

Innovation and Productivity: What we know and what we don't

December 2005

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Overview

- Introduction and caveats
- What is productivity and innovation?
- Some things we think we know
- Some things we don't
- A way forward

Introduction

What is productivity and innovation?

Some things we know

Some things we don't

Conclusions

Some caveats

- The slant of an empirical economist
- *“It ain’t what people don’t know that’s the problem. It’s what they know that just ain’t so”* (Will Rogers). Hope to avoid this, but old joke about the 7 economists in the room
- Necessarily selective
- Focus on some contributions coming out of BOX program at CEP
- And some things that have emerged over last 50 years of so of economic science

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What is labour productivity?

Basic “economic welfare” measure (GDP per capita)

$$\frac{GDP}{Population} = \frac{GDP}{hours} \times \frac{hours}{workers} \times \frac{workers}{population}$$

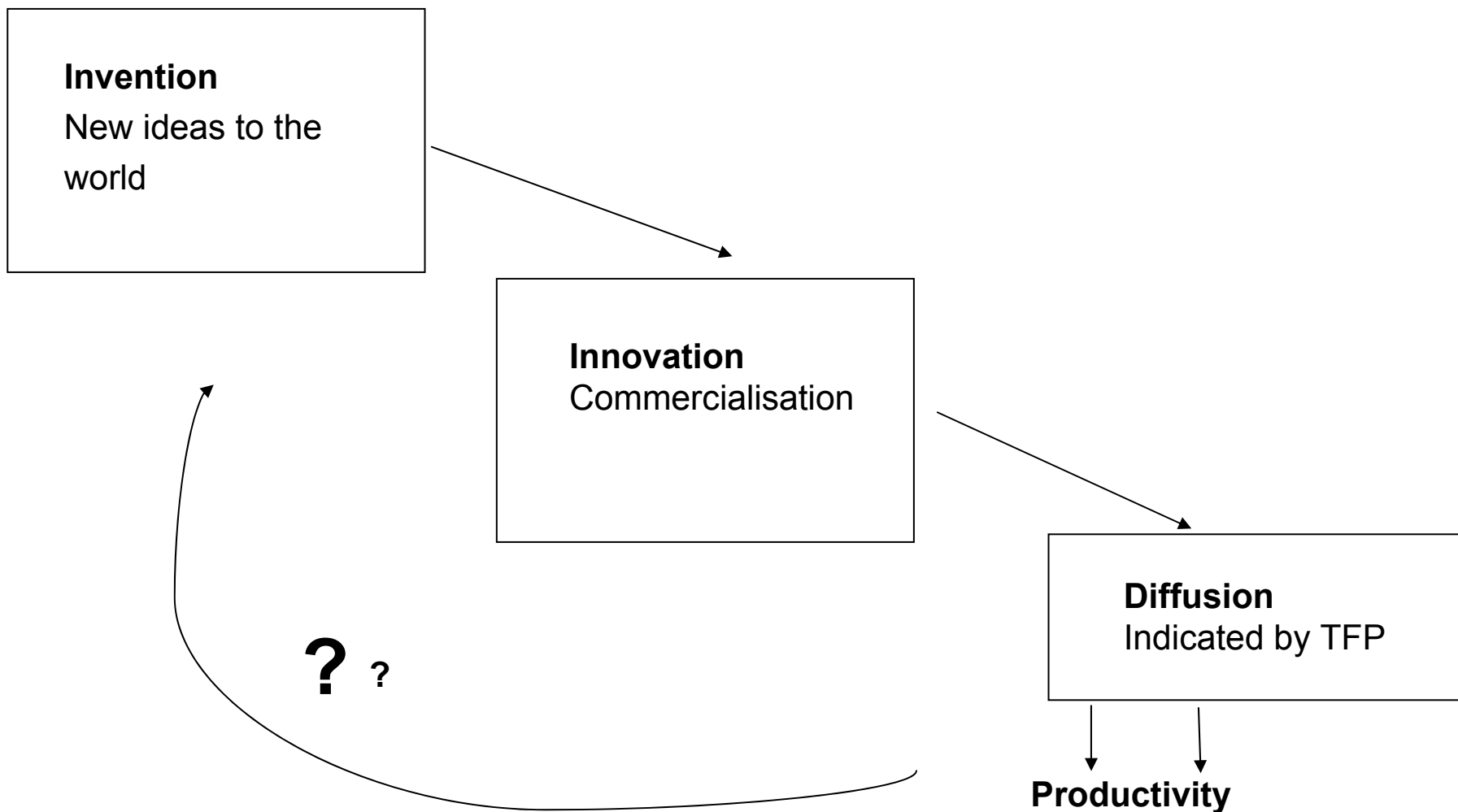
Labour productivity Employment rate

- Higher productivity (e.g. from innovation) generates a larger GDP cake
- Can be distributed in many ways – lower taxes, more public goods, More leisure, Improved environment etc. These are social choices

What is innovation?

- At its simplest, that part of productivity growth that is not due to an increase in inputs (labour, skills, capital, land, etc.)
- Sometimes called “Total Factor Productivity”
- Many other indicators of technological innovation. Example:-
 - Research and Development
 - Patents and other forms of IP
 - Innovation counts
 - Particular technologies (e.g. ICT – more properly thought of as capital)
- But many other kinds of innovation that we do not think of as conventional technology
 - New ways of working (e.g. Toyota and Lean manufacturing revolution)
 - Organisational
 - Managerial

Decomposing the Innovation Chain

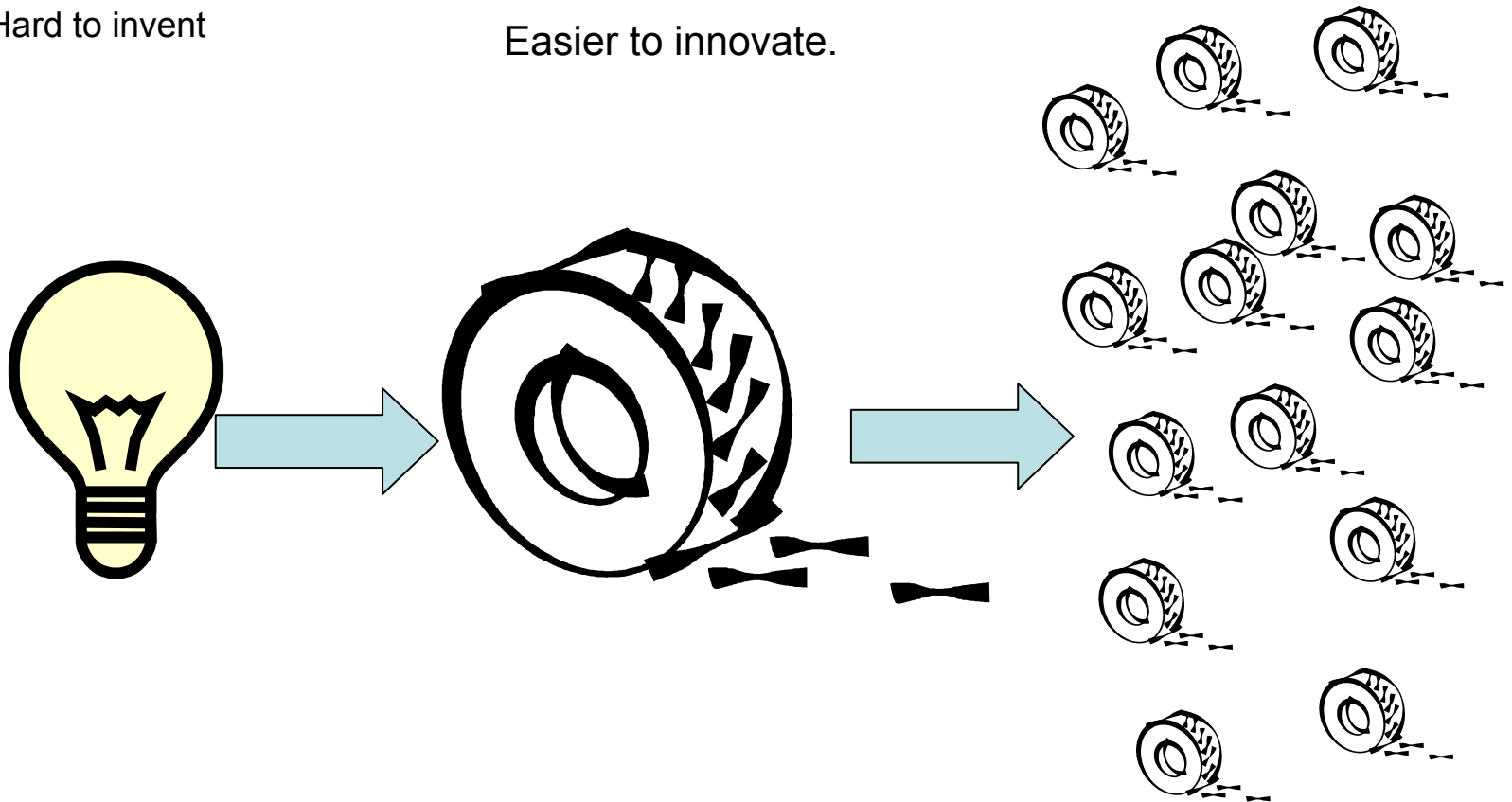


Invention and adoption: Example of the wheel

- Hard to invent

Easier to innovate.

