When μ is high enough, firms do research ($\sigma = 1$) until obtaining the new technology.
- When μ is low enough, firms develop with the incumbent technology ($\sigma = 0$).
- **For intermediate values of** μ, firms follow **fall-back strategies**: they do research until either of the firms obtains the new technology and develop afterwards.

For the rest of this talk, I'll focus on intermediate μ.

Unobservable Interim Breakthroughs

Allocation Policy

With unobservable interim breakthroughs, firms cannot condition their allocation on the opponents' technology.

An **allocation policy** $\sigma_i(t)$ indicates how much resources Firm i allocates to research at time t, conditional on that

- Firm i doesn't have the new technology.
- the race is still on.

$$\sigma_i : \mathbb{R} \to [0, 1]$$

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Evolution of Beliefs

Lemma

- Consider that
  - an opponent follows policy σ.
  - the race is ongoing by time t.
- The probability p_t that the opponent has the new technology evolves according to:

$$
\begin{aligned}
p_0 &= 0 \\
\dot{p}_t &= \underbrace{\mu \cdot \sigma(t) \cdot (1 - p_t)}_{\text{ME}} \quad \underbrace{- \quad [\lambda_H - (1 - \sigma(t))\lambda_L] \cdot p_t \cdot (1 - p_t}_{\text{BU}}
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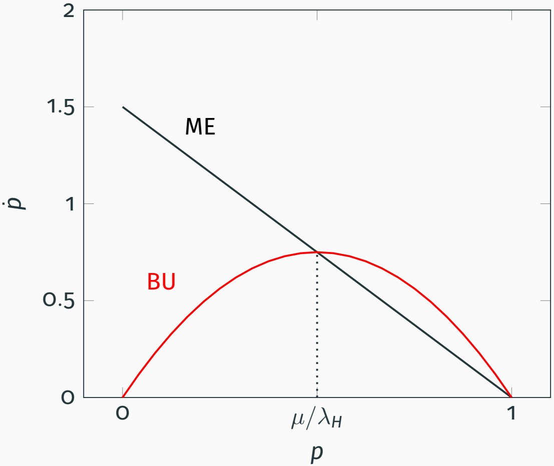

Figure 1: Mechanic and **Bayesian Updating** effects. $\sigma_j = 1$. $\mu = 1.5$, $\lambda_H = 3$, and $\delta = 2/3$.

Symmetric Markovian Equilibrium

Solution concept: (Pure) Symmetric Markovian Equilibrium (SME).

- Symmetric: $\sigma^A(t) = \sigma^B(t)$ for all t.
- Markovian: $p_t = p_{t'} \quad \Rightarrow \quad \sigma(t) = \sigma(t')$

Proposition

There is a **unique** SME. In this equilibrium

$$\sigma^A(t) = \sigma^B(t) = \begin{cases} 1 & t < T^* \\ \sigma^* & t \geq T^* \end{cases}$$

for some $T^* \in [0, \infty]$ and $\sigma^* \in [0, 1]$.

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T^* and σ^* are determined by two conditions:

- Keeping opponent indifferent between R & D.
- Keeping opponent's beliefs constant.

Equilibrium beliefs are strictly increasing until T^* and then constant.

Comparative statics:

- The effects of λ_L, λ_H and μ on T^* and σ^* are the expected ones.
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Same model as before with the following modifications:

- A firm that has the new technology can **apply for a patent**.
  - Patent applications are public.
- **First-to-invent**: The patent is granted if no other firm had the interim breakthrough before.
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The equilibrium allocations and payoffs are the same as in the unobservable case.

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Conclusion

We develop a model of innovation race with interim breakthroughs and show that

- Firms might not patent to conceal breakthroughs even when patent holders have all the bargaining power in licensing negotiations.
- Patents for interim breakthroughs are less effective when stakes are high.