Returns to R&D and the depreciation problem

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Adding R&D investment to SNA

- Adding R&D to SNA requires
  - Balance sheet: capitalizing R&D - need a measure of depreciation
  - Income statement: assumptions on or measurements of net rate(s) of return - need a measure of depreciation
  - Real measures – do we need an output measure for R&D?

What is R&D depreciation?

A measure of the extent to which knowledge no longer produces useful output; obsolescence

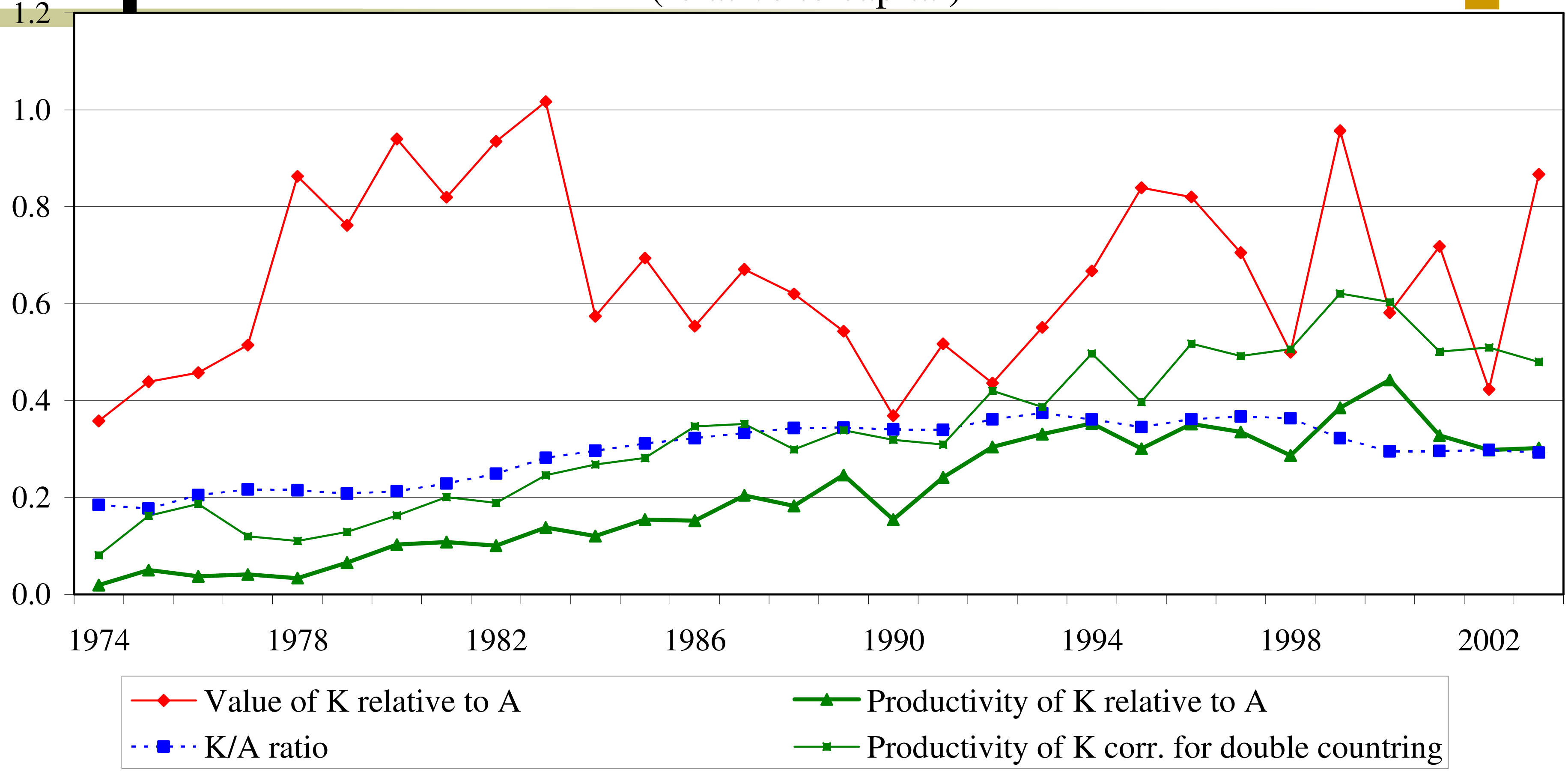
- Economy wide (appropriate for SNA) – should it be lower than private rate?