- Even easier to adopt

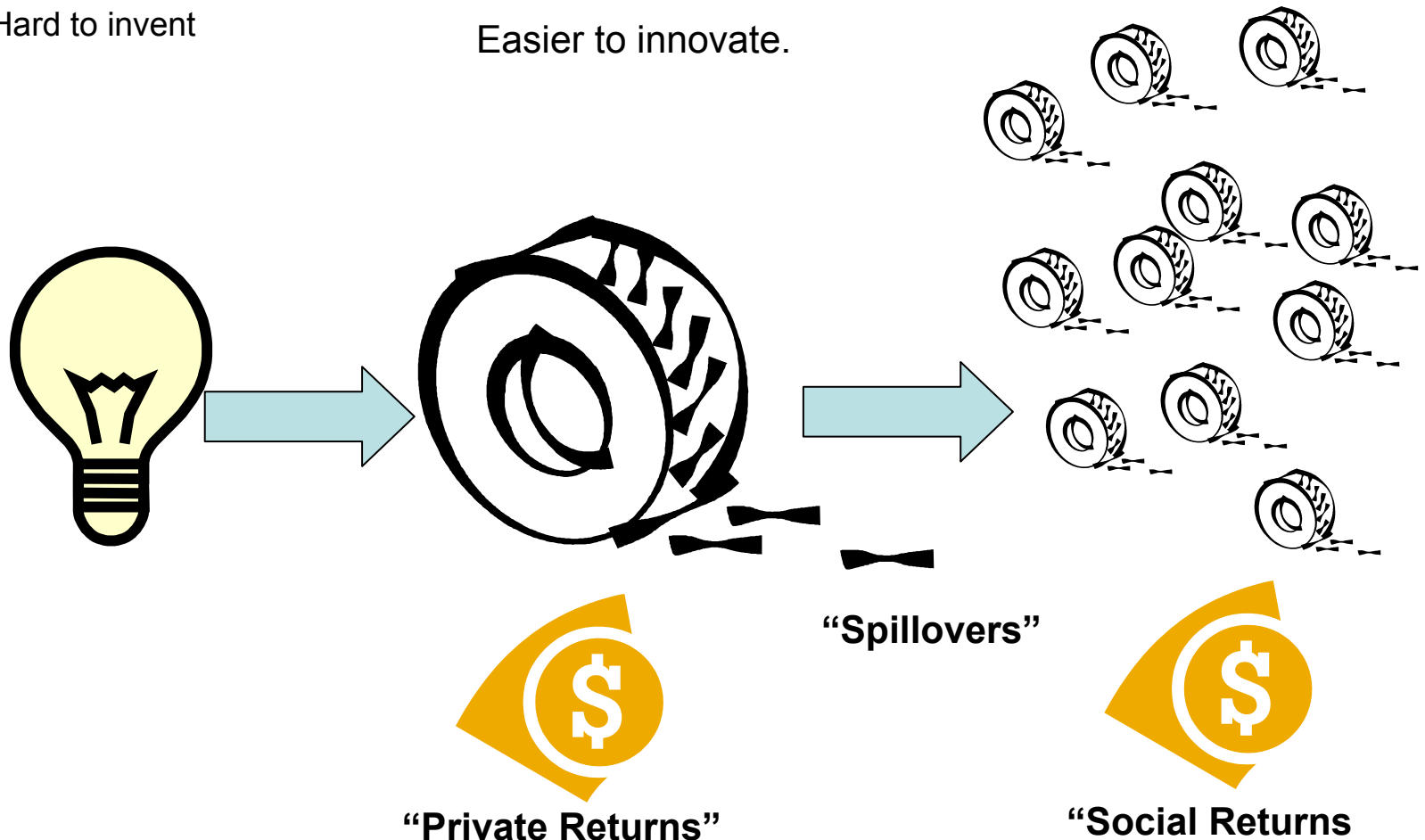


Private returns and spillovers

- Hard to invent

Easier to innovate.

- Even easier to adopt



Implications

- Knowledge an unusual economic good
- Producer finds it hard to capture all the value as it “spills over” to other agents (even with patent protection, secrecy lead time, etc.)
- “Positive externalities”
- Although effects in opposite direction – R&D hurts rivals in product market, R&D arms race causes duplicative R&D
- If positive externalities are larger then a reason for government support for innovation
- But how large are private and social returns?

Introduction

What is productivity and innovation?

Some things we know

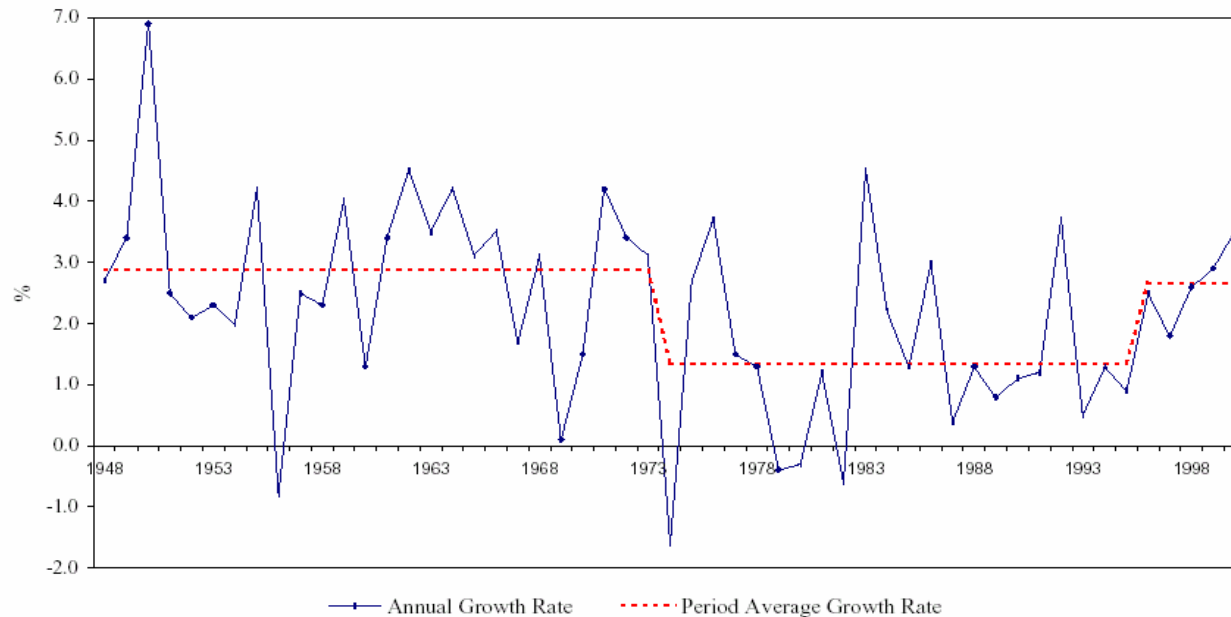
Some things we don't

Conclusions

Some Key Findings - Macro

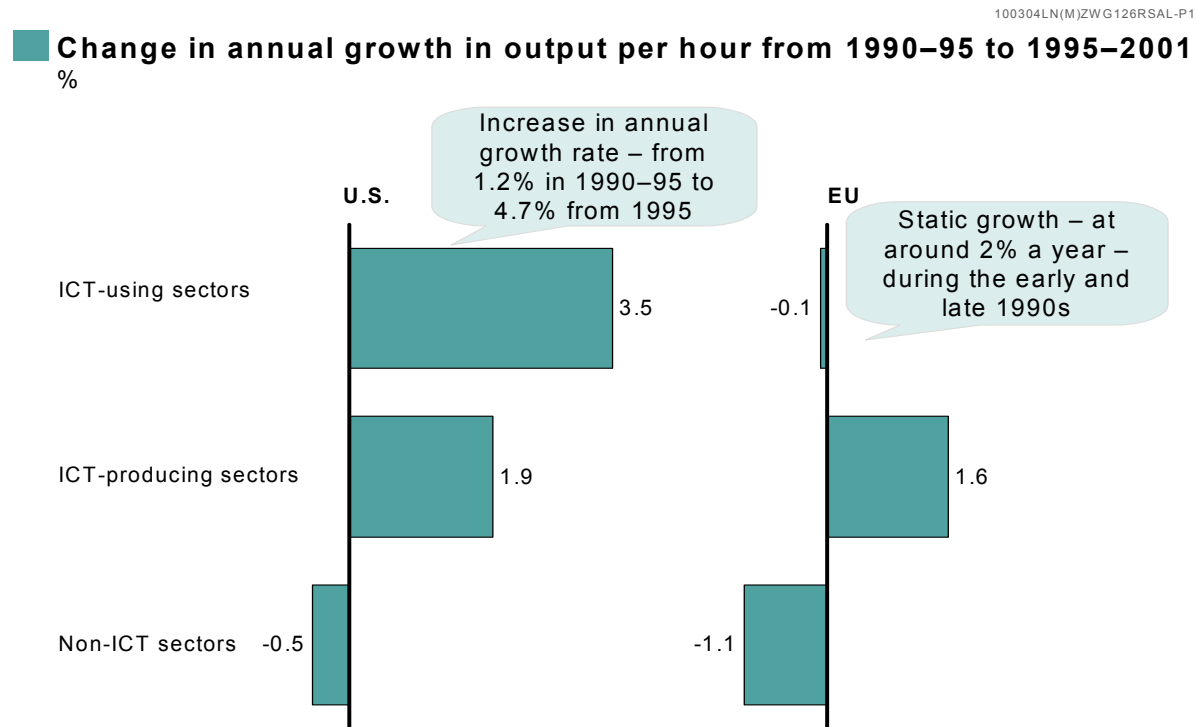
- Solow (1957) US growth over the long-run is driven by technological change (TFP) rather than growth of factor inputs (people, machinery, etc.)
- There are large and persistent differences between countries. A lot of these differences are due to difference in TFP rather than capital. Even within OECD big differences (e.g. in market sector output per hour 30% higher in US than in UK)
- There has been a gradual catch up of countries behind the productivity “frontier” to countries near at the frontier (USA). This is not uniform and there have been “convergence clubs” – e.g. OECD countries of EU, Japan and US. Africa has remained stuck. India/China significant catch since 1980s
- US productivity growth slowed down after 1973 (Oil Shocks), but since 1995 there has been a “productivity miracle” with output per hour growing at around 2.5% per annum (up from 11.5% per annum). ICT has an important role in this (IT producing industries like semi-conductors important but IT-using like finance and retail more important)
- EU countries have not experienced this acceleration in productivity growth. Surprising because IT generally available. Why?

Chart 1: U.S. Productivity Growth, 1947-2000



Source: BLS (2000b). Estimates are annual growth rates for the nonfarm business sector, except 2000 which is through three quarters. The average growth rates are for 1947-73, 1973-95, 1995-2000:Q3.

Since 1995 US productivity growth accelerated in ICT using sectors and the ICT producing sectors.....



