Knowing What You Can Implement Matters: A Life-cycle Theory of R&D and Markets for Knowledge

Kyriakos Frantzeskakis\textsuperscript{1} and Masako Ueda\textsuperscript{1}

\textsuperscript{1}School of Business, University of Wisconsin at Madison

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Commercialization Hurdle

Typical entrepreneurs have good ideas or good products. But the fact that they created good ideas or products do not warrant that they can commercialize these ideas or products successfully.

Established firms have overcome this hurdle.
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- Established firms have overcome this hurdle.
Literature

- Theory of Firm Growth
  - Jovanovic (1982) – Does not model the qualitative difference between idea generation and commercialization.
- Complementary Assets of Established Firms
- Theory of Serial Entrepreneurs
  - Holmes and Schmitz (1990) – Does not explain why a young firm is more likely to fail than an established firm.

Knowing What You Can Implement Matters
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**Theory of Serial Entrepreneurs** Holmes and Schmitz (1990) – Does not explain why a young firm is more likely to fail than an established firm.
A new firm is born without knowing what type of new knowledge it can implement. It may learn that by attempting to implement and observing the implementation outcome. (Success $\Rightarrow$ I am good at this.) We call a firm established if it has implemented knowledge successfully and learned what it can implement successfully.
A new firm is born without knowing what type of new knowledge it can implement.
Idea of the Model

- A new firm is born without knowing what type of new knowledge it can implement.
- It may learn that by attempting to implement and observing the implementation outcome. (Success $\Rightarrow$ I am good at this.)
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It may learn that by attempting to implement and observing the implementation outcome. (Success $\Rightarrow$ I am good at this.)

We call a firm established if it has implemented knowledge successfully and learned what it can implement successfully.
Results of the Model

A young firm appears to be more liberal than an established firm in selecting the type of knowledge to implement. An established firm buys knowledge, whereas a young firm does not. An established firm buys knowledge from another established firm if profitability and/or transaction cost are moderate and from a young firm if profitability is high and/or transaction cost is low.

A higher fraction of young firms attempt to implement knowledge when knowledge obsoletes slowly. Implementation is more likely to fail.
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- A higher fraction of young firms attempt to implement knowledge when
  - Knowledge obsolesces slowly.
  - Implementation is more likely to fail.
Economy

- Continuous-time infinite horizon stationary economy.
- Infinite number of risk neutral firms that
  - discount future payoffs at rate $r$ and
  - die at a random point of time with rate $\mu$. 
Production

Project type: \( \pi \in T_s = \{1, 2, \ldots, S\} \)

Firm type: \( s_f \in T_s \)
as well.

Revenue will be generated only if the project type is the same as the type of the implementing firm.
Production

- Project type: \( s_\pi \in T_S = \{1, 2, ..., S\} \)
- Firm type: \( s_f \in T_S \) as well.
- Revenue will be generated only if the project type is the same as the type of the implementing firm.
Firms

Each firm can do only one task at a time (discovery, implementation or harvesting).

Can be relaxed to “only finite number of tasks at a time.”

Each firm has infinite horizon but may die at a random point of time.
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Firms

Each firm can do only one task at a time (discovery, implementation or harvesting)

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Each firm has infinite horizon but may die at a random point of time.
A discovering firm does not exactly know which type of project it will discover until it will finish discovering.

A firm initially does not know which type it possesses. May learn from the implementation outcome.
Life-cycle of Firm

Young Firm
- Discover @ $c_0$
- Buy @ $p$
- Implement @ $c_1$
- Sell @ $p$, cost $\psi$
- Abandon
- Failure
- Learning
- Exit or Restart
- Success

Established Firm
- Discover @ $c_0$
- Buy @ $p$
- Implement @ $c_1$
- Sell @ $p$, cost $\psi$
- Abandon
- Implement @ $c_1$

Knowing What You Can Implement Matters
Life-cycle of Firm

Young Firm
Life-cycle of Firm

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Knowing What You Can Implement Matters
Life-cycle of Firm

Young Firm

- Discover
  - @c_0 p.p.
Life-cycle of Firm

Young Firm

- Discover @c_0 p.p.
- Buy @ P and Implement @c_1 p.p.
- Sell @ P, cost ψ or Abandon
- Failure Learning
- Exit or Restart
- Success p.p. Profit of y