  "An additional loss in value comes from the gradual leakage of information to competitors and the expiration of intellectual property protection that render the R&D asset less valuable to its owner." (Okubo et al, p. 34)
- Industry level – for future SNA
  - Likely to be highly variable across technology
- Firm level – endogenous to the activities of other firms (Schumpeterian competition)
  - Much of R&D is product development, which can become obsolescent quite easily
  - However the knowledge created in the process is cumulative and may still have substantial social (and even private) value

Some firm-level measurements

- Methodologies:
  - Production function
    - Derived from elasticity estimate
    - Measured directly from R&D intensity coefficient
  - Market value
    - Derived from shadow value of R&D
- All measures
  - private (do not include spillovers)
  - based on publicly-reported FASB-standard R&D (not on Frascati) – but differences are not large, except for foreign-performed R&D

Figure 2
Productivity and market value of R&D in US manufacturing firms
(relative to capital)



28,938 observations on 3,406 R&D-doing firms

Production function

- Include R&D capital (conventionally depreciated at 15%) as an input; estimate output elasticity γ
- In growth rates, bias from wrong choice of depreciation rate is small => consistent estimate of γ (in principle)
- Health warnings:
  - rate of return formulation assumes zero depreciation, so early reported estimates are strongly downward-biased
  - many reported estimates of γ do not correct for double counting of labor input, so they are downward-biased by approximately 0.03-0.10 (Schankerman, Hall-Mairesse)

Production function – Hall 2006

Assume:

1. cost of tangible capital c_A is observable
2. the ratio of the two capital shares (tangible A and R&D K) equals the ratio of the production function coefficients (does not require CRS or price-taking):