Source: O'Mahoney and Van Ark, 2003

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Source: O'Mahony and Van
Ark (2003)

Some Key Findings - Micro

- Large and persistent productivity differences between firms even in narrowly defined sectors. A puzzle for economists – how can the inefficient firms survive in competitive markets?
- What explains these differences?
 - Some of it is temporary. Creative Destruction (see over)
 - Technological Innovation and adoption
 - Other inputs: human capital, investment, etc
 - Management and organization

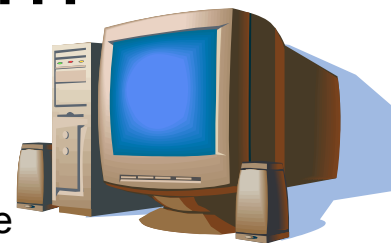
Creative Destruction

- Last 10 years has revolutionised the understanding of productivity because of the growth of huge databases with information on millions of firms that can be followed over time (longitudinal or panel data)
- Productivity growth accounted for
 1. Existing firms becoming more productive
 2. More productive firms gaining market share and less productive firms losing market share
 3. Less productive firms exiting the market, more productive firms entering the market
- Traditional focus of economists on 1. (Existing firms becoming more productive) BUT this is wrong! Much of aggregate productivity growth turns out to be driven by 2. and 3. (“creative destruction”) . This is especially true after a shock such as trade liberalisation, increase in competition, deregulation, etc.
- Implies that policies to reduce exit (e.g. “bailing out lame ducks”), block entry or stymie growth (e.g. regulatory burdens) can cause big efficiency losses

Innovation and firm performance: Private Returns

- Large econometric literature shows a robust and positive impact of innovation on firm performance (e.g. magisterial survey by Griliches, 1998)
- Studies cover thousands of firms, scores of countries, decades of data, many econometric techniques
 - Outcomes: Firm productivity or market value (or profits)
 - Technology indicator: R&D or patents or innovation)
 - Controls: capital intensity, size, industry, financial position, etc.
 - Long lags between R&D and firm performance (e.g. pharmaceuticals)
- Unsurprising because firms would not invest in R&D unless they expected some return on average. The “private return” varies between study but is generally high.
- Researchers have also uncovered a positive impact (on average) of technological innovation on wages, employment and skills (less obvious and more interesting). See Van Reenen (1996, 1997)

ICT (diffusion) and Firm Performance



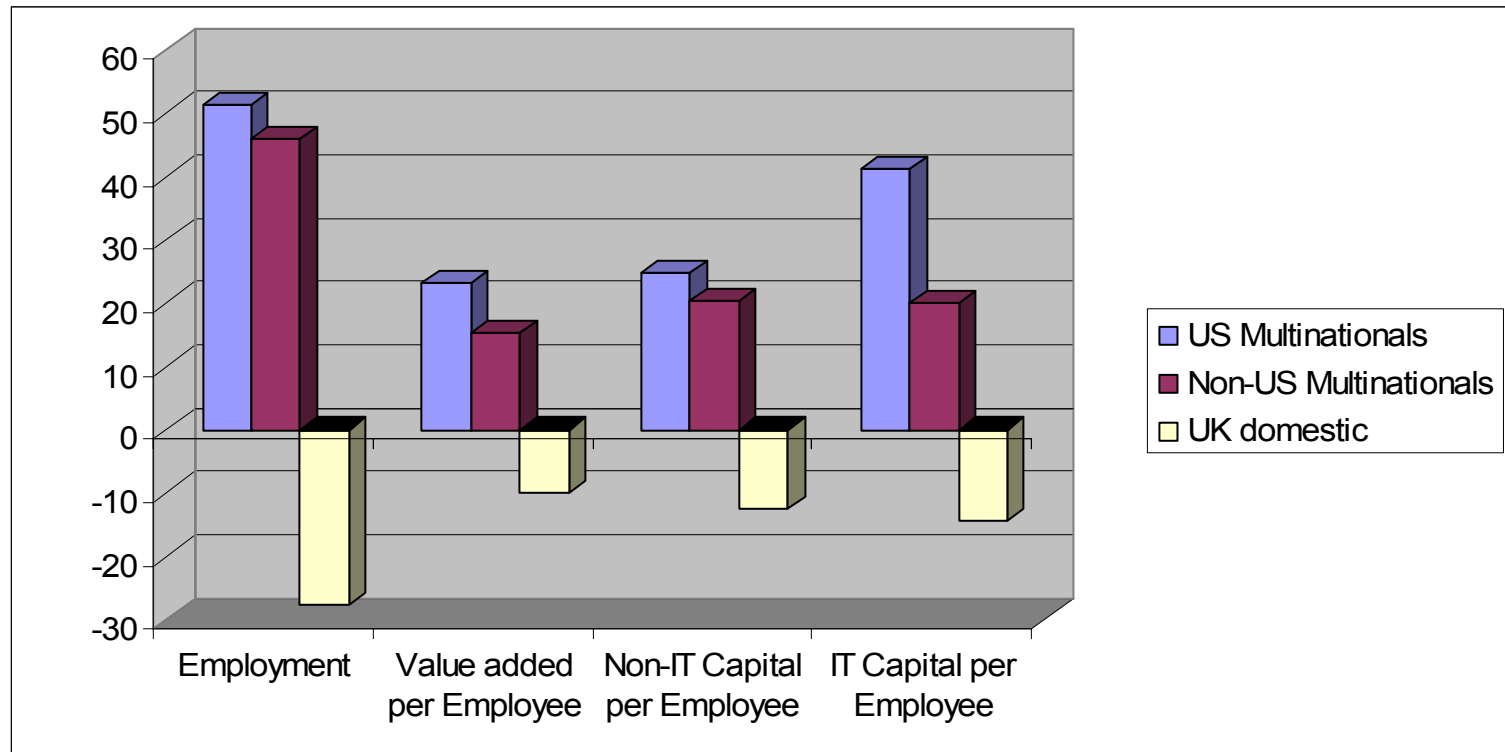
- Solow Paradox in 1980s. “You can see computers everywhere except for the productivity numbers”. Productivity slowed post 1973 just as computers seemed to take off.
- But (a) computers small part of total capital stock , (b) a lot of things are disguised by looking at macro-economic data. Need to dive beneath the surface to look at firms
- In recent years a number of studies examine firm productivity and IT. Now evidence that IT does have a substantial association with productivity.
- Almost all work in the US. As part of the BOX initiative we have built two panel datasets to look at the European evidence
 - Worked with ONS and DTI to build establishment dataset in UK 1994-2004 using ONS IT surveys that had not been used previously (Bloom Sadun and Van Reenen, 2005)
 - Harte-Hanks/FAME Database: UK, France and Germany, 1994-2004 (Draca et al, In Progress)

“It Ain’t What You do...”

Sadun and Van Reenen (2005)

- FT Editorial (November 2005)
- Over 20,000 observations
- We find that IT significantly boosts firm productivity with effects larger than would be predicted from conventional economic theory
- But this is due to many British plants owned by US multinationals. The US multinationals get a much larger return to their IT spend than other firms (e.g. non-US multinationals). In fact the higher IT returns explains all the well known US productivity advantage
- The result of the higher returns to IT for US firms are driven by a few industries that are responsible for the US productivity miracle (e.g. retail and wholesale)
- Findings not due to higher skills, more software, larger size, different industry, more capital, more outsourcing, etc. of US vs. non-US multinationals.
- Our explanation – US firms have better management/organisation that enables them to get more out of their IT. CEP management survey shows management better in US multinationals based in EU
- An potential explanation for failure of EU to keep up with the US? Need complementary managerial innovations.

Characteristics of establishments in the UK by ownership type (% difference from 4 digit industry mean in 2001)



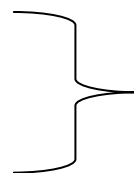
Observations - 576 US; 2228 other MNE; 4770 domestic UK

Innovation and Firm Performance: Social Returns

- Knowledge “spillovers” – innovator does not appropriate full returns of her effort because imitator copies at a lower cost. Recall invention/diffusion distinction
 - “**Innovation**” – always dangerous;
 - “**inventor**” a madman, no one listens to him, usually dies penniless in the asylum. It is not fair” Diderot, *Dictionnaire des idees recue*
- “Social Return” to innovation tries to measure the extent to which R&D (or innovation) benefits other individuals in addition to the firm who spends the money
- Empirical problem is how to determine who else benefits – what is the knowledge flow matrix?
 - Look at innovation of neighbours in the same industry, geographical region or technological area – does my neighbours innovative effort have a positive impact on my productivity?
 - Look at citations in the patent statistics (e.g. the 20 million patents on electronic USPTO database)
 - Look at the impact of frontier productivity growth on follower productivity

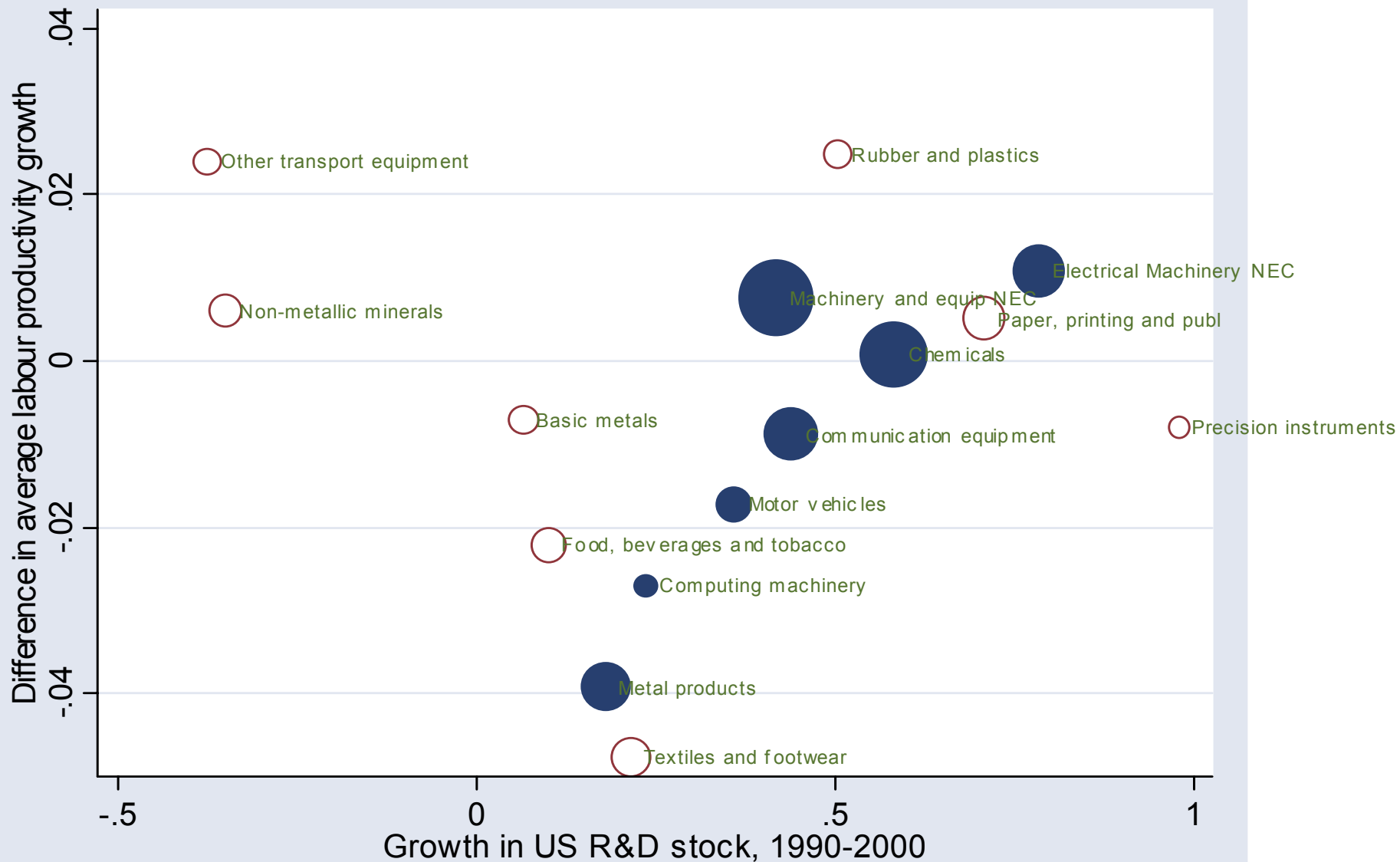
Findings on knowledge spillovers

- Knowledge spillovers exist and appear to be substantial – social return is much higher than private returns to R&D. This implies that the free market left to itself will not provide adequate incentives to invest in R&D.
- No good evidence that social returns to IT are higher than private returns (implies no “market failure” reason for government intervention)
- They spread internationally but are stronger for closer geographical areas (a reason for “clusters” like Silicon Valley)
- What are the factors that increase the flow of knowledge (“absorptive capacity”)?
 - R&D (“two faces”) – high R&D firms find it easier to absorb the knowledge of others
 - Skills – more human capital helps industries catch up
 - Product market Competition
 - Trade openness
 - Internal FDI
 - External FDI (example over)



