Industry Cohesion & Knowledge Sharing: Network based Absorptive Capacity

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- What is the impact of search cost on R&D allocation decisions?
- How does industry size and cohesion affect search cost and the optimal allocation of R&D investments?
Major findings

- Search and own R&D are complementary
- The impact of a growing number of firms is dependent on the existing number and network cohesion
- Network cohesion determines the quality and quantity of search
Theoretical Development

- Costless information (Arrow 1962)
- Absorptive capacity (Cohen and Levinthal, 1999, 2000)
- Joint knowledge production (Saxenian 1991)
- Sticky Knowledge (Sakakibara 2002; Alcacer et al. 2002; von Hippel 1994, 1988; Mansfield 1988; Allen 1977)
Spillovers

- Firm boundaries and knowledge sharing (Brynjolfsson 1994; Williamson 1975).
- Innovation by borrowing (von Hippel 1988; March et al. 1958)
- Appropriation mechanism to control spillover varies by industry (Levin et al. 1987).
- Formal and informal search
Networks

- Social ties among firms shape economic action
  Uzzi (1996)

- Firms make strategic decisions in determining who they partnered with Baum et al. (2003)

- Bounded Rationality (Simon 1945) leads to assertion that the size and shape of the firm’s network is a critical component of its knowledge investment decisions.
Model motivation

- Consider the actions of a single firm
- Profits depend on knowledge
- Allocating R&D in order to develop, learn and search
- Subject to a constraint.
  - Explicit budget
  - Implicit marginal return on investment > 0
- Find the optimal investment decision in terms of exogenous parameters (Lagrangian optimization)
Model development

- Profit maximizing firm.
- Profits depend on knowledge
- Constrained investment allocation

$$\Pi = \sum_{t=0}^{\infty} \pi(t)u(t) \quad \pi(t) = \pi(Z_t, K_t, L_t)$$

$$z = M + \gamma (\theta \sum_{j} \left( \chi_j \cdot Q_j \right) + T)$$

$$C \geq r \cdot M + s \cdot \alpha$$
Functional Forms

- Absorptive Capacity increases with $M$, decreases with Delta
- Search Effectiveness increases with investment and cohesiveness, decreases with industry size

\[
\gamma = (1 - e^{-M/\delta}) \quad \chi = (1 - e^{-\alpha/(1+J^2(1-\phi))})
\]

\[
\lim_{J \to \infty} J (1 - e^{-1/J}) = 1 \quad \lim_{J \to \infty} J (1 - e^{-1/J^2}) = 0
\]
Not Closed Form

\[
\left\{ \begin{array}{c}
\alpha \\
s
\end{array} \right\} + \frac{\alpha}{r} \left( e^{\frac{-M}{\delta}} \frac{\alpha}{\delta} \right) \left( 1 - e^{\frac{-M}{\delta}} \right) JQ \theta = 0,
\]

\[
(C - Mr - s \alpha) \left\{ \begin{array}{c}
-1 + \frac{e^{\frac{-M}{\delta}} \frac{\alpha}{\delta} \left( -1 + e^{\frac{-1+J^2 (-1+\phi)}{\delta}} JQ \theta - \tau \right)}{\delta} \\
r
\end{array} \right\} = 0
\]
Simulation

![Graph showing the relationship between search investment and the number of firms. The graph peaks at a certain number of firms and then decreases.]
Simplified Forms

\[ \gamma = M \cdot (1 - \delta), \quad \frac{\partial \gamma}{\partial M} > 0, \quad \frac{\partial \gamma}{\partial \delta} < 0, \quad 0 \leq M \leq 1 \]

\[ \chi = \alpha / (1 + J^2 (1 - \phi)), \quad \frac{\partial \chi}{\partial \alpha} > 0, \quad \frac{\partial \chi}{\partial \phi} > 0, \quad \frac{\partial \chi}{\partial J} < 0, \quad 0 \leq \alpha \leq 1 \]
Simplified closed-form solution

\[ \begin{align*} 
\{ & M \to 0, \lambda \to 0 \}, \\
\{ & M \to \frac{C}{r}, \lambda \to \frac{1 + \tau - \delta \tau}{r}, \alpha \to 0 \}, \\
M \to & \frac{C J Q \left( -1 + \delta \right) \theta - S \left( -1 + \left( -1 + \delta \right) \tau \right) \left( -1 + J^2 \left( -1 + \phi \right) \right)}{2 J Q r \left( -1 + \delta \right) \theta}, \\
\alpha \to & \frac{C J Q \left( -1 + \delta \right) \theta + S \left( -1 + \left( -1 + \delta \right) \tau \right) \left( -1 + J^2 \left( -1 + \phi \right) \right)}{2 J Q s \left( -1 + \delta \right) \theta}, \\
\lambda \to & \frac{C J Q \left( -1 + \delta \right) \theta - S \left( -1 + \left( -1 + \delta \right) \tau \right) \left( -1 + J^2 \left( -1 + \phi \right) \right)}{2 r s \left( -1 + J^2 \left( -1 + \phi \right) \right)} \} 
\end{align*} \]
Complementarities

\[ \partial^2_{\alpha} z = - \frac{e^{-\frac{\alpha}{1+J^2 (1-\phi)}} \left( 1 - e^{-\frac{M}{\delta}} \right) JQ \Theta}{(1 + J^2 (1 - \phi))^2} < 0 \]

\[ \partial_{\alpha, MZ} = \frac{e^{-\frac{\alpha}{1+J^2 (1-\phi)}}}{\delta (1 + J^2 (1 - \phi))} \frac{JQ \Theta}{M \delta} > 0 \]

\[ \partial_{\alpha} z = \frac{e^{-\frac{\alpha}{1+J^2 (1-\phi)}} \left( 1 - e^{-\frac{M}{\delta}} \right) JQ \Theta}{1 + J^2 (1 - \phi)} > 0 \]
Results

- Own R&D improves search
- Cohesion increases search, infer it changes type of search
- Information economics predicts more search
Thoughts

- Open Source focuses on the Search component
- R&D investment as cost of entry (Pay to Play)
- Joint Ventures as Loss Leaders
Questions?