The UK's productivity problem – *the role of innovation and R&D*

Richard Jones

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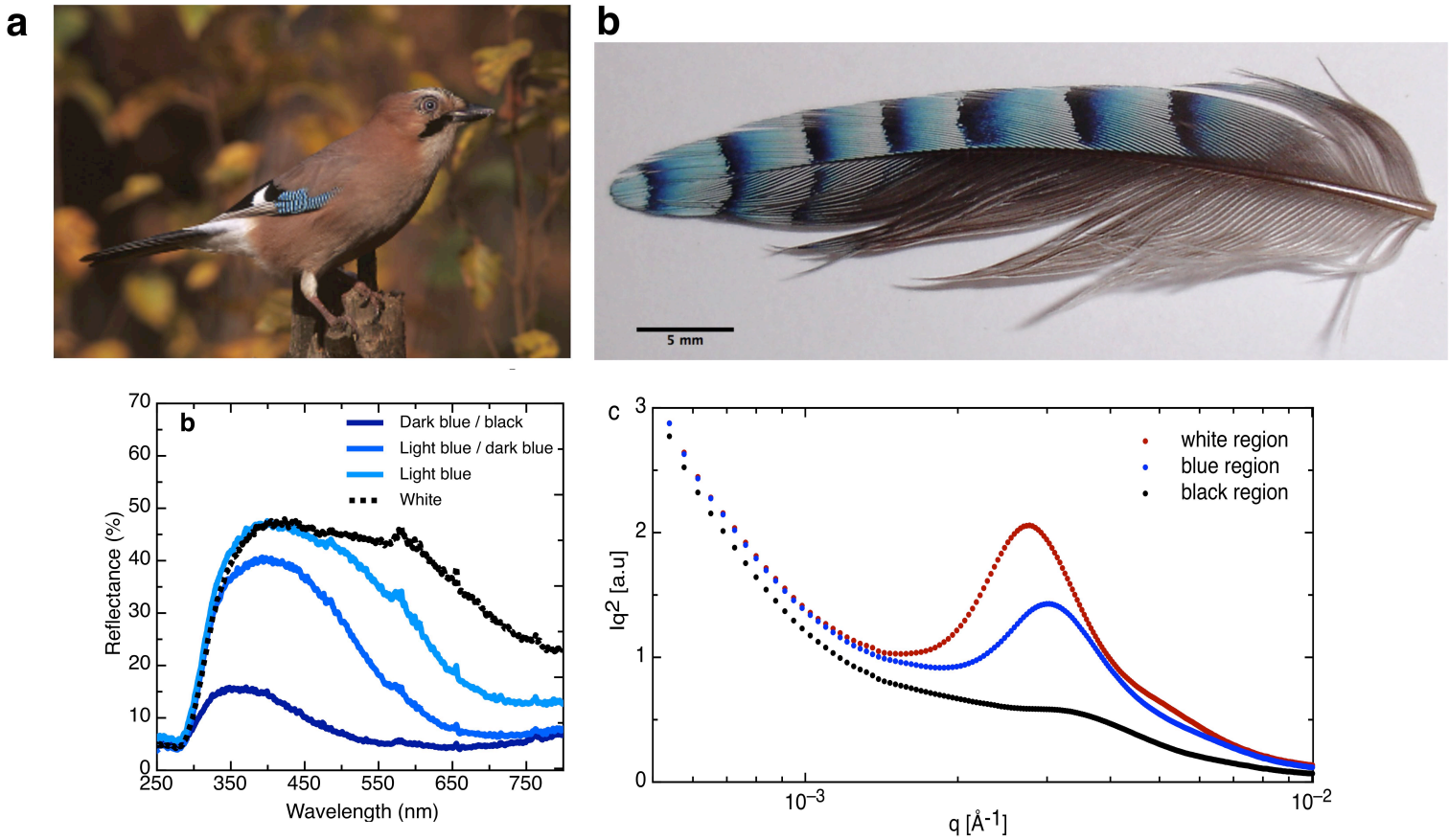
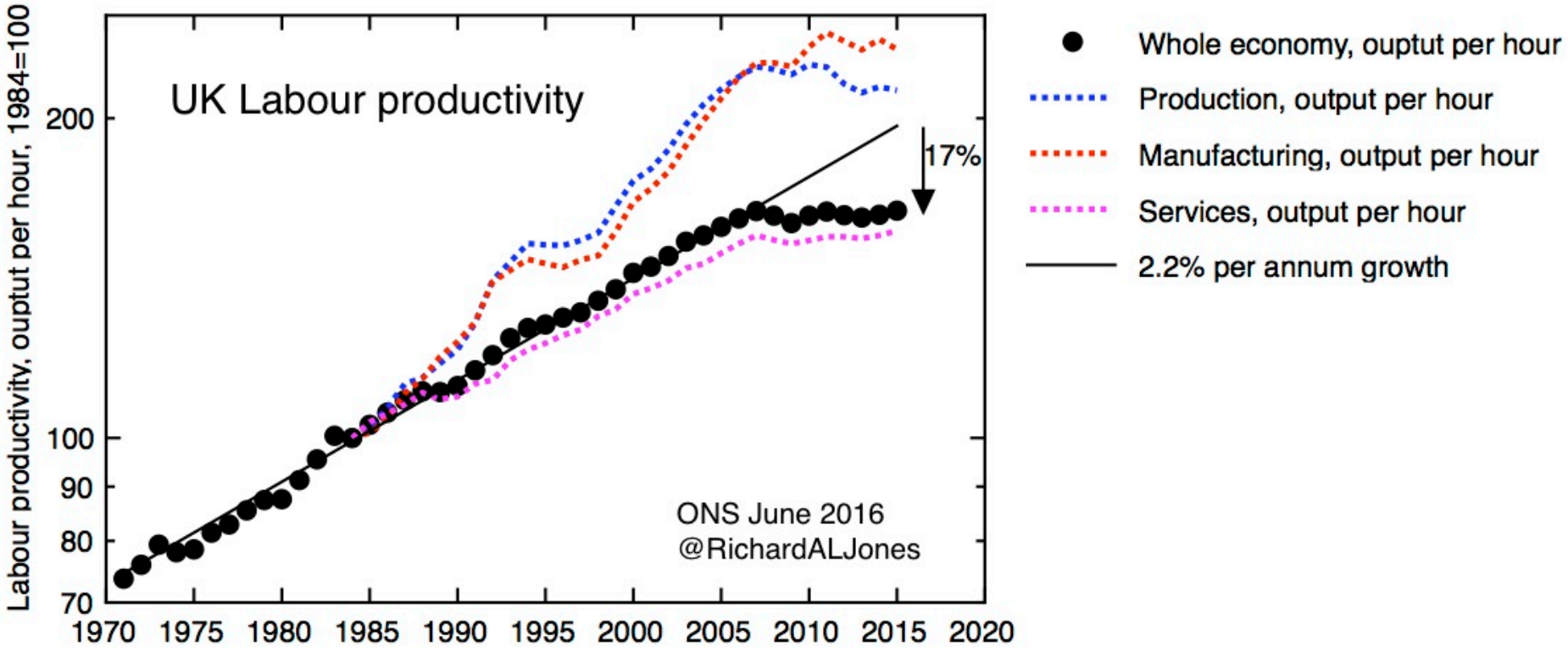
What I do for a living: experimental soft matter physics