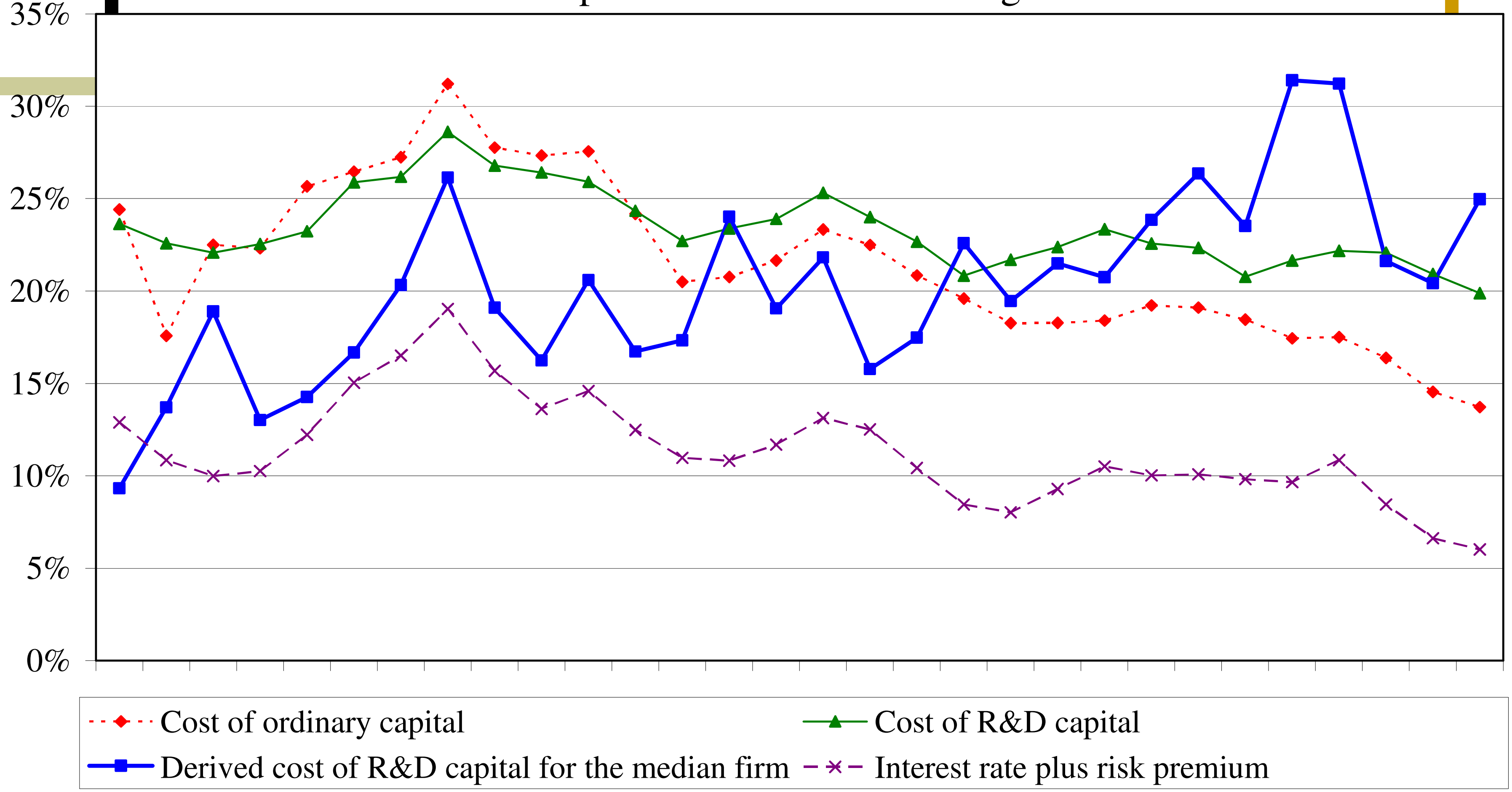
$$\frac{\gamma}{\beta} = \frac{c_K^* K^*}{c_A A}$$

(*s denote the true values)

This approach allows us to do two (different) things:

1. Compute the cost of R&D capital implied by measured K
2. Assume a cost of R&D capital based on a required rate of return and derive the implied depreciation rate for R&D. (assumed risk premium = 5%)

Figure 3
Cost of Capital for US Manufacturing Firms



$$c_j = p_j \left[1 - \frac{(1-\delta_j)[p_j(+1)/p_j]}{1+\rho} \right] \quad j = A, K$$

Deriving depreciation estimates

$$c_K^* K^* = (p_K K) \frac{(\rho + \delta_K)(g_R + 0.15)}{(g_R + \delta_K)(1 + \rho)}$$

- $c_K{}^*K^*$ is estimated from prod fcn [$= (\gamma/\beta)\ c_A A$]
- $p_K K$ is *measured* current R&D capital (using 15%)
- ρ is the assumed required rate of return
- g_R is the past growth of R&D in the firm

Note the difficulty of identifying δ

For each year, compute δ firm by firm and take the median

Production function estimates (Least absolute deviations)

Period	Ratio of capital coefficients	Standard error	Implied cost of R&D capital	Implied deprec. Rate	Median standard error
1974-1978	0.111	0.023	11.9%	-11.1%	2.3%
1979-1983	0.215	0.032	24.8%	-1.4%	2.4%
1984-1988	0.240	0.032	16.8%	-9.7%	1.1%
1989-1993	0.363	0.043	21.7%	-6.5%	0.6%
1994-1998	0.405	0.035	22.9%	-7.8%	0.4%
1999-2003	0.559	0.060	36.7%	-4.1%	0.3%
All years	0.258	0.014	19.7%	-6.0%	0.4%