Globalisation

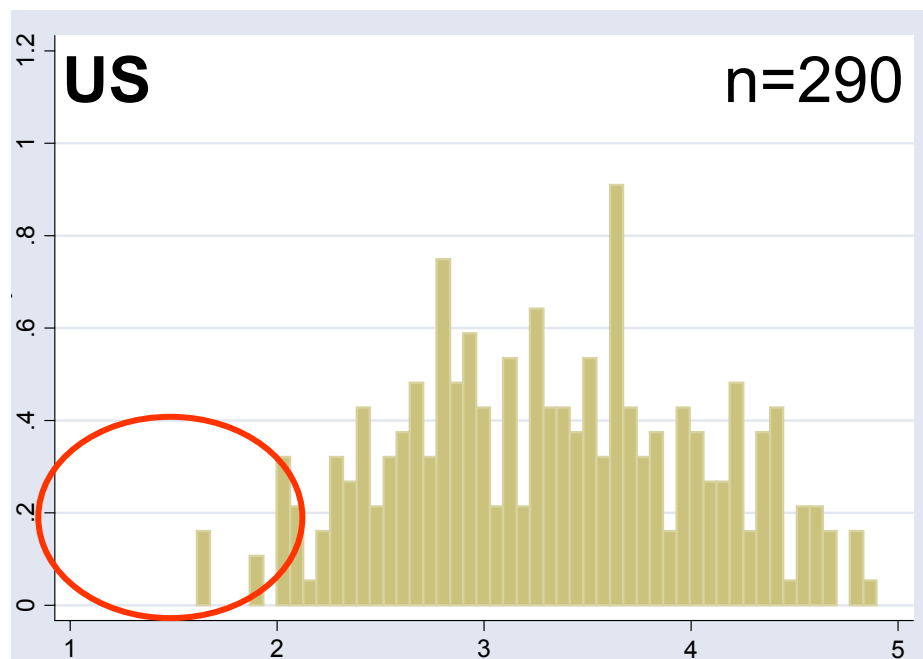
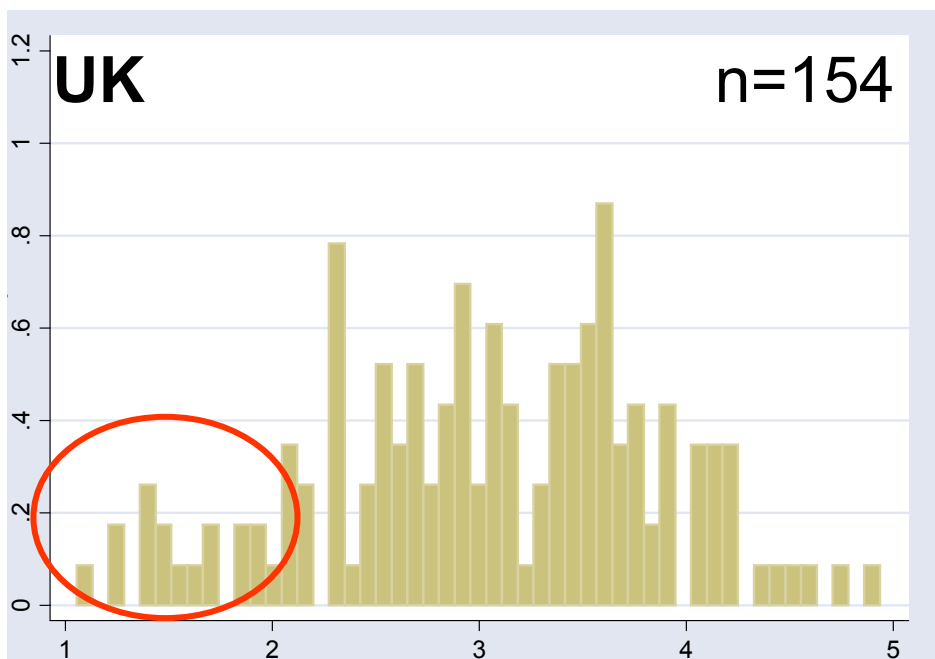
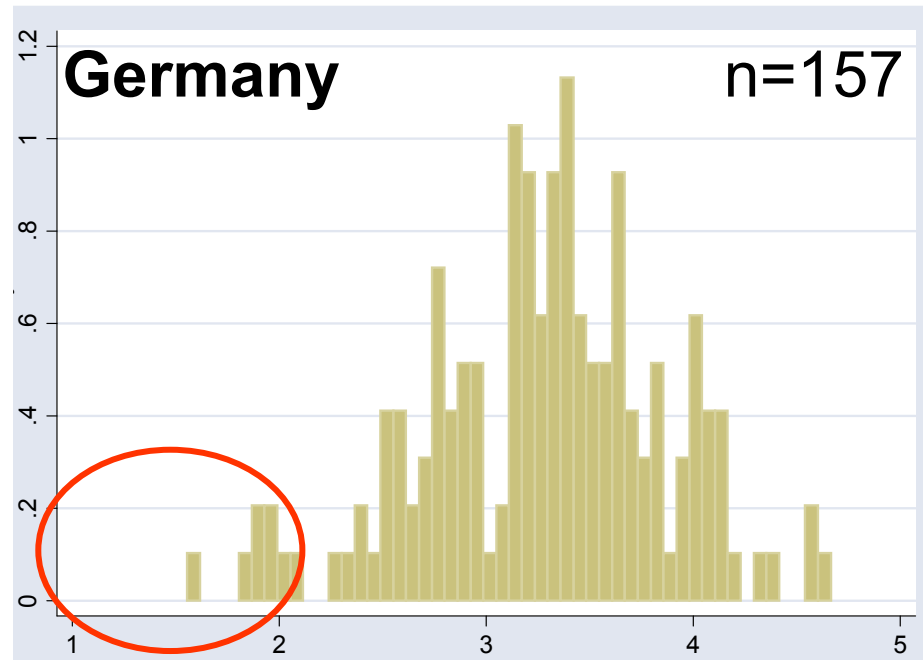
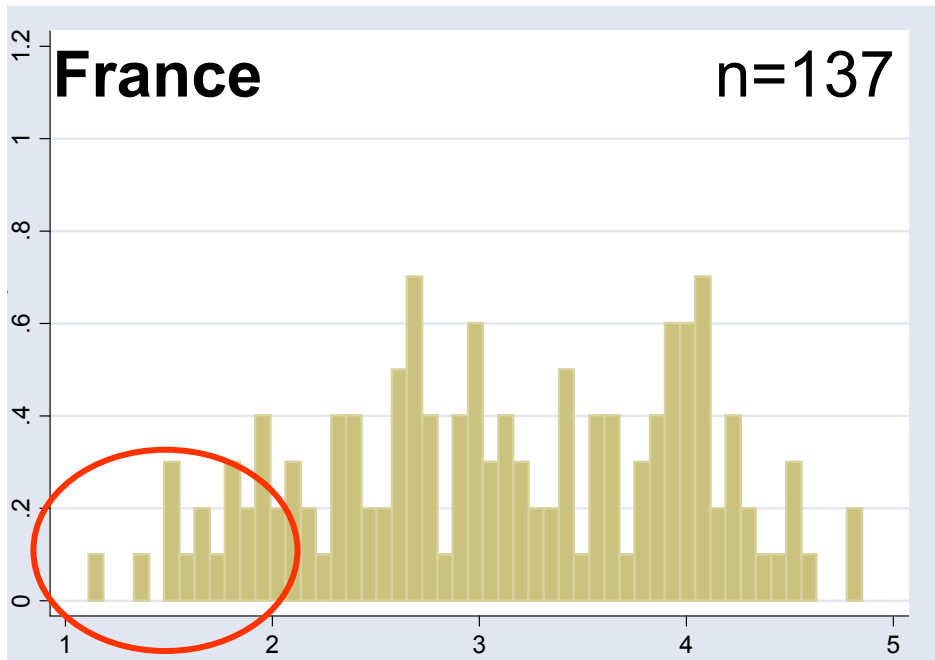
Difference in labour productivity growth: 'High TFP gap' industries shaded



Organisational innovation

- Organisational, managerial.
 - Example of Toyota and Lean manufacturing.
 - Wal-Mart and Lean Retailing?
- May be more important than pure technological change
- Lots of anecdotal evidence from case studies and a lot of economic theory on organizations. But hardly any empirical work.
 - Major CEP study on management practices over last 18 months (Bloom and Van Reenen, 2005)
 - 732 firms in US, UK, France and Germany surveyed
 - 18 dimensions of managerial performance: incentives, targets, monitoring and modern manufacturing

