Financing private sector investment in research and development

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Overview

- Defining the issues – the economics of R&D
  - Reasons for policy concern
  - The R&D investment decision
- Financing problems and solutions
- Brief look at the composition of US spending
- Conclusions
Economics of R&D investment

Competitive markets produce too little R&D (or the wrong kind) because of

- Positive externalities => incomplete appropriability.
- R&D is usually a fixed cost – the resulting imperfect competition and market power implies output in R&D industries will be below the first best level.
- Financing R&D is expensive because of risk, uncertainty, and asymmetric information

*Arrow (1962), Nelson (1959)*
Economics of R&D investment

**BUT**

Competitive markets can produce too much R&D because

- negative externality to competitors’ R&D in a winner-take-all competition for the market
  - One firm does not take into account the negative effect of his own R&D on other firm’s probability of success, so over-invests from society’s point of view

*Spence (1984), among others*

Empirical evidence:

- on balance, too little R&D, rather than too much
Private and social return to R&D

Return or cost

Optimal subsidy

Social return

Cost (supply of funds)

Private return

Level of R&D spending

RC

RS

C

S

Optimal subsidy
Optimal subsidy varies

(a) Basic Research (or generic technology)

social return

private return

cost

(b) Development (or proprietary technology)

social return

private return

cost
Private and social cost of R&D

Level of R&D spending

Return or cost

Optimal subsidy

Social return

Private return

Cost of capital

Social cost of capital

RC

C

S

RS

RS
Characteristics of R&D investment

>50% of expenditure is wages and salaries of scientists and engineers

- Knowledge asset created is partly *tacit* and embodied in their human capital; lost if they leave the firm

=> R&D spending tends to be smooth over time within the firm (and should be)

=> R&D investment behaves as though it has high adjustment costs and therefore a high required rate of return
Characteristics of R&D investment

High degree of uncertainty/serendipity
- Especially at the beginning of a project
- Probability distribution of outcomes sometimes has no variance (Pareto with parameter $<1$)

(Scherer 1998)

- Option value to continuation - Sometimes a project with negative expected value is worth continuing if it has a small probability of great success
The R&D investment decision

Definition: user cost of R&D $\rho = \text{required pre-tax real rate of return on marginal R&D that earns } r \text{ after (corporate) tax.}$

$$\rho = \frac{1 - A^d - A^c}{1 - \tau} (r + \delta + MAC)$$

$A^d = \text{value of depreciation deductions (usually=tax rate)}$
$A^c = \text{value of tax credits, if any}$
$\tau = \text{corporate tax rate}$
$\delta = \text{depreciation rate}$
$MAC = \text{marginal adjustment costs}$

*NB: When R&D expensed, and there are no tax credits, corporate tax rate does not enter the decision.*
The R&D investment decision

R&D user cost equation – factors that matter:

- tax treatment such as tax credits or capital gains
- economic depreciation or obsolescence $\delta$
  - sensitive to the rate of technical change in the industry, determined by such things as market structure and the rate of imitation. $\delta$ is not an invariant parameter
- the marginal costs of adjusting the level of the R&D program, likely to be high
- the investor’s required rate of return $r$, subject of considerable research interest – why might it be higher than for other investments?
The R&D investment decision

Some reasons for high required rates of return:

- Insufficient appropriability
- Asymmetric information between owner/manager or investor/innovator
- Moral hazard on the part of manager or innovator
Asymmetric information in R&D

- lemons problem
  - inventor/innovator cannot credibly signal the value of his invention, so in equilibrium investor requires a high rate of return

- Signaling or revealing the idea to reduce asymmetry also reduces the private value
Evidence on asymmetric information

- Various announcement effect studies that imply high rates of return associated with new R&D projects, especially when funded externally
- Existence of the venture capital industry, which tries to solve the problem with monitoring and non-disclosure agreements
- Tendency of R&D in biotechnology firms to be financed via joint ventures with pharmaceutical firms (who are able to assess project quality)
Moral hazard in R&D

Two types of owner/manager conflict:
- Manager over-invests in perks and pet projects
  - Solution is to limit free cash flow, but that raises the cost of R&D capital by forcing the firm to external capital markets
- Inherent conflict between need for managerial discipline and cost of external capital in R&D firms
- Manager tends to avoid high-risk R&D projects that diversified investor (owner) would favor
Evidence on moral hazard

- Anti-takeover amendments not followed by R&D cuts, or followed by R&D increases
- Some evidence that larger shares of institutional ownership is favorable for R&D projects – better monitoring?
- Magnitude of these effects, and whether they are sufficient to close the gap, unknown
Summary

- Asymmetric information and/or moral hazard (principal/agent conflict) imply relatively higher costs of external versus internal finance for R&D
- Reinforced by lack of collateral for debt finance
- => retained earnings important for funding R&D in established firms

(Schumpeter 1956)
Some solutions

- R&D tax credits or subsidies for established firms
- Government programs that target small firms and new entrants; cost-sharing
- Venture capital of various types
  - Traditional (private investor)
  - Corporate “incubators”
  - Government “incubators”
Government funding

- Many countries have programs targeted to startups and new entrants
  - US SBIR/SBIC programs ($2B per year); ATP program ($0.2B per year)
  - Germany – both federal and state level
  - Sweden – investment companies, plus favorable capital gains treatment
  - UK – enterprise companies that fund small high technology firms; guaranteed loan program for small business
  - And so forth
Venture capital finance

- A partial solution to problems of asym info and moral hazard – combines strengths of market-centered and bank-centered financial systems
- VC contracts allocate rights to investors and innovators in complex ways (Kaplan and Stromberg 2000)
  - More like debt when firm is doing badly (control goes to investor)
  - More like equity when firm is doing well (control to innovator)
- Works best when there is an active stock market that allows early stage investors to exit by selling their shares. (Black and Gilson 1997; Rajan and Zingales 2001)
**How *is* private sector R&D financed?**

<table>
<thead>
<tr>
<th>Description</th>
<th>US in 1996</th>
</tr>
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<tbody>
<tr>
<td>Total R&amp;D spending</td>
<td>$197B</td>
</tr>
<tr>
<td>Industry R&amp;D spending, of which</td>
<td>$146B</td>
</tr>
<tr>
<td>Source is industry</td>
<td>$123B</td>
</tr>
<tr>
<td>Source is federal govt., of which</td>
<td>$23.5B</td>
</tr>
<tr>
<td>Defense/space</td>
<td>$19B</td>
</tr>
<tr>
<td>Federally funded labs (energy)</td>
<td>$2.3B</td>
</tr>
<tr>
<td>Other (energy, health), of which</td>
<td>$2B</td>
</tr>
<tr>
<td>Small business programs</td>
<td>$0.9B (avg 1994-98)</td>
</tr>
<tr>
<td>Dept. of Commerce (ATP, etc)</td>
<td>$0.2B</td>
</tr>
</tbody>
</table>
Conclusions

- Small and startup firms in R&D-intensive industries face a higher cost of capital than their larger competitors and than firms in other industries
  - fairly clear evidence, based on theory, surveys, and empirical estimation
- VC solution to the problem of financing innovation has its limits:
  - only a few sectors at one time
  - minimum size of investment that is too large in some fields.
  - good performance requires a thick market in small and new firm stocks (such as NASDAQ), to provide an exit strategy for early stage investors.
- Effectiveness of policies like government incubators, seed funding, loan guarantees, etc., deserves further study
  - experimental or quasi-experimental setting
  - using cross-country variation, because the outcomes may depend to a great extent on institutional factors that are difficult to control for using data from within a single country