

# The Financing of R&D and Innovation

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# Survey sources

- Hall, B. H. and J. Lerner (2010), The financing of R&D and innovation, in Hall and Rosenberg (eds.), *Handbook of the Economics of Innovation*.
- Hall, B. H. (2009), The financing of innovation, *European Investment Bank Papers* 14 (2): 1-23.
  - Reprinted (2010) in the *Review of Economics and Institutions* 1(1). <http://www.rei.unipg.it/rei>

# Outline

- R&D as an investment
- Implications for financing R&D
  - *Asymmetric information*
  - *Agency costs*
- Evidence

# R&D vs innovation

- R&D only part of innovation expenditure, in addition we have
  - Worker training, etc.
  - New capital equipment (process innovation)
  - Marketing, etc for new and improved products
- But, only recently are data available on these, so most empirical literature uses R&D as an indicator

# Economics of R&D and innovation

**Arrow 1962** – market fails to allocate adequate resources to innovation because of ...

1. **Lack of full appropriability of returns**
  - unpriced positive externalities
2. **Indivisibility of output**
  - implies market power for innovator from returns to scale
3. **Financing is costly**
  - because of info asymmetry and risk
  - especially when financier and entrepreneur are different

# R&D as investment

- **Similarity:**
  - Expenditure undertaken today to secure (uncertain) returns in the future
  - => creates a capital asset for the firm
- **Differences:**
  - Composition – wages of scientists and engineers are more than half of spending
  - Asset created is intangible
    - Unknown share is human capital (partly owned by employees)
    - Not easily tradeable (low salvage value)
  - Level of uncertainty much more extreme

# Implications for policy and practice

- Production of knowledge is not intemporally separable  
→ adjustment costs high
  - Policy changes take time to have an impact
  - Measurement difficulties - R&D does not exhibit much variation over time within a firm
    - Responds slowly to changes in capital cost
    - Little variation to identify its productivity
  - Firms respond by smoothing R&D, holding cash
- Uncertainty – in some cases, distribution of returns is Pareto with a parameter value that implies no second moment – Scherer, Harhoff, etc.

# Choosing the level of R&D

- Profit-maximizing firm invests in R&D until the after-tax marginal product of the resulting capital asset is equal to the tax-adjusted user cost of capital.

$$(1 - \tau)MPK = c_t = (1 - \tau)(1 - \varphi) \left[ (r + \delta)p_t - \dot{p}_t \right]$$

- Therefore, R&D will depend on
  - Investor's required rate of return  $r$
  - (Economic) depreciation rate of the asset  $\delta$
  - Marginal adjustment cost of R&D program (not shown)
  - Corporate tax rate  $\tau$
  - Tax credits, if present ( $\varphi$ )
- If R&D is expensed and there is no tax credit, tax effects will not matter ( $1-\tau$  cancels out)



# Implications for R&D finance

- **Depreciation** (private obsolescence) highly variable and endogenous to other firms' behaviors
  - possibly higher than aggregate rate of 12 or 15%
- **Debt versus equity finance**
  - Debt sometimes cheaper than equity due to interest deductability
  - However, debtholders prefer physical assets as collateral and R&D creates an intangible asset that may have low salvage value
- **Evidence that equity strongly preferred over debt for external financing in R&D firms in the US, and elsewhere**
  - In systems without thick public stock markets, debt finance is used, at least for smaller firms (e.g., Belgium)

# Required rate of return to R&D

- Probably higher than that for ordinary investment:
  - Uncertainty and risk
  - Asymmetric information between financier and firm implies there is a lemons premium
    - Mitigating asym info by revealing idea to potential investor is costly and can lead to imitation
    - Akerlof (1970): if lemons premium large enough, market disappears
    - One solution: hands-on venture capital investment
  - Agency costs – can arise in any setting where the goals of a principal and his/her agent conflict

## Testing for financing constraints due to info asymmetry

- **Information asymmetry** implies internal funds are cheaper than external funds
- **Test:** set up R&D investment equation and test for “excess” sensitivity to cash flow shock (as is often done for investment)
- That is, if a constrained firm has a surprise increase in cash flow, does it increase investment in R&D more than an unconstrained firm?
- But remember that many firms will hold cash to avoid this situation, so also look at stock of cash (working capital)