Structural colour in birds and beetles

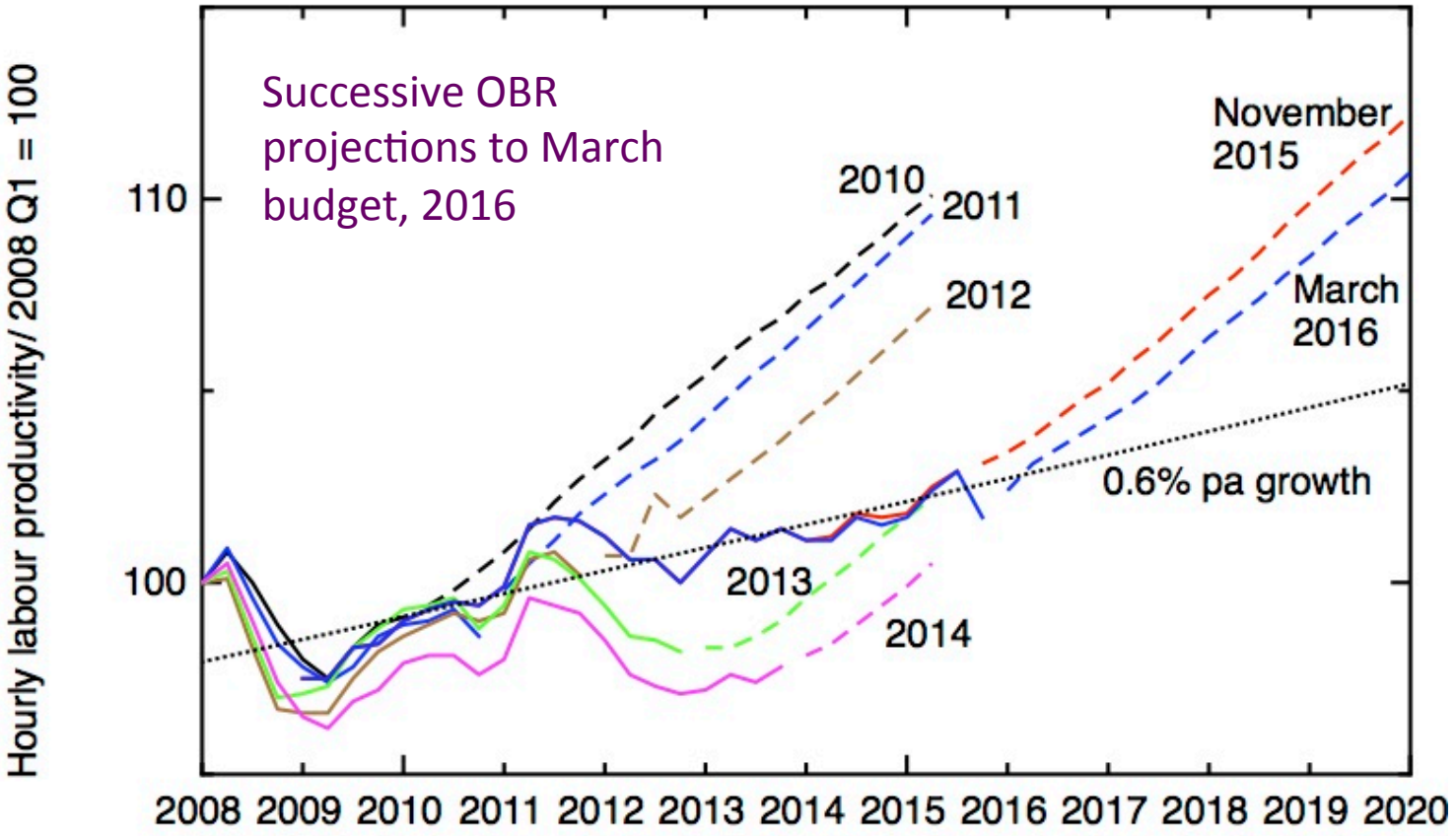


Some biological structural colour arises from intracellular spinodal phase separation – understanding the mechanism means we can copy it in synthetic systems