Knowing What You Can Implement Matters
Life-cycle of Firm

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Success Learning Exit or Restart

Failure Learning

Knowing What You Can Implement Matters
Life-cycle of Firm

**Young Firm**
- Discover
- Buy\( @ p \) and Implement \( @ c_0 \) p.p.
- Sell \( @ p \), cost \( \psi \) or Abandon

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Life-cycle of Firm

**Young Firm**

- Discover
  - Sell @\(p\), cost \(\psi\)
  - or Abandon
- Buy @\(c_0\) p.p.
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Life-cycle of Firm

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Learning

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Knowing What You Can Implement Matters
Life-cycle of Firm

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  - \( @c_1 \) p.p.
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  - \( p.p. \) Profit of \( y \)
  - Learning

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Life-cycle of Firm

Young Firm

Discover

Sell @p, cost ψ
or Abandon

Buy @p and Implement @c_0 p.p.
Implement @c_1 p.p.

Failure
Learning
Exit or Restart

Established Firm

Discover

Success
p.p. Profit of y
Learning

Buy @p and Implement @c_1 p.p.
Implement @c_0 p.p.

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Life-cycle of Firm

Young Firm

- Discover
- Implement @c₀ p.p.
- Sell @p, cost ψ
  - or Abandon
- Fail or Learn
- Exit or Restart

Established Firm

- Discover
- Implement @c₁ p.p.
- Buy @p and Implement @c₁ p.p.
- Success p.p. Profit of y Learning
- Abandon or Restart
Life-cycle of Firm

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Knowing What You Can Implement Matters
Stationary Equilibrium

- Rationality: The decision between “discover” and “buy” is optimal.
- Market Clearing: Supply of new knowledge is equal to demand.
- Stationality: For each type and stage, mass of firms is the same over time.
- Non-Triviality: A positive mass of young firms implements.
- Free Entry: Expected profit of an entering firm is zero.

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Without Markets for Knowledge

Proposition
Young firms implement knowledge of any type. Established firms implement knowledge that matches their types and abandon it otherwise.

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Selection Ability of Established Firms

Proposition

Established firms become buyers but not young firms because established firms know which new knowledge to buy for successful implementation, whereas young firms do not.

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Selection Ability of Established Firms

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Knowing What You Can Implement Matters
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Knowing What You Can Implement Matters
Efficiency Gains from Market for Knowledge

1. Est-Est Transaction: An established firm sells redundant (unmatched) knowledge to another established firm of the type matched with the knowledge.

2. Young-Est Transaction: A young firm sells knowledge to an established firm of the type matched with the knowledge.

3. Gain from trade in Est-Est transaction is higher than that in Young-Est transaction. ⇒ Est-Est transaction is more robust to higher transaction cost and lower potential profitability.

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Est-Est Market: Exploration Equilibrium

**Young Firm**
- Discover @ \(c_0\) p.p.
- Implement @ \(c_0\) p.p.
- Buy @ \(p\) and Implement @ \(c_0\) p.p.
- Sell @ \(p\), cost \(\psi\) or Abandon
- Failure Learning
- Exit or Restart

**Established Firm**
- Discover @ \(c_0\) p.p.
- Implement @ \(c_0\) p.p.
- Buy @ \(p\) and Implement @ \(c_0\) p.p.
- Sell @ \(p\), cost \(\psi\) or Abandon
- Success p.p. Profit of \(y\) Learning
- Failure Learning
- Exit or Restart

Knowing What You Can Implement Matters
Efficiency Gains from Specialization

Young-Est transaction facilitates specialization. A young firm specializes in discovering knowledge and avoids failing in implementation. An established firm specializes in discovering and avoids discovering unmatched knowledge. Due to this specialization benefit, Young-Est transaction dominates Est-Est transaction if transaction cost is low and/or potential profit is high.

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Knowing What You Can Implement Matters
Efficiency Gains from Specialization

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Knowing What You Can Implement Matters

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Efficiency Gains from Specialization

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Efficiency Gains from Specialization

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Efficiency Gains from Specialization

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  - A young firm specializes in discovering knowledge and avoids failing in implementation.
  - An established firm specializes in discovering and avoids discovering unmatched knowledge.

