Financing private sector investment in research and development

Bronwyn H. Hall
UC Berkeley, NBER, and IFS London

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

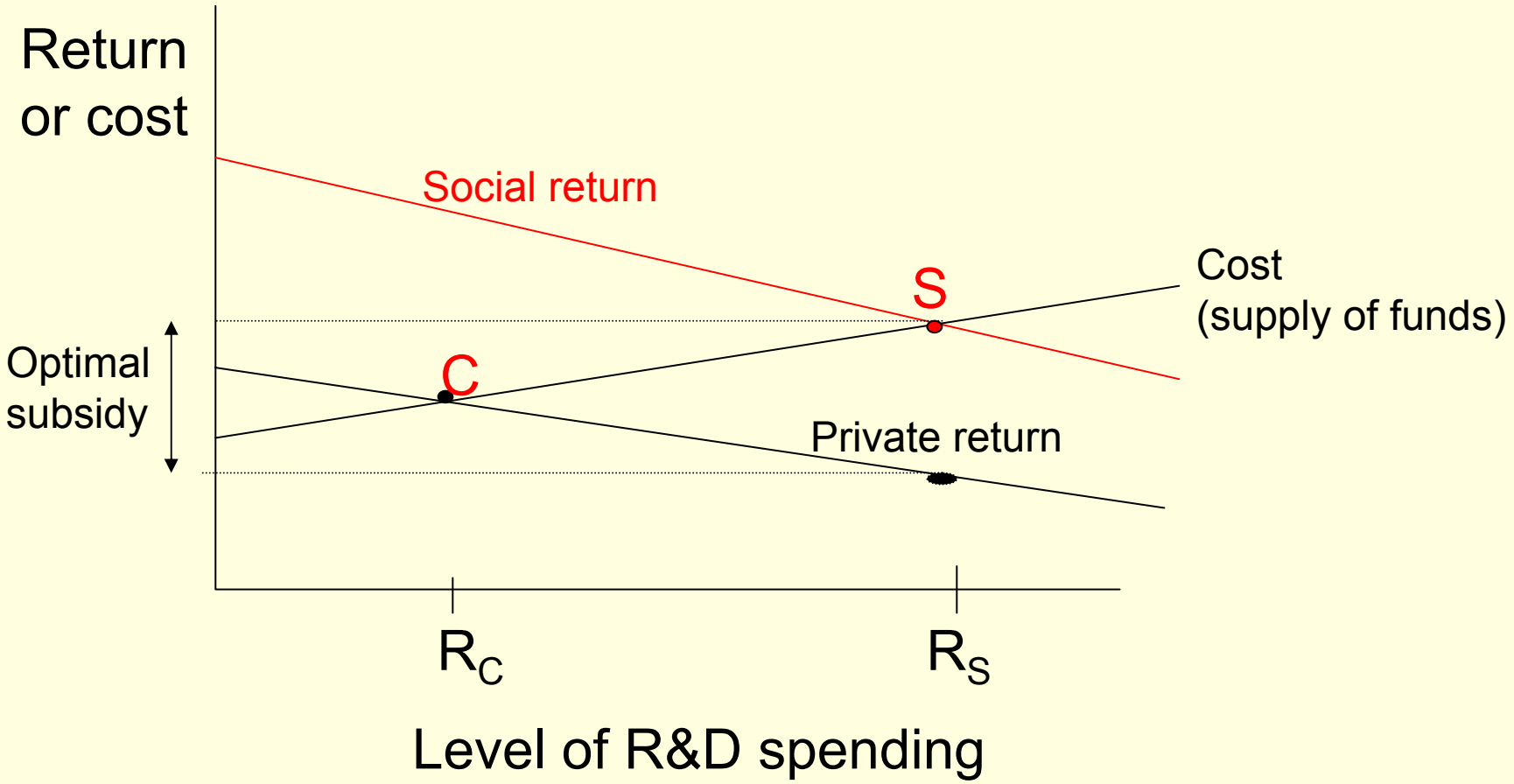
- negative externality to competitors' R&D in a winner-take-all competition for the market
  - One firm does not take into account the negative effect of his own R&D on other firm's probability of success, so over-invests from society's point of view