# Test variations

- ADL (autoregressive distributed lag) model of R&D as a function of output or revenue
- Euler equation based on the FOC for R&D from the dynamic program of a profit-maximizing firm
- For either functional form, alternative tests:
  1. Cash flow as proxy for cost of capital
  2. Classify firms in two groups by exposure to financial constraints (credit rating, dividend-paying, etc.) – look at differences

Figure 1  
Unconstrained Firm

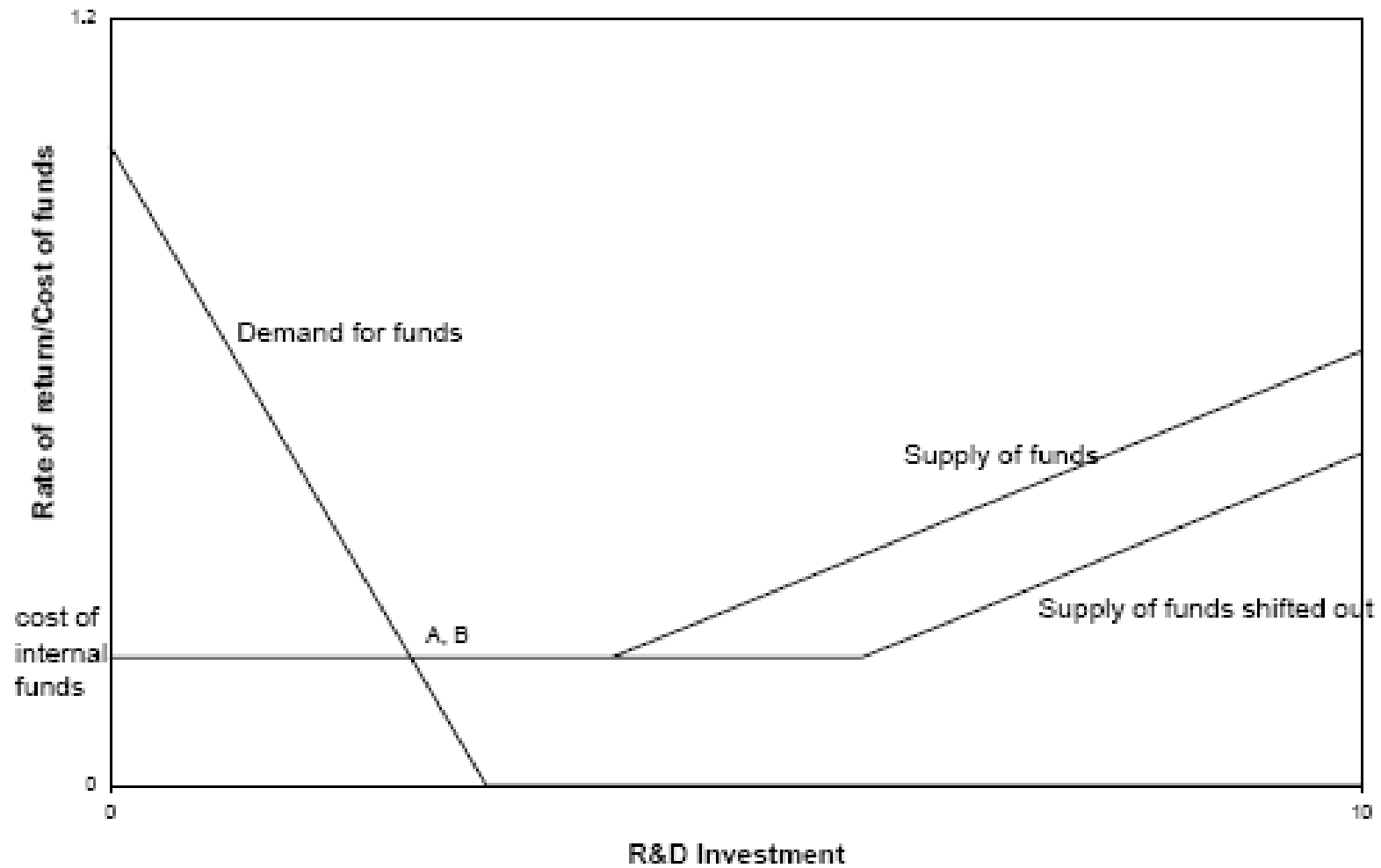


Figure 2  
Constrained Firm

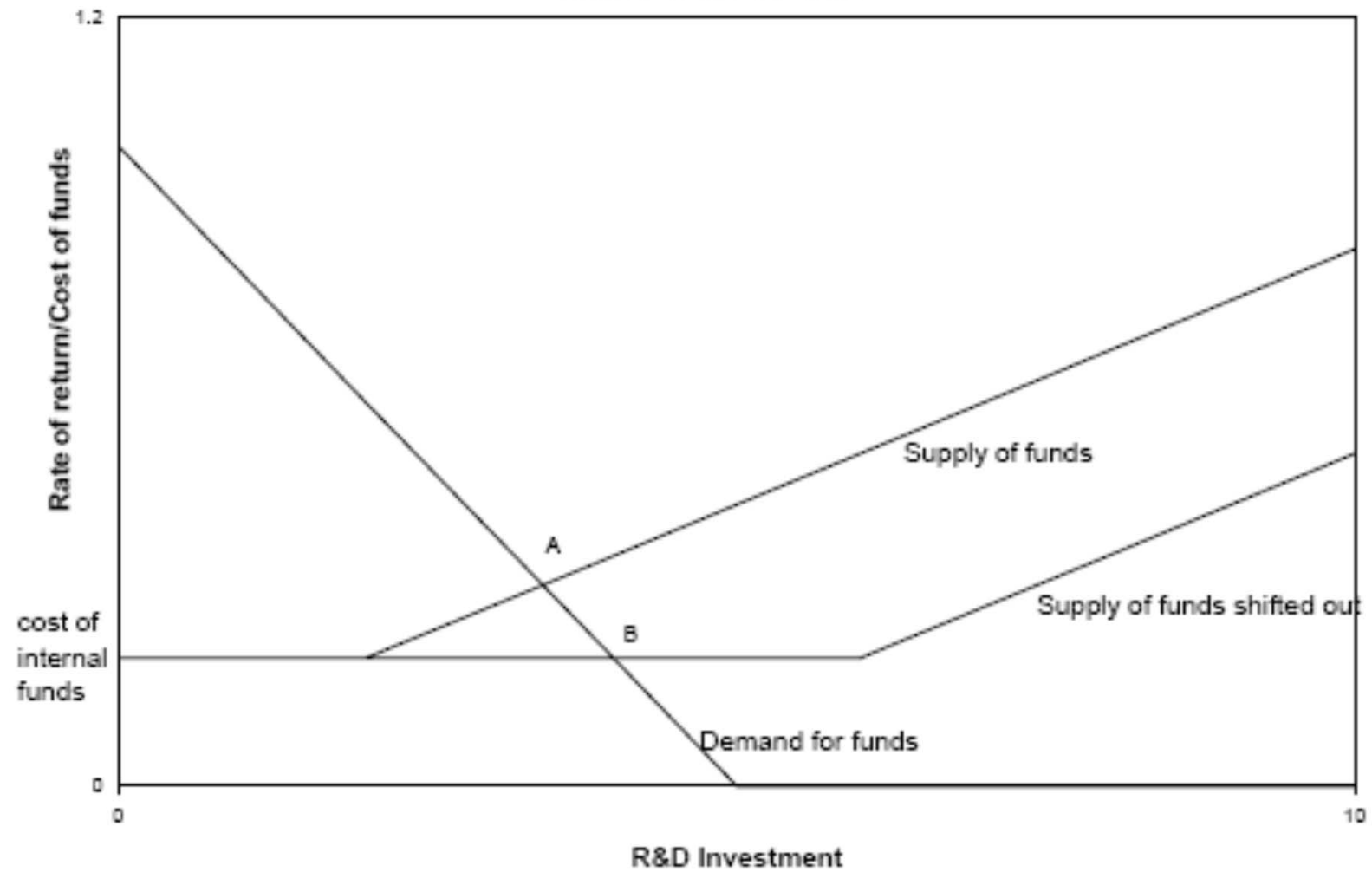
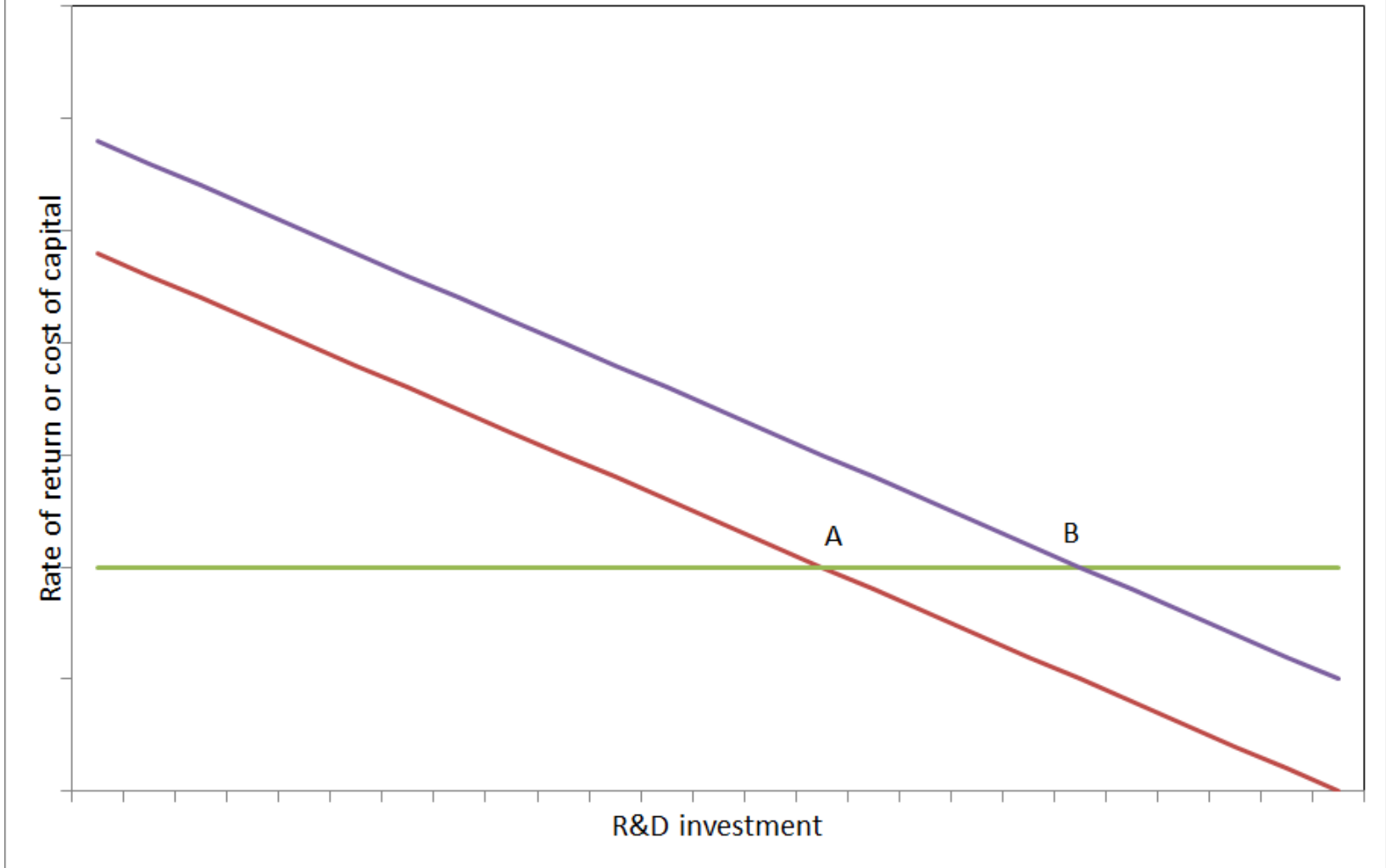