Due to this specialization benefit, Young-Est transaction dominates Est-Est transaction if transaction cost is low and/or potential profit is high.
Est-Young Market: Exploitation Equilibrium

Young Firm

- Implement $@c_0$ p.p.
- Discover $@c_0$ p.p.
- Buy $@p$ and Implement $@c_0$ p.p.
- Sell $@p$, cost $\psi$ or Abandon
- Success p.p. Profit of $y$
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Established Firm

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Knowing What You Can Implement Matters
Proportion of specialized young firms
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Research Specialized Firms
Proportion of specialized young firms

Research Specialized Firms

Proportion of discovery-specialized young firms in Est-Young Markets is higher if

If knowledge obsoletes more quickly, established firms come back to the market for knowledge more quickly. If implementation by young firms are more likely to be successful, many established firms are available for buying knowledge from young firms.
Proportion of specialized young firms

Research Specialized Firms

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- Long-run Paradox: implementation by young firms (non-specialization) are more likely to be successful.
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- Long-run Paradox: implementation by young firms (non-specialization) are more likely to be successful.

Intuition

- If knowledge obsoletes more quickly, established firms come back to the market for knowledge more quickly.
- If implementation by young firms are more likely to be successful, many established firms are available for buying knowledge from young firms.
Performance

Implementation by young firms is more likely to fail. IPO firms' operating performance are worse than those of matching firms. (Jain and Kini, 1994; Roper and Zhang, 2006).

Sold knowledge discovered by young firms is implemented more successfully than unsold knowledge. Gorman and Sahlman (1989) and Hellmann and Puri (2002) document that VCs frequently replace the management of their portfolio firms. VC-backed firms perform better than non-VC backed firms. (Jain and Kini, 2002; Hellmann and Puri, 2000)
Performance of Young Firms

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Performance of Transferred Knowledge

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- VC-backed firms perform better than non-VC backed firms. (Jain and Kini, 2002; Hellmann and Puri, 2000)
We develop a model of firms' life-cycles over which a young firm may become an established firm by implementing knowledge successfully and thereby learning what the firm can implement.

We find:

- A young firm is more liberal in selecting knowledge to implement.
- An established firm buys knowledge but not a young firm.
- If transaction cost is low and/or potential profit is high, then a young firm becomes a seller of knowledge.
- If transaction cost is moderate and/or potential profit is moderate, then an established firm becomes a seller of knowledge.
- Quicker knowledge obsolescence and easier implementation of knowledge by young firms encourage young firms' specialization in discovering.
Summary

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  - Quicker knowledge obsolescence and easier implementation of knowledge by young firms encourage young firms’ specialization in discovering.
How to test this model? (1)
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- In a country in which IPs are well protected, do established firms buy new knowledge from young firms?
- In a country in which IPs are moderately protected, do established firms buy new knowledge from other established firms?
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- In a country in which IPs are moderately protected, do established firms buy new knowledge from other established firms?
- In an industry in which value of IPs are high, do established firms buy new knowledge from young firms?
How to test this model? (1)

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- In a country in which IPs are well protected, do established firms buy new knowledge from young firms?
- In a country in which IPs are moderately protected, do established firms buy new knowledge from other established firms?
- In an industry in which value of IPs are high, do established firms buy new knowledge from young firms?
- In an industry in which value of IPs are moderate, do established firms buy new knowledge from other established firms?
How to test this model? (2)

In an industry in which knowledge obsoletes more quickly (e.g. patents citing more recent patent), do more young firms specialize in discovering knowledge?

In an industry in which implementation by young firms is more likely to fail (a higher failure rate of IPO firms), do more young firms implement their discovered knowledge?
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Patent and Emergence of Research Specialized Firms

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  - Patent lawyers acted as intermediaries of IP markets.
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  - Patent lawyers acted as intermediaries of IP markets.
Declining Costs of Selling IPs

Along with stronger IP protection, innovations in communication technology have reduced transaction costs of selling knowledge.

- Easier to find buyers.
- Easier to find infringement.
Percentage of Companies with High Reliance on External Sources for Technology

Source: Unpublished IPC global survey of large technology-intensive companies (>\$100M/yr in annual R&D expenses in 1999) (N=209)