Spence (1984), among others

Empirical evidence:

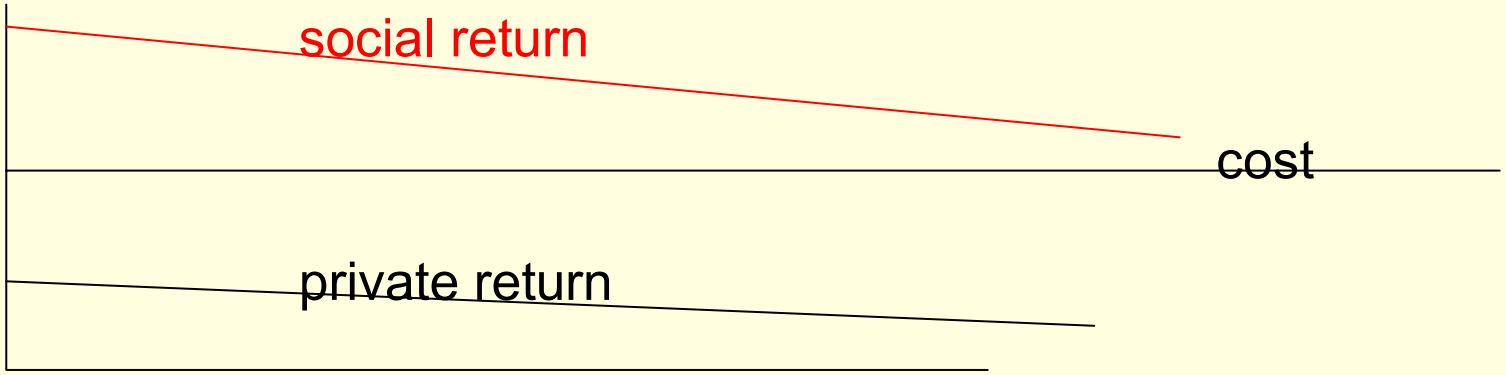
- on balance, too little R&D, rather than too much