What I'm here to talk about: UK's productivity problem



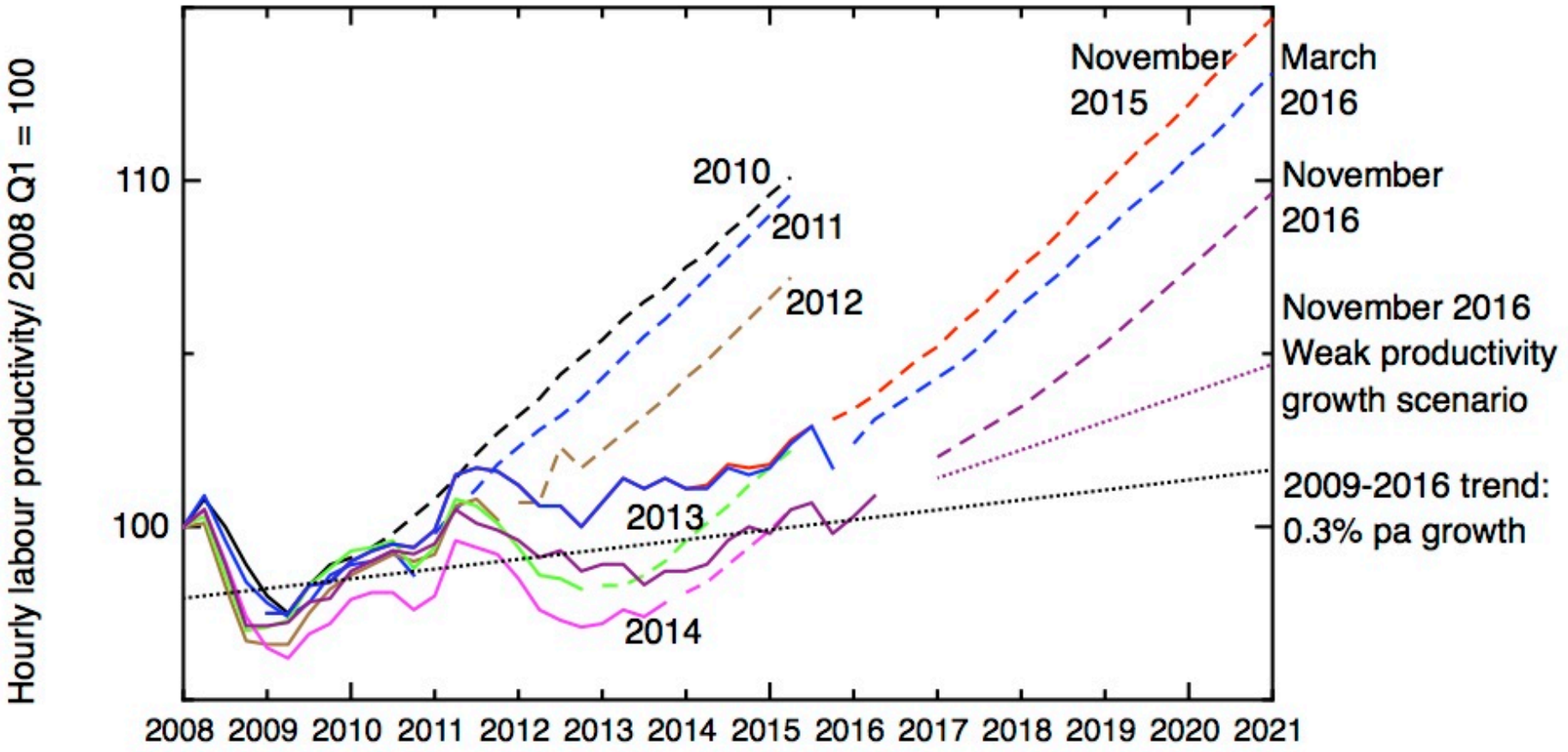
Waiting for the upturn – March 2016