FIRM LEVEL AVERAGE MANAGEMENT SCORES



COUNTRY LEVEL MANAGEMENT SCORES*



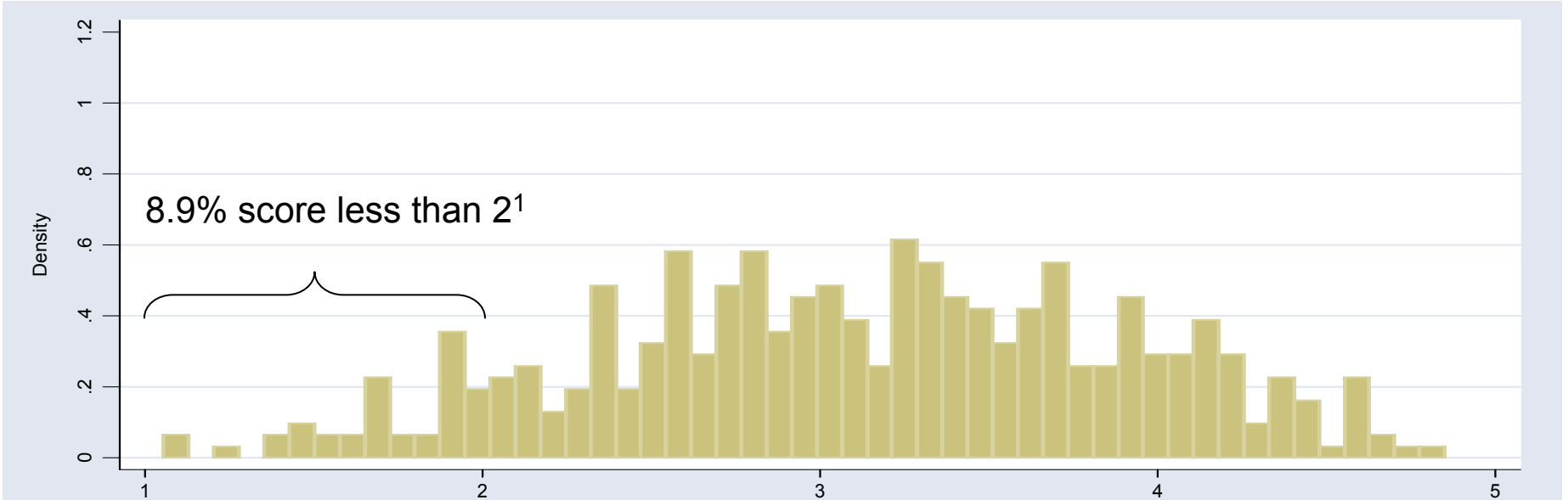
Typical UK managers?

* With controls for size & public/private values are 3.35, 3.27, 3.16 & 3.07 respectively.
Gaps between UK/France and the US significant at the 5% level

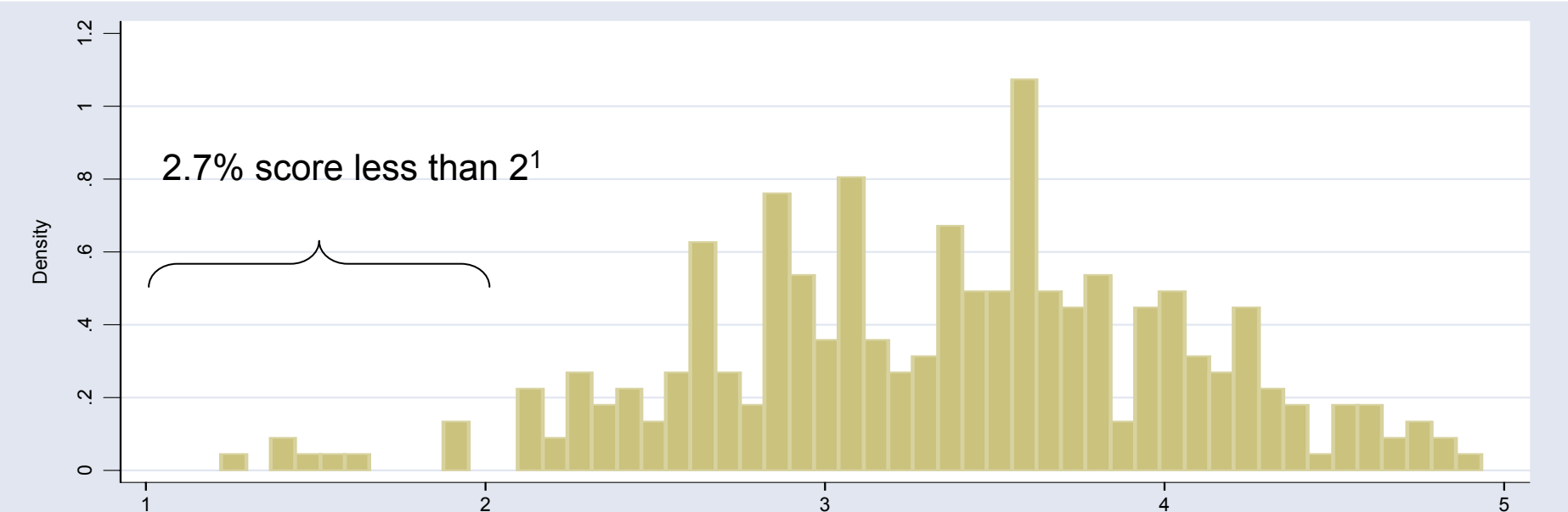
Drivers of innovation

- Basic science, universities and incentives
- Product market structure. Schumpeterian assumptions underlying modern growth theory is that monopoly fosters innovation incentives. Much recent empirical evidence that this is wrong: competition frequently helps innovation.
- Financial markets (firm size issues, venture capital, etc.)
- Ownership (family management and ownership)
- Labour markets
- Intellectual property (Quah)
- Government policies
 - Unlike many areas of economics (e.g. rigorous evaluation of welfare reform, education, tax, etc. a major area of study in last 10 years) relatively few high quality evaluations of innovation and productivity policies
 - One of most studied areas is fiscal incentives for R&D/R&D tax credits. Use this as an example

FEW COMPETITORS AND/OR NO *PRIMO GENITURE* FAMILY FIRMS, N=415



MANY COMPETITORS AND NO *PRIMO GENITURE* FAMILY FIRMS, N=307



¹ **SOCIAL RESPONSIBILITY** defined as a score ≤ 2 . In the whole sample 6.5% of firms are in the tail **PERFORMANCE** 29

R&D tax credits

- Many other countries with R&D tax credits
- UK followed many other countries and adopted in 2000, first for small firms and now for all firms
- Current cost about £430m p.a.
- Good econometric evidence that R&D does react to changes in its tax-price (Hall and Van Reenen, 2000)
- But why no pick-up (even a fall in 2004)?
- – takes about 10 years for most of effect to be felt

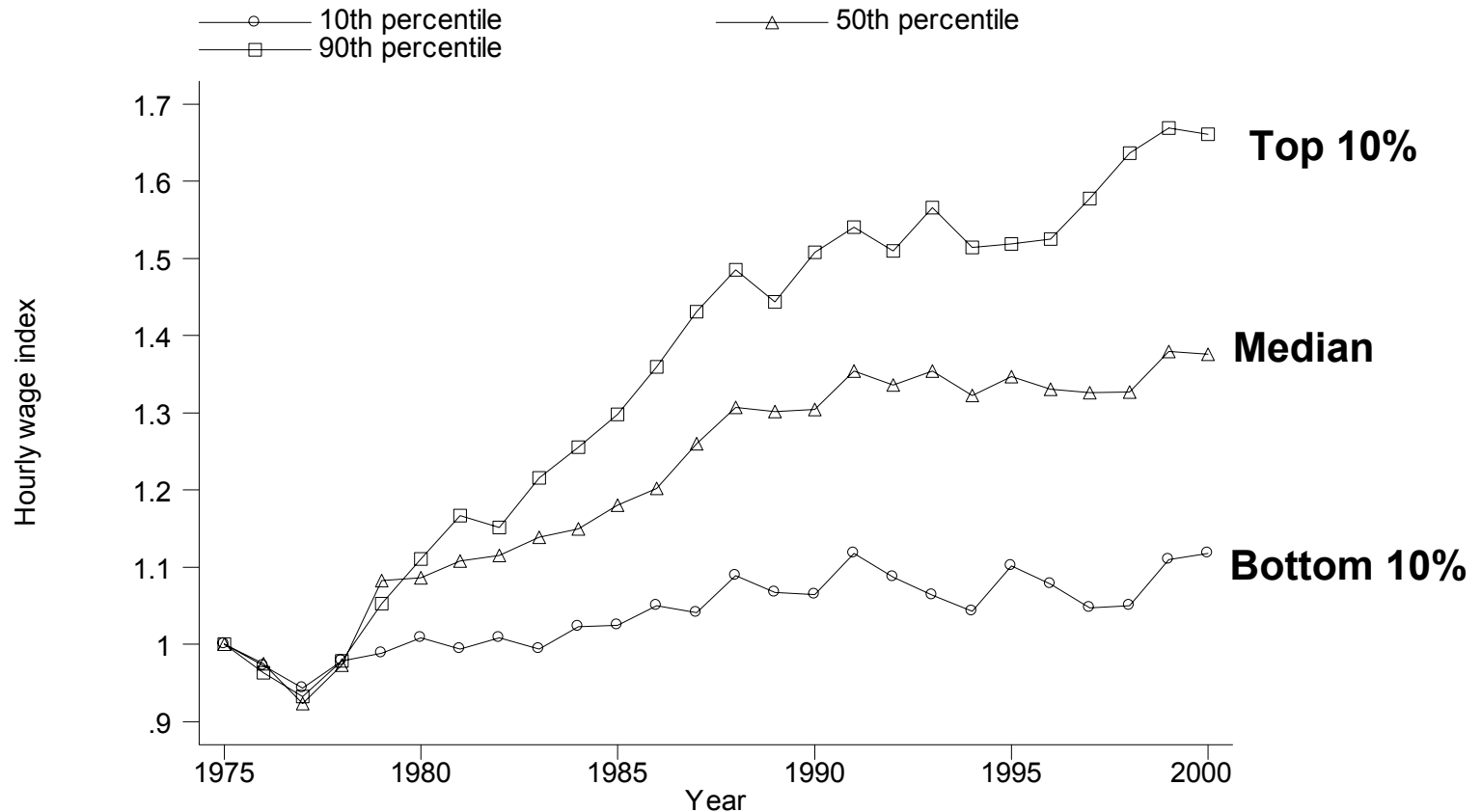
Problems with R&D tax credit

- Slow response – If price falls by 10% R&D only increases by 1% in first year, even though long-run impact about 10% (Bloom, Griffith and Van Reenen)
- Cost - SME credit only £150m started in 2000, large firms in 2002
- Relabelling?
- All R&D subsidies increase wages of (high income) R&D workers

Human Capital policy - Skill biased technical change

- One robust finding is that technical change tends to increase the demand for skilled workers (e.g. Machin and Van Reenen, 1998; Caroli and Van Reenen, 2001)
- Skilled workers better at dealing with uncertainty associated with rapid technical change
- Although supply of skills has increased it has failed to keep up with the demand side. Consequently there has been a tendency for inequality to rise over the last 25 years (particularly in US and UK). See over
- Skill biased technical change seen in many countries all over the world – not just the richer countries
- Implication is that increasing the supply of skills could be a win-win “innovation policy”
 - Increase diffusion of new technologies
 - Reduce inequality
- Still uncertainty over what type of skills. Evidence that some non-routine manual skills are safe (e.g. cleaners) whereas some routine non-manual skills are being replaced (clerks)