Private and social return to R&D

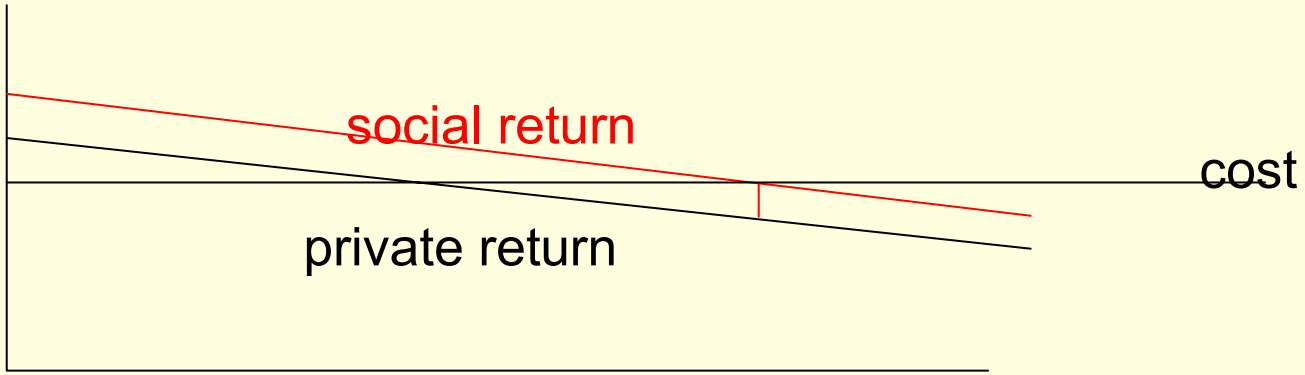


Optimal subsidy varies

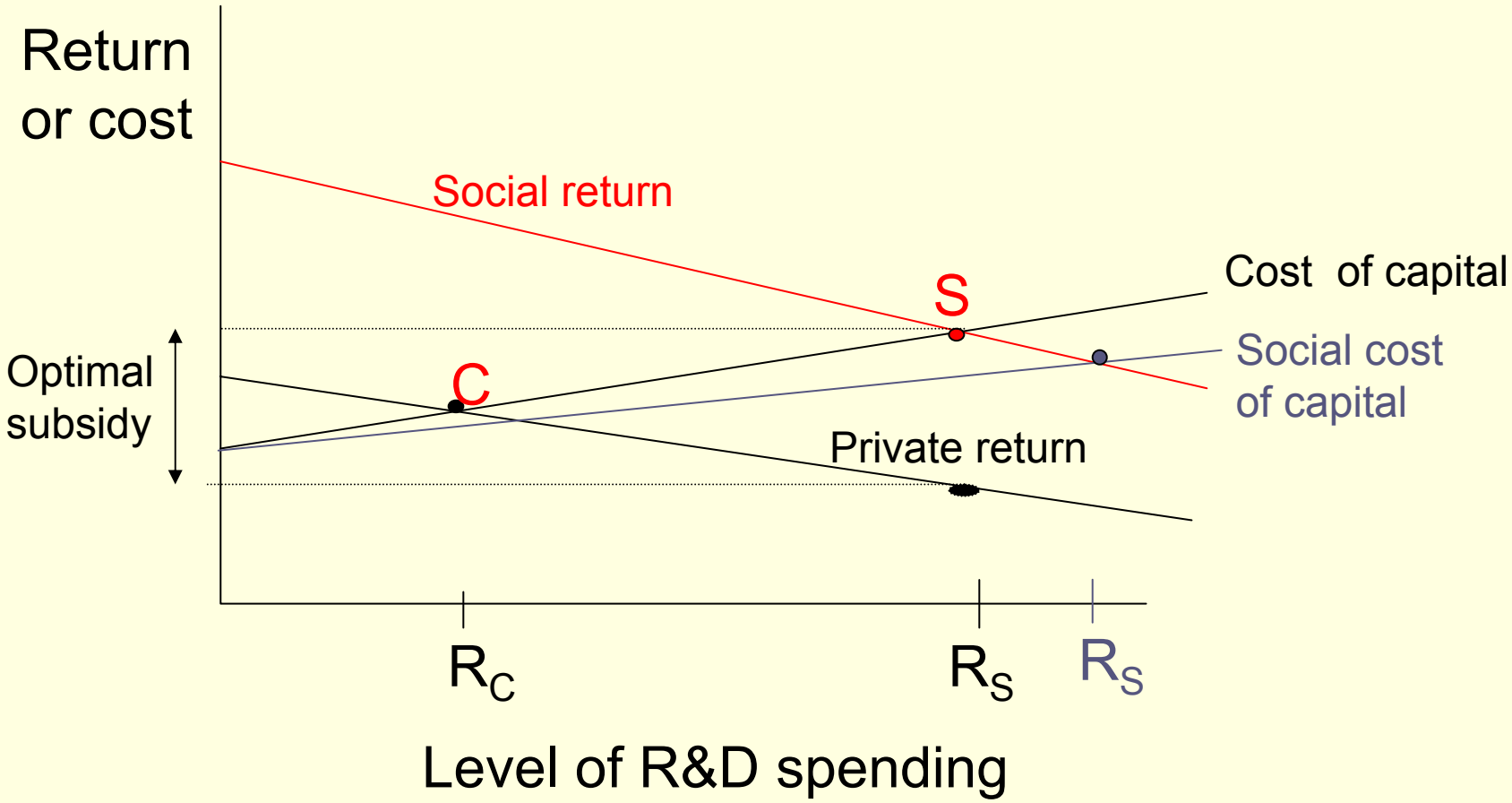
(a) Basic Research (or generic technology)



(b) Development (or proprietary technology)



Private and social cost of R&D



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 ρ = required pre-tax real rate of return on marginal R&D that earns *r* after (corporate) tax.

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

A^d = value of depreciation deductions (usually=tax rate)
A^c = value of tax credits, if any
τ = corporate tax rate
δ = depreciation rate
MAC = 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 δ
  - sensitive to the rate of technical change in the industry, determined by such things as market structure and the rate of imitation. δ 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?

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

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