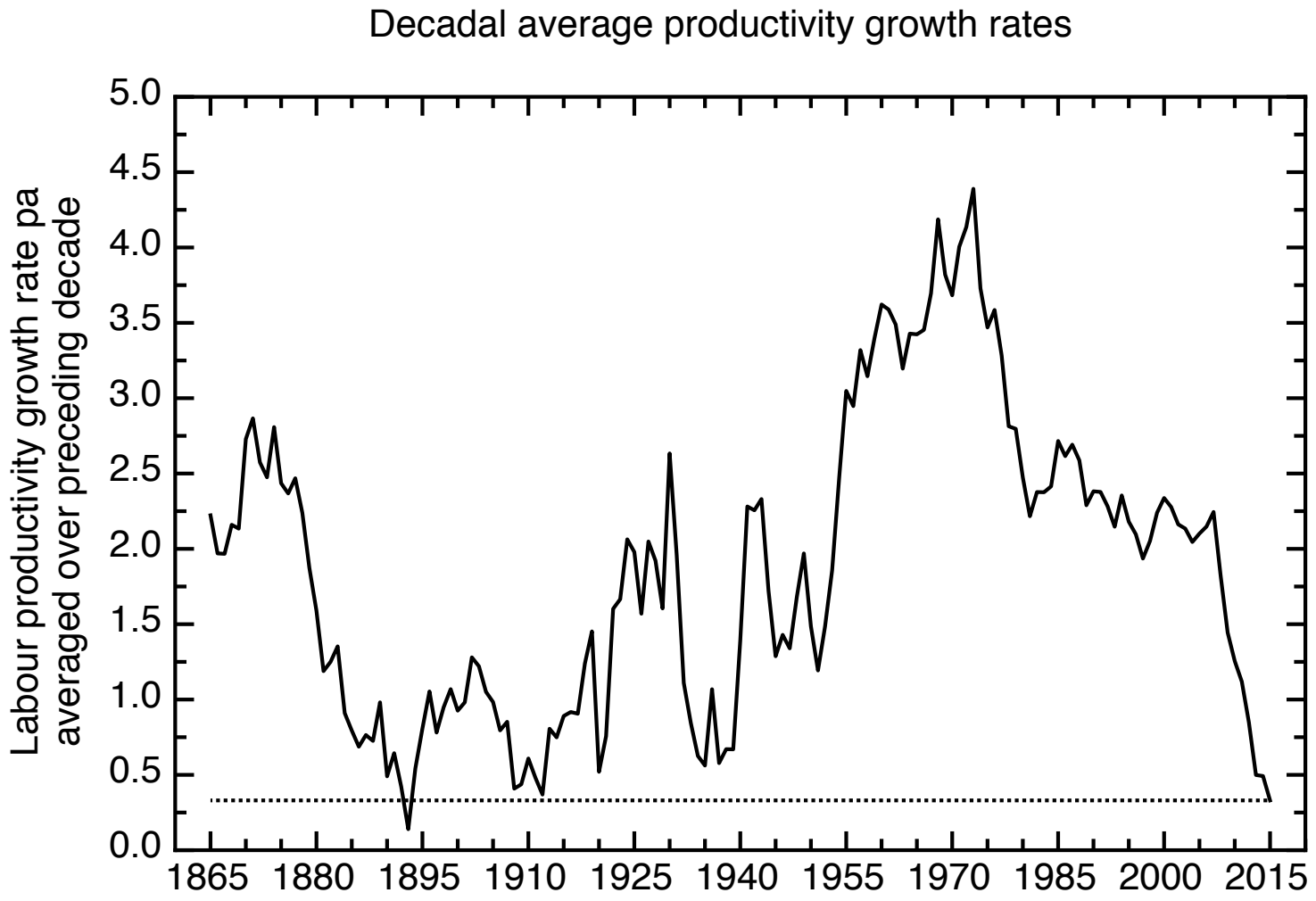
↕ Extra £55 billion on the deficit

Sources: Oct 2015 OBR Forecast Evaluation Report, March 2016 OBR Economic and Fiscal Outlook.