Corrected for double counting (linear function of R/S)

Not very sensitive to risk premium assumption

By sector

Period	Chemicals & chem-based	Drugs & med inst	Electrical	Computers & inst	Metals & machinery	Miscella neous
1974-1978	1.9%	-9.0%	-12.5%	-12.3%	2.7%	3.7%
1979-1983	1.0%	-3.6%	-14.9%	-2.0%	0.6%	-1.3%
1984-1988	-11.3%	-13.7%	-3.5%	-6.4%	-4.2%	-4.2%
1989-1993	-6.1%	-8.9%	-4.2%	-6.0%	-3.2%	-5.2%
1994-1998	-4.7%	-8.4%	-9.4%	-7.6%	-5.6%	-7.2%
1999-2003	-1.2%	-6.8%	-4.3%	-5.3%	-3.7%	-2.9%
All years	**-2.3%**	**-10.9%**	**-3.0%**	**-5.0%**	**-1.8%**	**-2.3%**

Relative magnitudes are somewhat sensible

Overall, values too low!

Market value approach

Estimate a hedonic market value equation:

$$logQ_{it} = log\ q_t + log(1+\gamma_t K_{it}/A_{it})$$

Assume true shadow values of K and A are equal and A measured correctly.

(Relative risk? Adjustment costs? Taxes?)

Derive depreciation from the following equation and take the median:

$$\hat{\delta}_{it} = \frac{0.15 + g_{it}}{\hat{\gamma}_t} - g_{it}$$

Nonlinear least squares estimates

Period	K/A Coefficient	Std. err.	Implied depreciation rate	
			Median	Median s.e.
1974-1978	0.526	0.025	31.2%	5.1%
1979-1983	0.595	0.025	28.8%	4.1%
1984-1988	0.385	0.028	49.9%	7.3%
1989-1993	0.382	0.031	50.0%	6.2%
1994-1998	0.551	0.037	33.8%	4.5%
1999-2003	0.794	0.040	20.1%	2.4%
All years	0.503	0.032	27.5%	1.2%

By sector

Period	Chemicals	Drugs & med inst	Electrical	Computers & inst	Metals & machinery	Misce-llaneous
1974-1978	25.2%	7.0%	47.1%	27.8%	<-100%	35.7%
1979-1983	11.6%	16.9%	19.7%	58.6%	20.4%	40.1%
1984-1988	11.1%	6.6%	24.8%	91.4%	>100%	>100%
1989-1993	39.8%	22.3%	>100%	52.8%	>100%	60.3%
1994-1998	24.1%	20.1%	62.4%	44.2%	39.5%	4.7%
1999-2003	36.8%	18.0%	55.1%	23.9%	15.5%	3.4%
All years	**22.2%**	**16.1%**	**52.1%**	**42.0%**	**43.0%**	**24.1%**

Relative magnitudes are somewhat sensible

Overall, values too high?

Conclusion from these estimates

- Large comprehensive sample of firms
- Robust estimation methods
- *Nevertheless,* rates of return and depreciation still highly variable over time and sector
  - Suggests caution in using these methods as direct input to R&D satellite accounts
    - Might it be useful to explore prod fcn approach at a more aggregate level?
    - We need R&D by technology or industry (LOB)
- Caveat:
  - firm-level estimates ignore the output deflation problem (as they should)
  - Once we move to the economy level, the “productivity” of R&D becomes important
  - Allocation of benefits between sectors strongly affected by market structure (prices) but aggregate bottom line is not.

Do we need an output measure for R&D?

- I am skeptical that this is an achievable goal
- It is difficult to conceive of a measure that is distinct from its effects on productivity or prices
  - Encouraging that scenarios B,C,D give approximately the same results
- Ignore the problem for the moment and let increased productivity show up in MFP (as in the case of spillovers)?