Figure 3  
Unconstrained firm facing demand shift



# Results of tests for asym info

- Various methods applied to large and small firms in the US, UK, France, Germany, Italy, Ireland, and Japan
  - Cash flow sensitivity is greater in Anglo-Saxon economies (US, UK, Ireland), although some of the effect may be a response to demand shocks
  - Low, but not zero, in France, Germany, Japan
  - Greater for smaller and younger firms – more likely to have to rely on external finance (e.g., [Holtz-Eakin \*et al\* 1994](#))
  - May be mitigated by patents – signaling and salvage value



# Newer work on R&D finance

- **Brown, Petersen, and co-authors**
  - importance of R&D smoothing behavior
  - young US firms use cash holdings to dampen volatility in R&D ~75% during the 1998-2002 boom and bust in equity issues
- **Brown, Martinsson, and Petersen (2010)**
  - limited access to equity finance significantly limits innovative activity in smaller, younger firms in 16 European countries (1995-2007)
    - System GMM estimation
    - Control for R&D smoothing: include changes in cash holdings (-), additional stock issues (+)
  - Effects stronger in UK, Sweden, lower in France, Germany

# Work on innovation finance

- CIS enables one to look at self-reported financing constraints and innovative activity other than R&D
  - Challenge is endogeneity
  - Hajivassiliou & Savignac (2008) – simultaneous binary model of financing constraints and innovation (France)
    - Innovating firms more likely to face financing constraints
    - Financing constraints discourage innovation
    - Strong state dependence
  - Canepa and Stoneman (2008) – cost and availability of finance matters more for high tech and small firms (UK)

# Work on innovation

- **Tiwari, Schim van der Loeff, Mohnen, and Palm (2013)**
  - Dutch firms; multi-equation model of innovation, financing constraints, and R&D investment
  - Small, young, levered firms that don't pay dividends more likely to be constrained
  - Novel control function approach to estimation in a panel data setting with endogeneity
- **Gorodnichenko and Schnitzer (2011)**
  - Use BEEPS surveys of Eastern European and former CIS firms (2002/2005)
  - Related TFP and innovative activity to financing constraints, estimated with IV (cash flow shocks - use of barter, delayed pay to suppliers, lost sales for exogenous reasons)
  - Innovation reduced by financial constraints, especially for smaller, younger, and domestically owned firms

# Agency costs for innovative firms

Principal	Agent	Agency cost
owner	manager	risk aversion; preference for “easy life”
minority shareholder	majority shareholder	private benefits preferred to share value maximization
VC firm	entrepreneur	diversion of funds; overconfidence

# Testing for agency costs

- Previous approach will not work – firm is assumed to maximize something other than shareholder value
  - Use marginal (Euler) condition and add indicators of owner-manager separation?
  - Usual method - measure effects of increasing managerial security or the managerial share of firm
  - Examine differences in investment behavior across different ownership structures (simultaneity problems)

# (1) Do agency costs matter?

- Managers vs. owners: tests are sometimes weak and evidence is unclear (and magnitude unknown):
  - Antitakeover amendments do not reduce and may increase R&D (US)
  - Institutional ownership associated with higher R&D (US) and higher R&D productivity (Aghion, Van Reenen and Zingales 2009)
  - Diffusely held firms less innovative (measured by R&D spending) (US & UK)
  - In the US, evidence that shareholders discount future expected returns from R&D at a *lower*, not higher rate (Hall and Hall 1993)

## (2) Do agency costs matter?

- Majority vs. minority shareholders (Europe)
  - Hall and Oriani – R&D in majority-controlled firms valued less (essentially zero in Italy) – one manifestation of “tunnelling”?
  - Munari, Oriani, and Sobrero – family-controlled firms do less R&D
  - Cf Bloom, Van Reenan 2005 – productivity disadvantage of family-owned firms

# Policy implications?

- **Asymmetric info and risk**
  - Evidence does not contradict Arrow's argument that there will be underinvestment in innovation without some policy attention
  - Small and new firms are even more disadvantaged
  - Lowering the cost of capital to R&D-doing firms is recommended (subsidized credit, tax credits, etc) and has been effective in many places
- **Agency costs - the story is incomplete**
  - No obvious policy recommendation specific to R&D
  - May be governance implications in general



# Another view?



(Thanks to Peter Klein for the cite)