Technology-push, Demand-pull, and Strategic R&D Investment

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Outline

Background

Model

Numerical Simulations
  Motivations for Stimulating Innovation
  Market Failure Sensitivity Analysis

Conclusions
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Conclusions
Two Types of Technology Policy

▶ Technology-push
  - Reduce the private cost of engaging in innovation
  - Examples
    ▶ Public R&D
    ▶ Government funding for private R&D
    ▶ Support for higher education to enlarge pool of innovators

▶ Demand-pull
  - Create or expand markets to increase the payoff to successful innovation
  - Examples
    ▶ Subsidies for consumer purchases
    ▶ Direct government procurement
    ▶ Stronger intellectual property protection
Retrospective Analyses

- Empirical and case study literatures indicate that each policy type is generally ineffective if used alone.

- **Technology-push**
  - Mod program for wind turbines, U.S., 1970s
    - Loiter and Norberg-Bohm (1999)
  - GAVE program for biofuels, Netherlands, 1998–2002
    - Suurs and Hekkert (2009)

- **Demand-pull**
  - Tax credits for wind installations, California, 1980s
    - Nemet (2009)
  - Tax credits for solar installations, California, 1970s–present
    - Taylor (2008); Wiser et al. (2007)
Portfolio Approach

- Technology-push and demand-pull policies are complementary, and the ideal technology policy portfolio should include policies of both types (Gallagher et al., 2012).

- The relative importance of technology-push and demand-pull varies across applications (Pavitt 1984).

In this study, a bilevel optimization model is developed to determine the optimal balance of technology-push and demand-pull policies for a given technology policy application.
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Key Model Features

Unique features
- Includes a policymaker and firms as separate decision-making agents
- Represents both technology-push and demand-pull
- Represents both process and product R&D
- Captures uncertainty in R&D outcomes

Three market failures
- Incomplete appropriability of innovation
- Imperfect competition
- Negative production externality

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1 Contrast these to how energy technology R&D is incorporated into IAMs (Bosetti et al., 2009).
## Strategic Innovation in an Oligopoly

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<th>Study</th>
<th>Duopoly</th>
<th>Oligopoly</th>
<th>Process R&amp;D</th>
<th>Product R&amp;D</th>
<th>Spillovers</th>
<th>Uncertainty</th>
<th>Policy Intervention</th>
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The Model

**Policymaker Problem**
- Technology Push
- Demand Pull

**Firm Problem**
- Product R&D Investment

Product R&D Success?
- Process R&D Investment
- Output of Existing Good

Output of New Good

**Social Welfare**

**Profit**
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Three Different Motivations for Stimulating Innovation

Case 1: Combat negative externality
- The new good is a close and expensive substitute for the existing good, but the latter has a negative production externality (e.g. nuclear fission to fusion).

Case 2: Reduce cost
- The new good is a close substitute for the existing good, but can ultimately be produced at lower cost (e.g. crystalline silicon to organic PV).

Case 3: Create demand
- Developing the new good is expensive, but it has a large potential demand that is not being met by the existing good (e.g. new energy-consuming end-use appliance).
Case 1: Combat Negative Externality
Case 2: Reduce Cost

(a) Expected Welfare
(b) Expected Profit
(c) Product R&D Investment
(d) Process R&D Investment
Case 3: Create Demand

(a) Expected Welfare
(b) Expected Profit
(c) Product R&D Investment
(d) Process R&D Investment
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Product R&D

![Graph (a)](Incomplete Appropriability)

- Spillover Strength ($\nu_S$ and $\nu_T$)
- Product R&D Under Optimal Policy ($\$$)

![Graph (b)](Negative Production Externality)

- Negative Production Externality ($\omega$)
- Product R&D Under Optimal Policy ($\$$)

![Graph (c)](Imperfect Competition)

- Number of Firms ($n$)
- Product R&D Under Optimal Policy ($\$$)
Expected Profit

(a) Incomplete Appropriability

(b) Negative Production Externality

(c) Imperfect Competition
Expected Welfare

(a) Incomplete Appropriability

- No Policy
- Optimal Policy

(b) Negative Production Externality

- No Policy
- Optimal Policy

(c) Imperfect Competition

- No Policy
- Optimal Policy
Optimal Technology-push Policy

- **Incomplete Appropriability**: The figure shows the relationship between optimal R&D subsidy and spillover strength ($\nu_S$ and $\nu_I$) as a function of spillover strength. The subsidy decreases as the spillover strength increases.

- **Negative Production Externality**: This graph illustrates how the optimal R&D subsidy changes with the negative production externality ($\omega$). The subsidy increases as the externality increases.

- **Imperfect Competition**: Here, the graph displays the relationship between optimal R&D subsidy and the number of firms ($n$). The subsidy decreases as the number of firms increases.
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Conclusions

- Process and product R&D are substitutes.
- If innovation serves to combat a negative externality, technology policy should emphasize technology-push, but it is difficult to enhance welfare through technology policy.
- Firms perform less product R&D under stronger spillovers, but expected welfare is higher.
- Each firm performs less product R&D under greater competition, but total industry R&D rises.
- Expected welfare decreases with competition in the no-policy case, but increases with competition if optimal technology policies are imposed.
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Thank You for Listening!
References