Waiting for the upturn – Nov 2016



The historical context



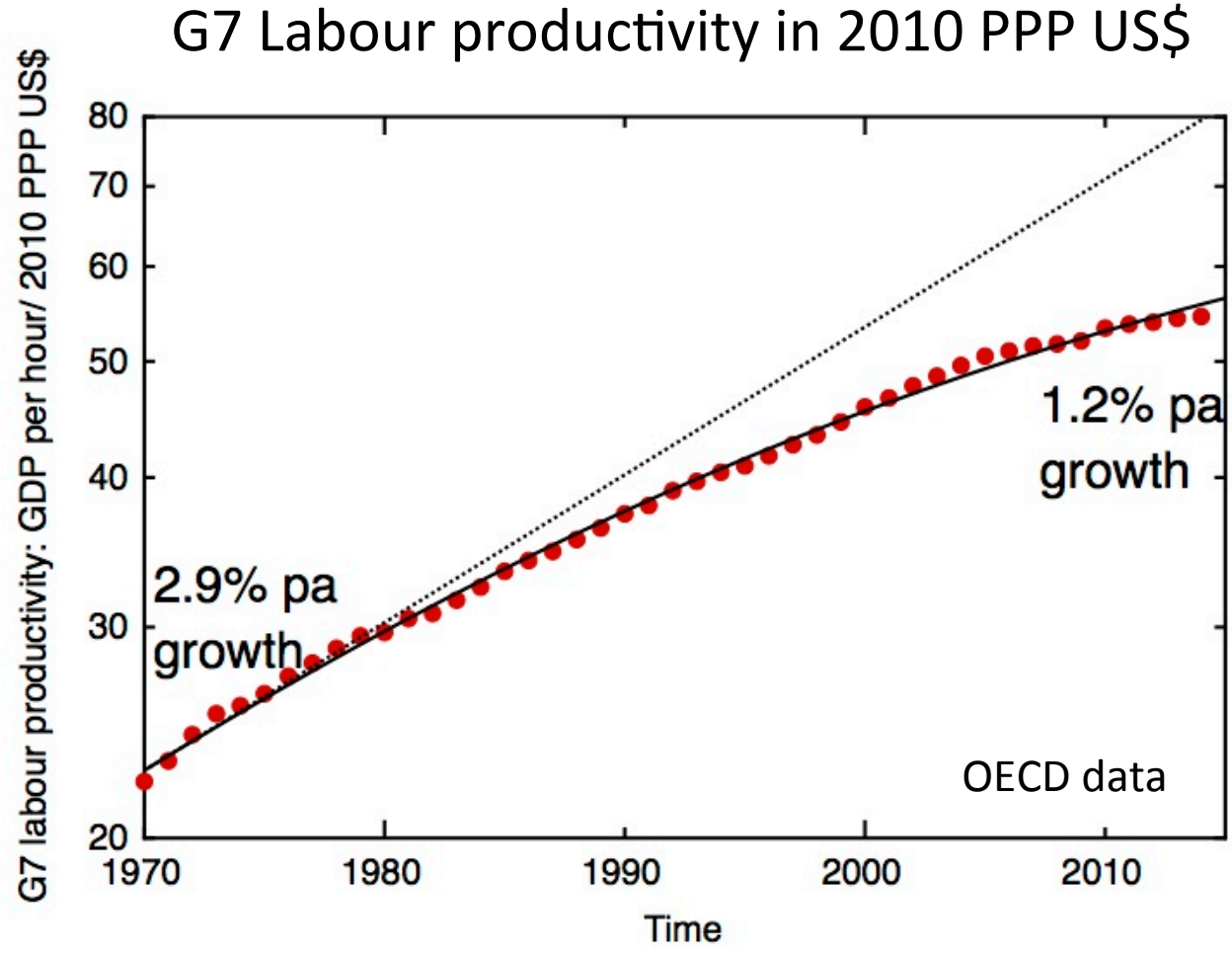
Worse than: 2 World Wars and a depression

Data from Hills, S, Thomas, R and Dimsdale, N (2015) "Three Centuries of Data – Version 2.3", Bank of England.

A phenomenon on this scale doesn't happen for no reason(s)