Male Real Hourly Wage Inequality, (UK Family Expenditure Survey)



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Some things we don't know

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What Don't we know? Policy focus

- Changing a country around to improve its innovation and productivity
 - Human capital
 - Subsidies for R&D and skills not agriculture & incumbent national champions (Sapir Report)
 - Increasing product market competition especially by removing barriers to entry and exit
 - Regulation of labour markets
 - Institutions often the root cause and these are hard to change: legal origin, colonial patterns
 - Sequencing of reforms (e.g. Europe)
- Policy evaluation of innovation

What don't we know? Research agenda

- Clusters – Real Agglomeration or sorting, unobserved variables?
- Need to understand internal structure of firms – organisation and management talked about, but little hard empirical evidence
- IT impact on productivity – is it really organisation/management? Need for interaction between researchers and people “on the coalface”
- Service sector – still an over-focus on manufacturing because this is easier to get data on.
- In particular, Public sector productivity and IT (CEP work on IT in schools by McNally and Machin, 2005 a start)
- Role of multinational organisations in spreading productivity internationally
- Types of skills appropriate for knowledge economy
- We know a lot more about consequences than causes of innovation

Conclusions

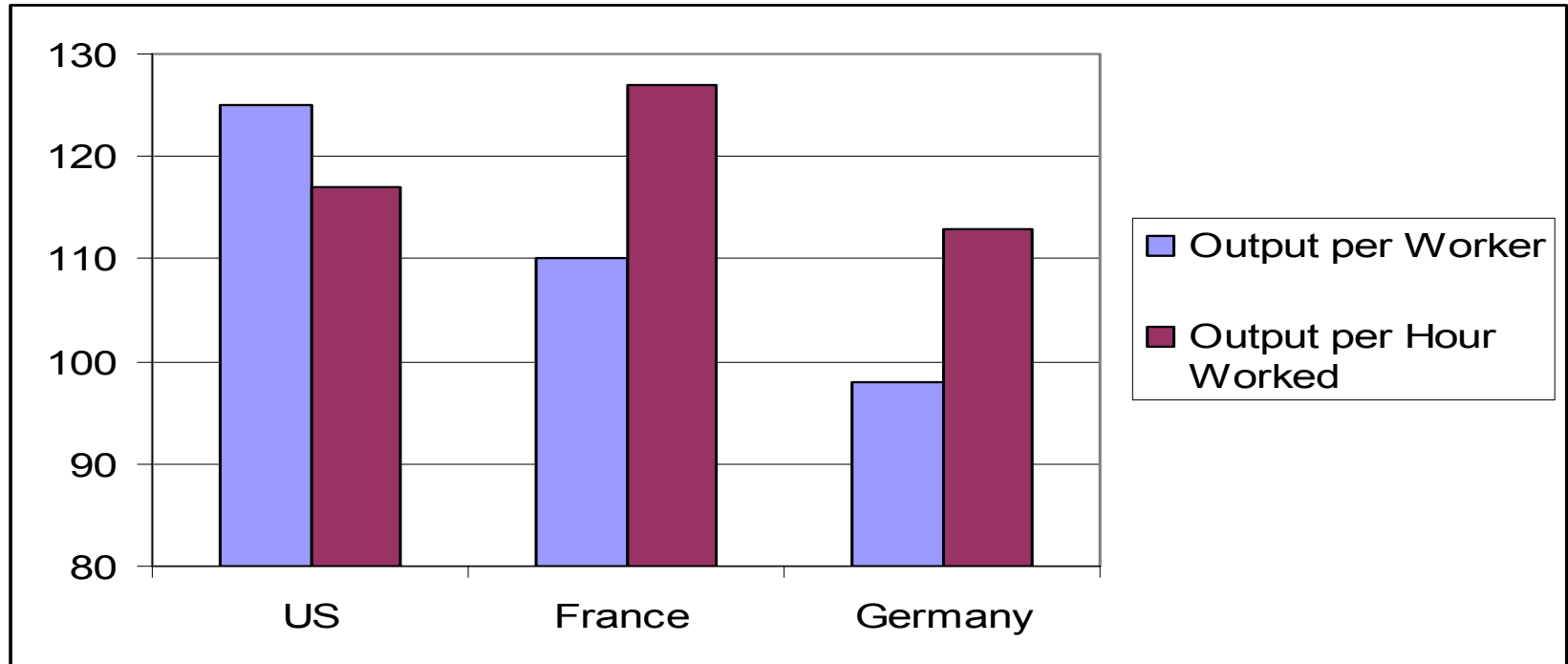
- Is the glass half full or half empty?
- Rapid improvement in computing power have enabled the gathering, codification and interrogation of large scale databases. Rapid accumulations of many findings at the micro-economic level
 - Innovation and performance
 - IT and productivity
 - Technology and skills
- But puzzles (a) massive dispersion of performance, (b) long-standing differences (e.g. UK-US), (c) recent divergence of US and EU ending convergence process
- Lots of interesting work to do!

Further reading

- Easy introduction to the debates (on cep website)
- http://cep.lse.ac.uk/people/vanreenen/papers/productivity_mindthegap.pdf
- Griffith, Redding and Van Reenen (2005):
<http://cep.lse.ac.uk/pubs/download/dp0509.pdf>;
<http://cep.lse.ac.uk/pubs/download/dp0458.pdf>
- Nickell and Van Reenen
- Bloom, Sadun and Van Reenen (2005)
- Bloom and Van Reenen (2005)
- Griffith, Harrison and Van Reenen (2005)
- Blundell, Griffith and Van Reenen (1999)
- Bloom et al (2005)
- Hall and Van Reenen (2000)

Back up slides

Labour Productivity lower in UK relative to Other countries (UK=100)



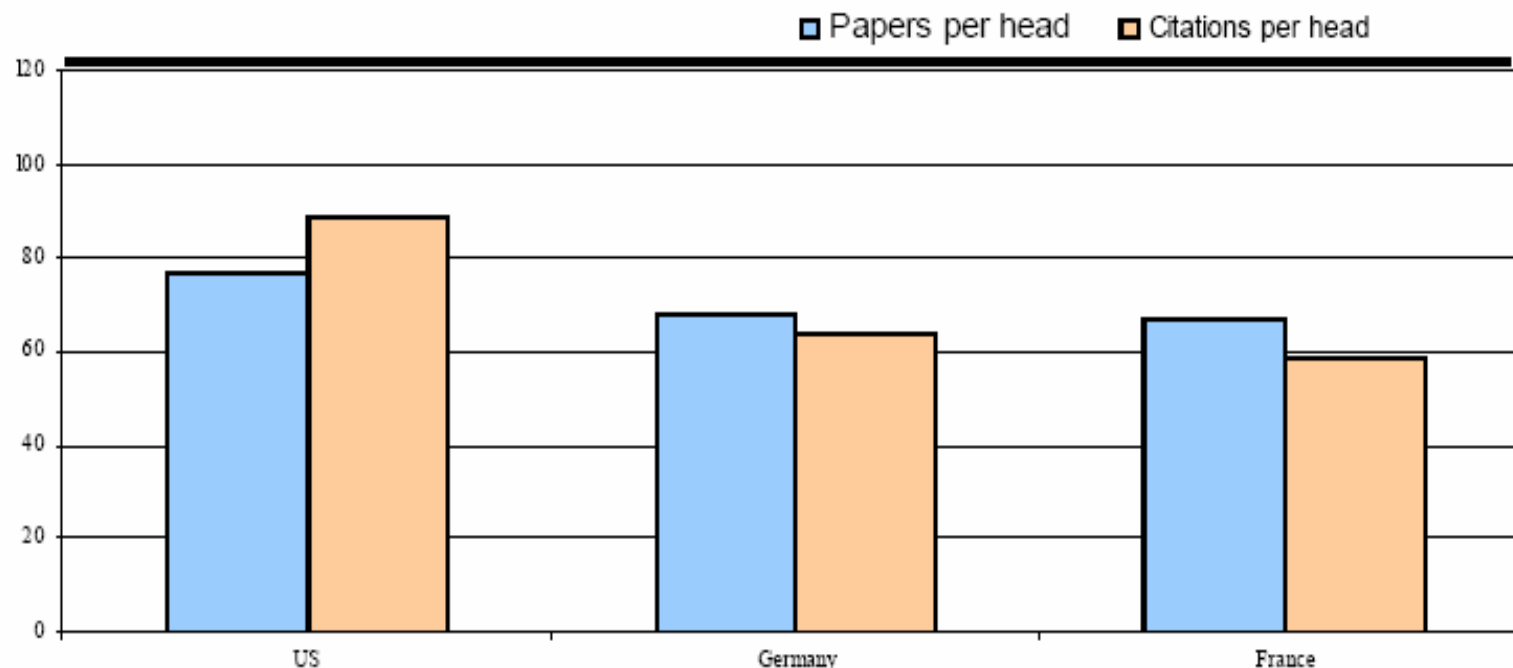
Source: ONS (2005)

What are the “causes” of low UK Productivity?

1. **Technological Innovation**
2. Management
3. Human capital
4. Others (infrastructure, public sector productivity, investment, regional policy, IT, etc.)

