Learning as Signaling
How do we think about the failure in repeated innovation

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Question

Who and **how** should repeated innovation be funded?

Motivation

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Empirical Evidence

1. Repeated innovation is common
    1. Specialized researchers
    2. Serial Entrepreneurs

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    1. Specialized researchers
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2. Success depends on effort ...
3. and luck!

Literature

1. Failure: Landier 2006 (Abandoned); Cahn, Girotti & Landier 2017; Nanda & Rhodes-Kropf 2013
2. Experimentation: Keller, Rady & Cripps 2005 ECMA; Bonatti & Horner 2011 AER; Kremer, Mansour & Perry 2014 JPE; Halac, Kartik, & Liu 2016 RES, 2017 JPE
3. Venture Capital: Birgeman & Hege; Sabrina Howell
4. Innovation Financing: Hall & Lerner,
5. Signaling: Bobtcheff & Levy 2017 AEJMi
6. Real Option: Dixit Pindyck 1994
7. Reputation: Khanna Mathews 2017

Model Setting

1. Time $t \in [0, +\infty)$
2. Projects $s \in \{G, B\}$, prior $p_0 = \Pr(s = G)$
    1. Need funding I to start with. Equity financing: repay $(1 - \alpha)F$
    2. $s = G$, success comes at rate $\lambda_t(e_t) = \lambda_0 + \lambda e_t$
    3. $s = B$, no success
    4. $\dot{p}_t = (p_t - 1)\lambda_t < 0$ conditional on no success
3. Innovator $\theta \in \{L, H\}$: prior $\mu_0 = \Pr(\theta = H)$
    1. cost of effort $c^\theta(e_t) = \frac{e_t}{\gamma^\theta}$ with $e_t \in [0, 1]$ ($\frac{e_t^2}{2\gamma^\theta}$ is very hard!)
4. Discount rate r (relevant when $\lambda_0 \neq 0$)

Trivial Case: First Best (Deep Pocket Innovator)

The payoff of the type γ is

$$v(p_{0-}) = \sup_{e_0^t, \kappa} \mathbb{E}^{\mathbb{Q}(e_0^t)} \left[V - I - \int_0^{\tau(e_0^t) \wedge \kappa} e^{-rt} \frac{e_t}{\gamma} \mathrm{d}t \right]$$

where $V = e^{-r\tau(e_0^t)} p_0 \alpha F 1_{\tau(e_0^t) < \kappa} + e^{-r\kappa} v(p_{0-})(p_0 1_{\tau(e_0^t) > \kappa} + 1 - p_0)$

$$e_t^* = \begin{cases} 1 & \lambda(\alpha p_t F + v'(p_t)(p_t - 1)) > \frac{1}{\gamma} \wedge v(p_t) > v(p_{0-}) \\ 0 & \text{otherwise} \end{cases}$$

$$p_t = \begin{cases} 1 - (1 - p_0) e^{(\lambda_0 + \lambda) t} & 0 < t \leq t^* \\ 1 - (1 - p_{t^*}) e^{\lambda_0 (t - t^*)} & t^* < t < \kappa \end{cases}$$

where $t^* = \inf\{t : \lambda(\alpha p_t F + v'(p_t)(p_t - 1)) \leq \frac{1}{\gamma}\}$

Trivial Case: First Best (Deep Pocket Innovator)

Assume I is large, such that $v(p^*) > v(p_{0-})$,
Quitting belief

$$p_q = \frac{rv(p_{0-})}{\lambda_0 \alpha F}; v(p_q) = v(p_{0-})$$

Shirking Belief

$$rv(p^*) = p^* \lambda_0 \alpha F + v'(p^*)(p^* - 1)\lambda_0$$

$$\alpha F \lambda p^* + \lambda(p^* - 1)v'(p^*) = \frac{1}{\gamma}$$

$$v(p^*) = \frac{\lambda_0}{\lambda \gamma r}$$

Expected results

Proposition

There is no pooling equilibrium surviving Cho and Kreps's intuitive criterion or D1.

Proposition

There is a fully separating equilibrium ....in which the low type behaves as in the best best ...

Proposition

There might be some partially separating equilibrium ...

Major Challenges

1. Model Implication: Success is less informative than failure
2. Equilibrium Selection: Intuitive Criterion, D1, Pareto-Dominance, Least Cost, etc
3. Financing Choice:
    1. Debt: Debt Overhang Problem
    2. Equity: Internalization of Incentives
    3. Or Optimal Contract
4. Complexity vs. Tractability
5. Empirical Relevance