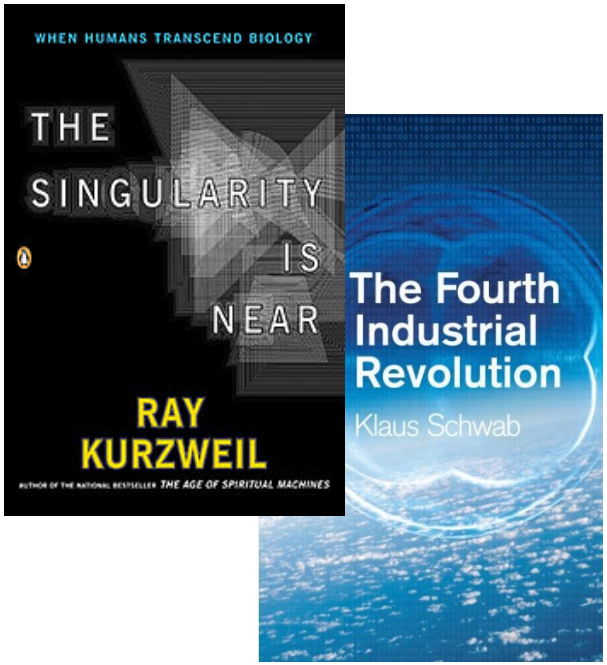
- How much of this is a UK problem, how much part of a bigger global problem?
- What big changes have happened to the UK economy over the last couple of decades?

Productivity growth is slowing throughout the developed world

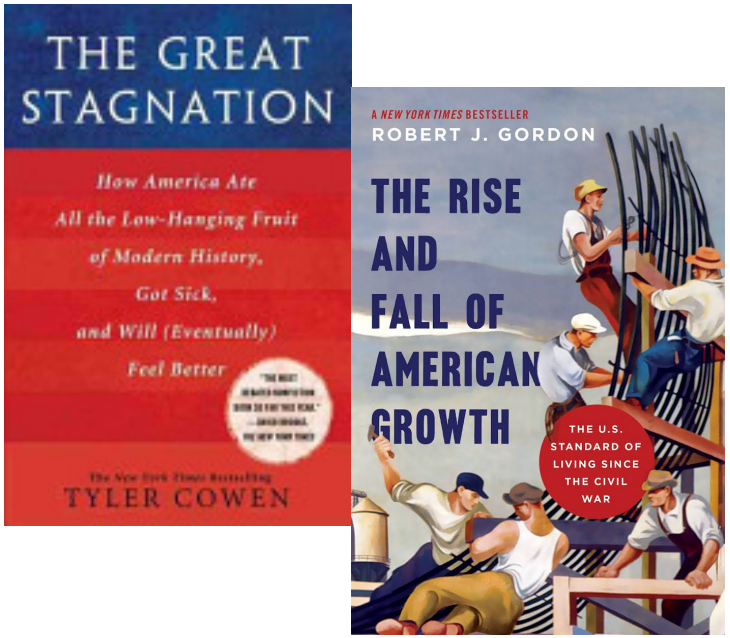


Accelerating change… or innovation stagnation?

Two contradictory narratives about innovation:



- Technological innovation is accelerating
- The pace of innovation is beyond society's ability to control it



- Technological innovation is slowing down
- The pace of innovation is insufficient to save us from secular stagnation

Resolving the paradox

- Mismeasurement
  - GDP doesn't capture the full value of technological improvements
    - Certainly true…
    - But is it obviously truer now than in 1920 or 1950?
- Misconception of technology as a single thing, with a single rate of progress
  - *"We wanted flying cars, instead we got 140 characters."* Peter Thiel
  - Different realms of innovation progress at different rates
    - The digital realm
    - The material realm
    - The biological realm