UK does well in elite science

****More papers per head and citations per head than main competitors**

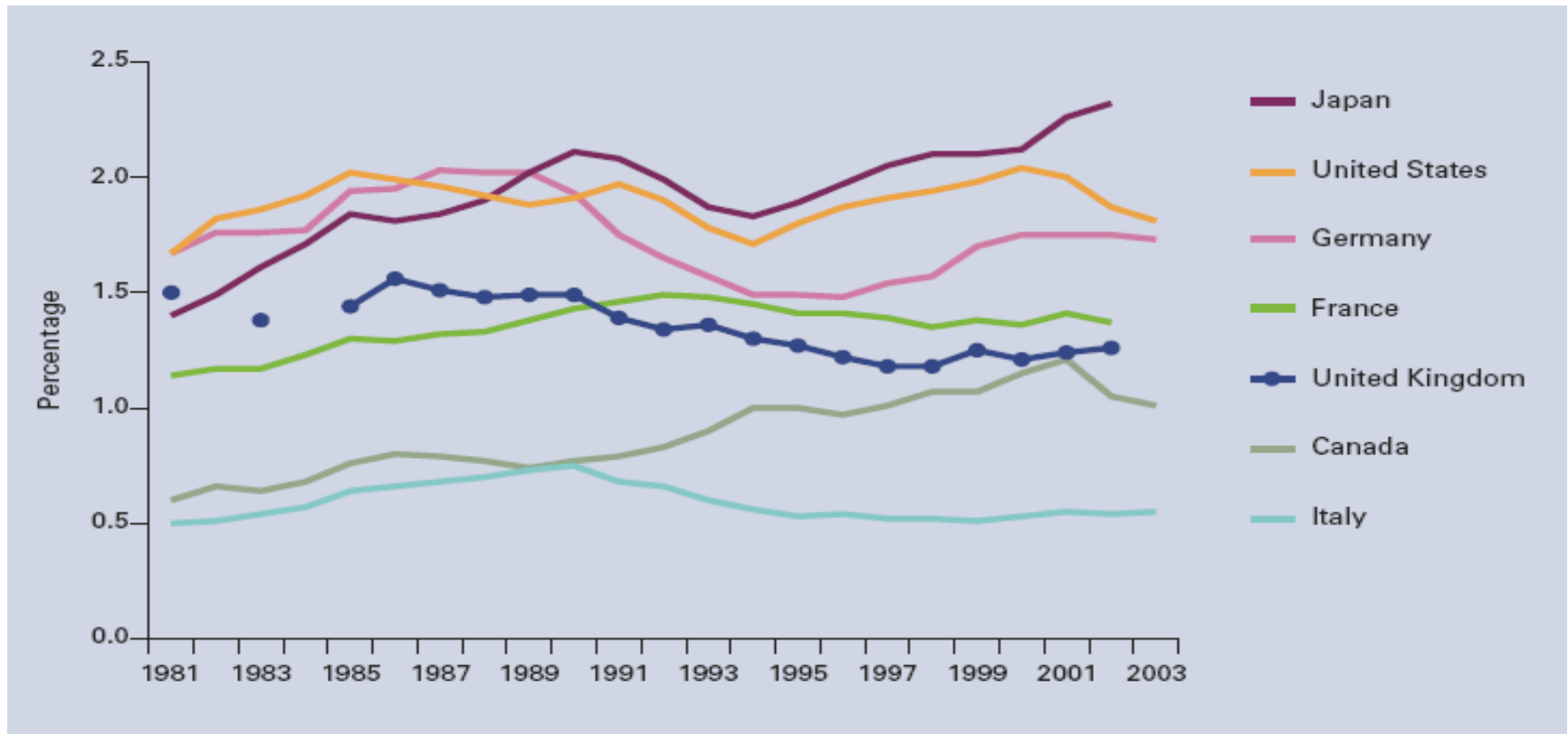


Papers and citations per head (UK=100), average over 1998-2003

Source: Evidence Ltd. Thomson ISI (2004)

But not good at translating the base into commercial innovation...

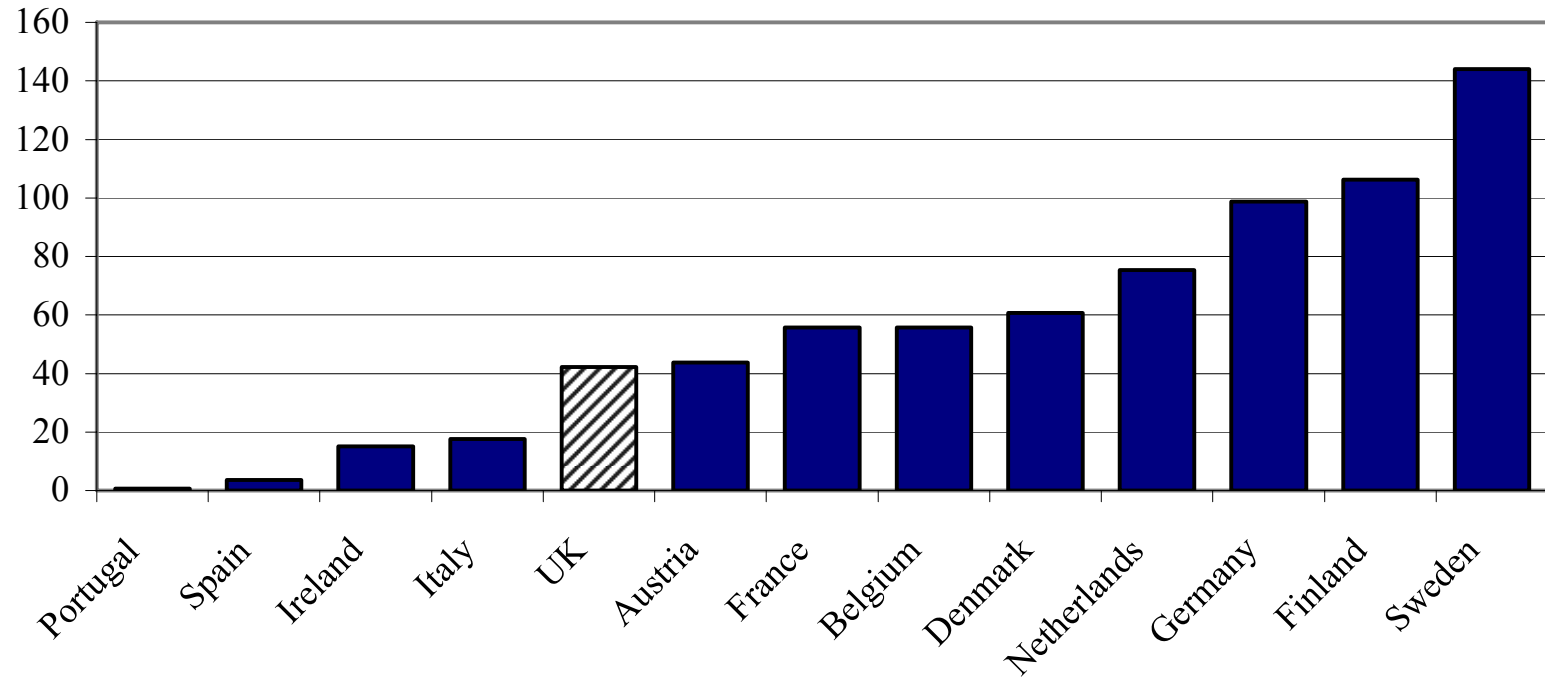
Business Enterprise R&D as a proportion of GDP



UK major patents per person

Per working-age
population,
per million

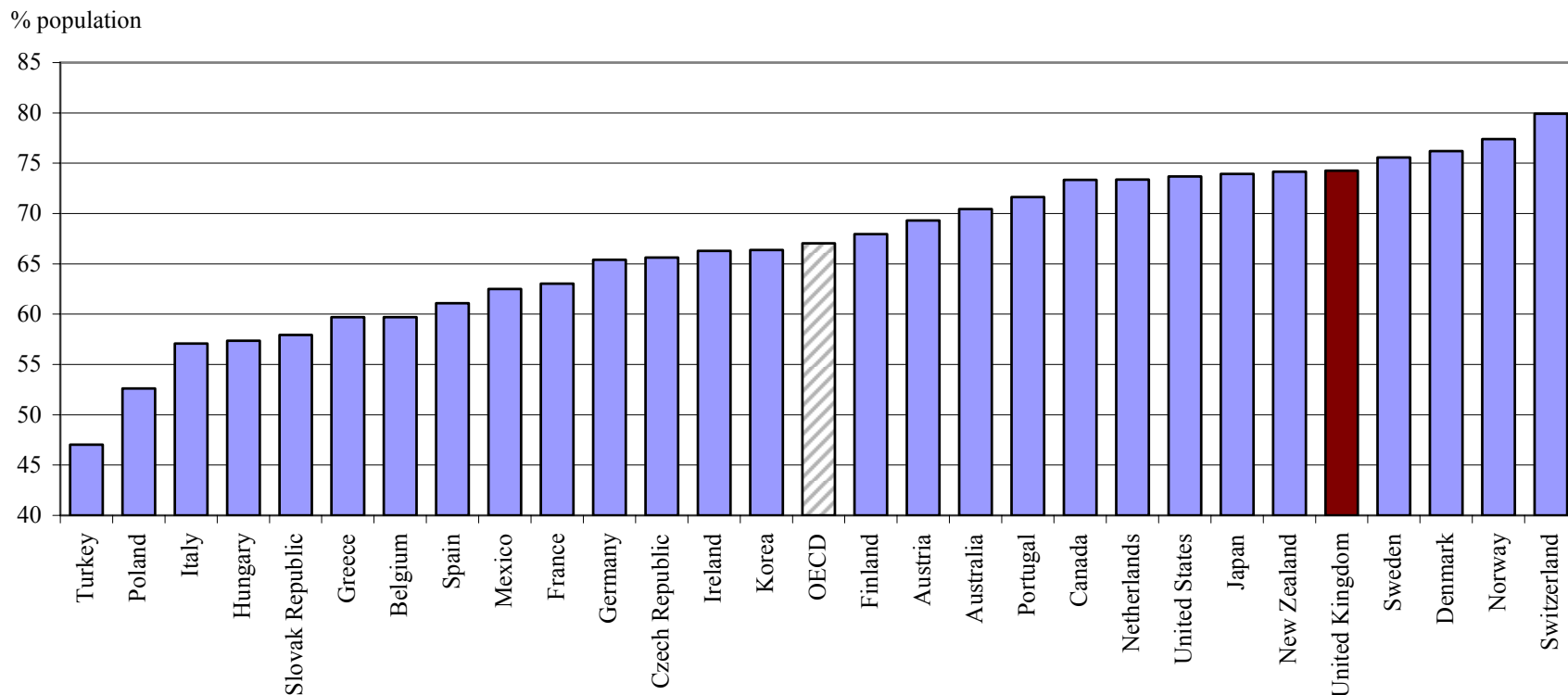
Triadic patents



Note: Data for 1995-1999.

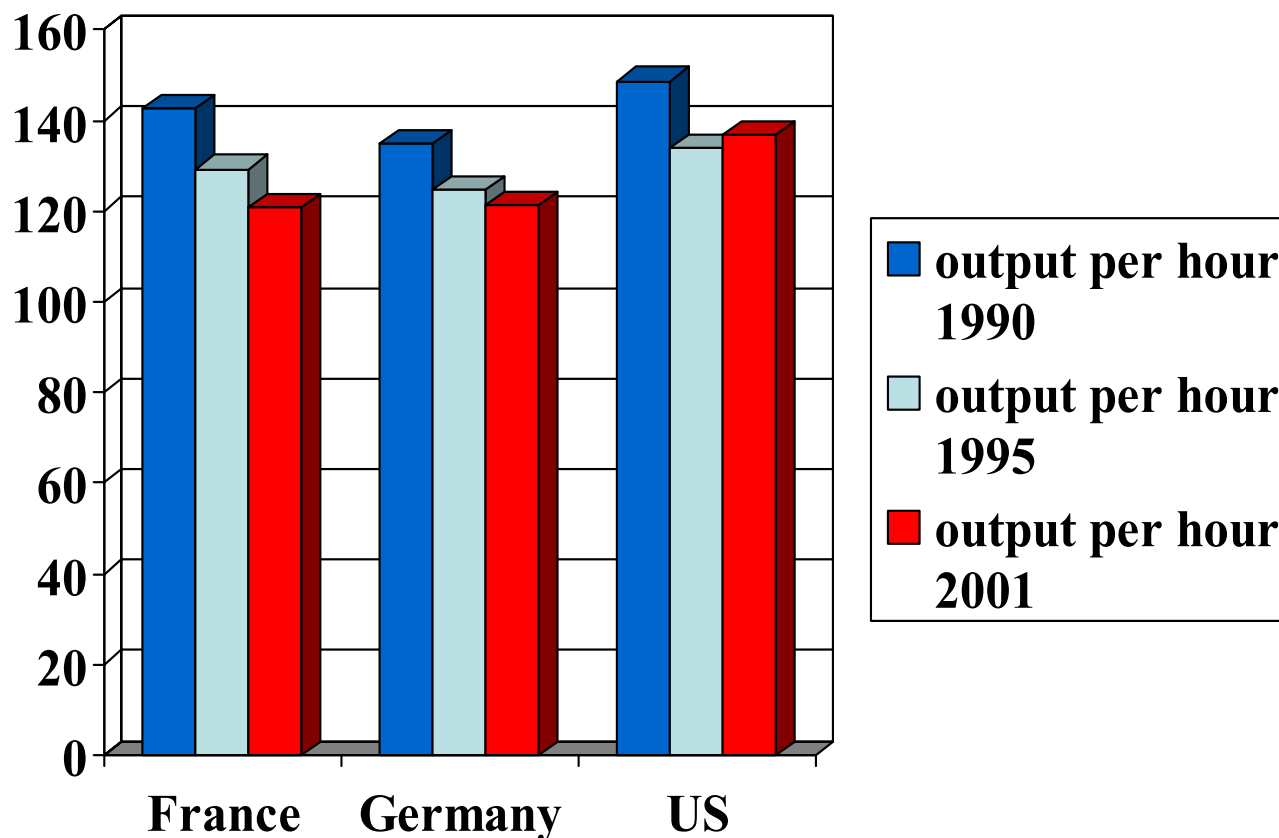
2.2 UK (and USA) have high proportion of population in work

Employment Rate, 2003



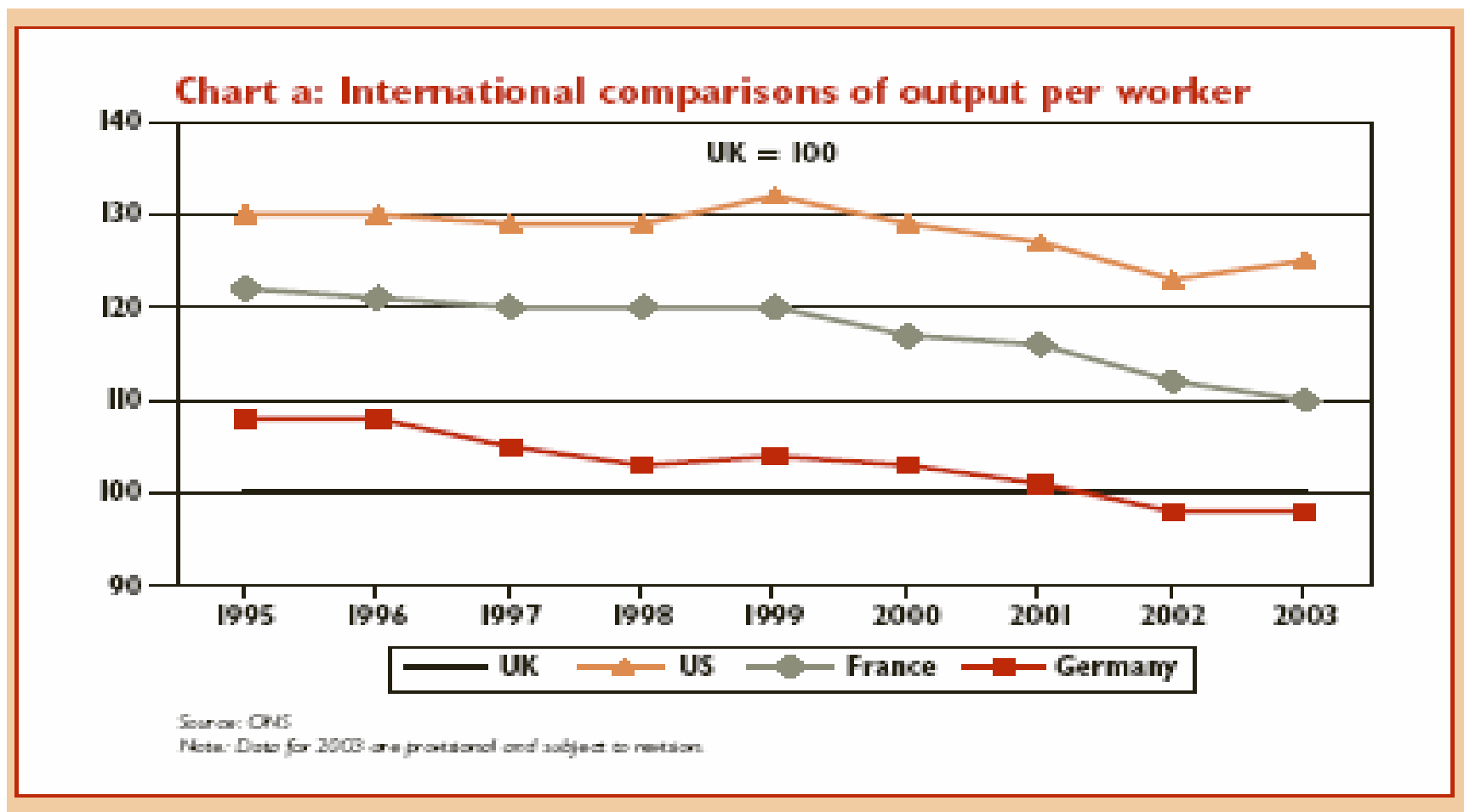
Source: OECD Labour Force Statistics.

Productivity Gap, 1990-2001, Market Economy (UK=100)



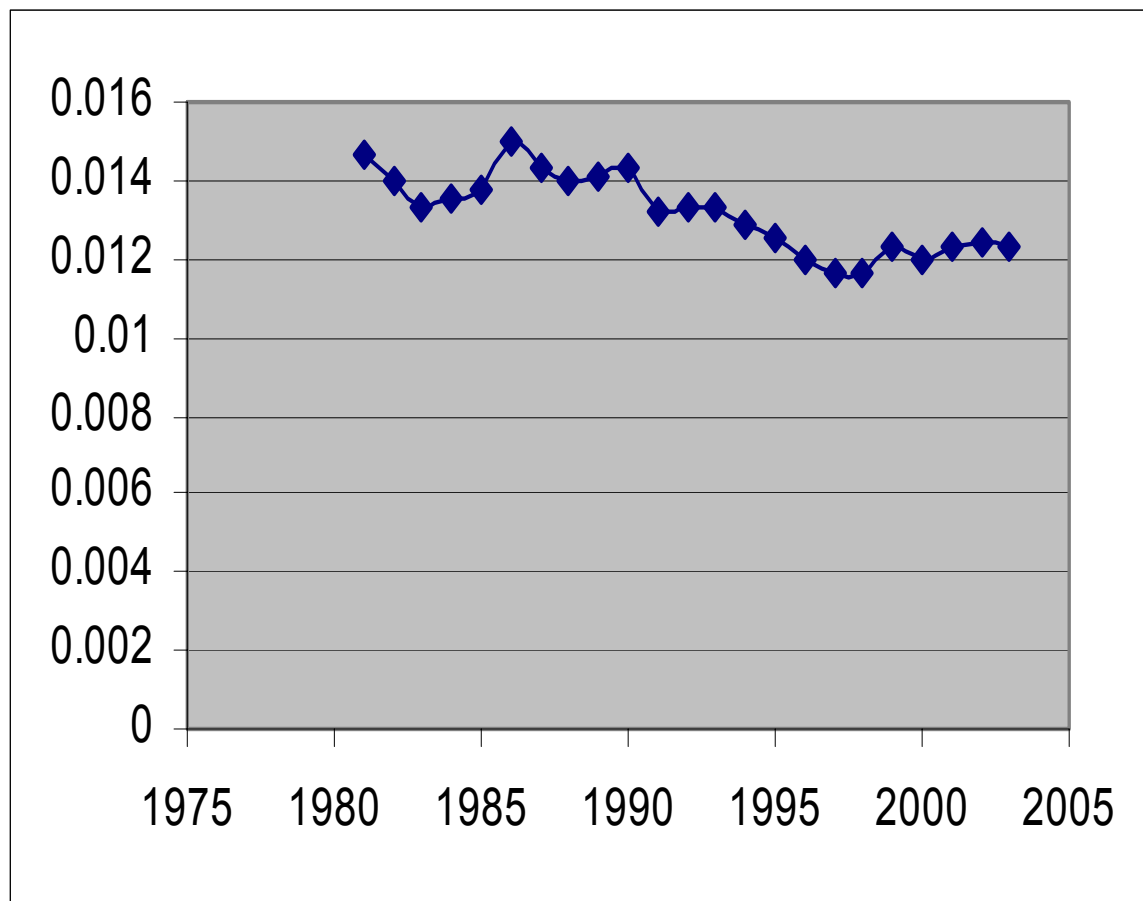
Source: Broadberry and O'Mahony (2005)

Changes over time in output per worker



Source: Budget 2005

Business Enterprise R&D/GDP, 1981-2003



Source: ONS (2005)

Despite this, still read popular nonsense such as:

“Money doesn’t buy results. There is no relationship between R&D spending and the primary measures of economic or corporate success, such as growth, enterprise profitability, and shareholder return” (<http://www.strategy-business.com/resilience/rr00027>

• Joris Beerens, Thomas Goldbrunner, Richard Hauser, and Georg List, “Mastering the Innovation Challenge: Results of the Booz Allen Hamilton European Innovation Survey,” Booz Allen Hamilton white paper, www.boozallen.com, December 2005

- **Nonsense because:**
- Economic success not well measured just by profits, etc. – profits can go up at the expense of consumer welfare (e.g. a cartel). Productivity better
- Confuses looking at a relationship in one year with following firms over time to see if past R&D leads to future success
- Ignores huge academic literature which *does* find robust relationship between R&D and firm performance