What you need for innovation in the digital realm

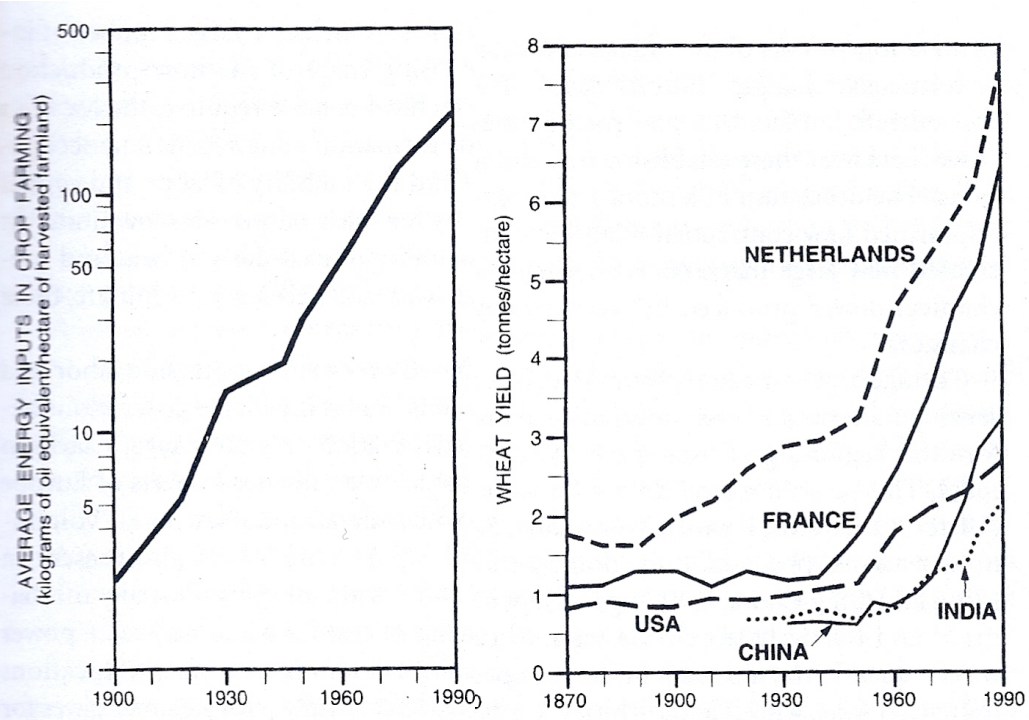
- *"At one point the entire early Twitter service was running on Glass' laptop. 'An IBM Thinkpad,' Glass says, 'Using a Verizon wireless card.'"**
- Creativity, a handful of engineers and some low-cost hardware…
- …and a huge pre-existing material base of hardware and software, developed in decades of public and private research and development

*From "The Real History of Twitter", Nicholas Carson, Business Insider 2011

Material realm

- Big advances in chemicals, materials, energy, electronics need sustained, long-term investment of capital and people – R&D
- From 1871 – 1991, motivated as much by state power as economic growth

Haber-Bosch process

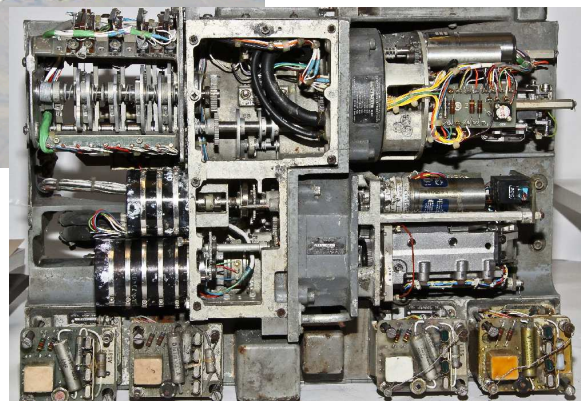


1900 to 1990 saw a 30% increase in cultivated land, but energy inputs per hectare – from artificial fertilizers and mechanical farming implements - increased more than *eightyfold*. The result was big increases in yield per hectare.

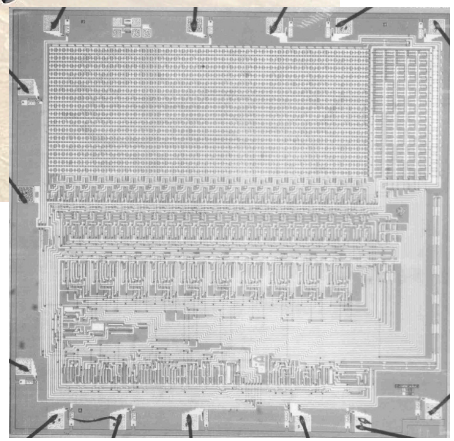
- Mass use of artificial fertiliser possible via Haber-Bosch process, developed 1909-1918
  - $100m 1919 prices, $1 billion current money, $19 billion as share of economy,
  - half from German government

From *Energy in World History*, Vaclav Smil

First microprocessors - 1970



Electromechanical flight control computer for F4 Phantom - 1960

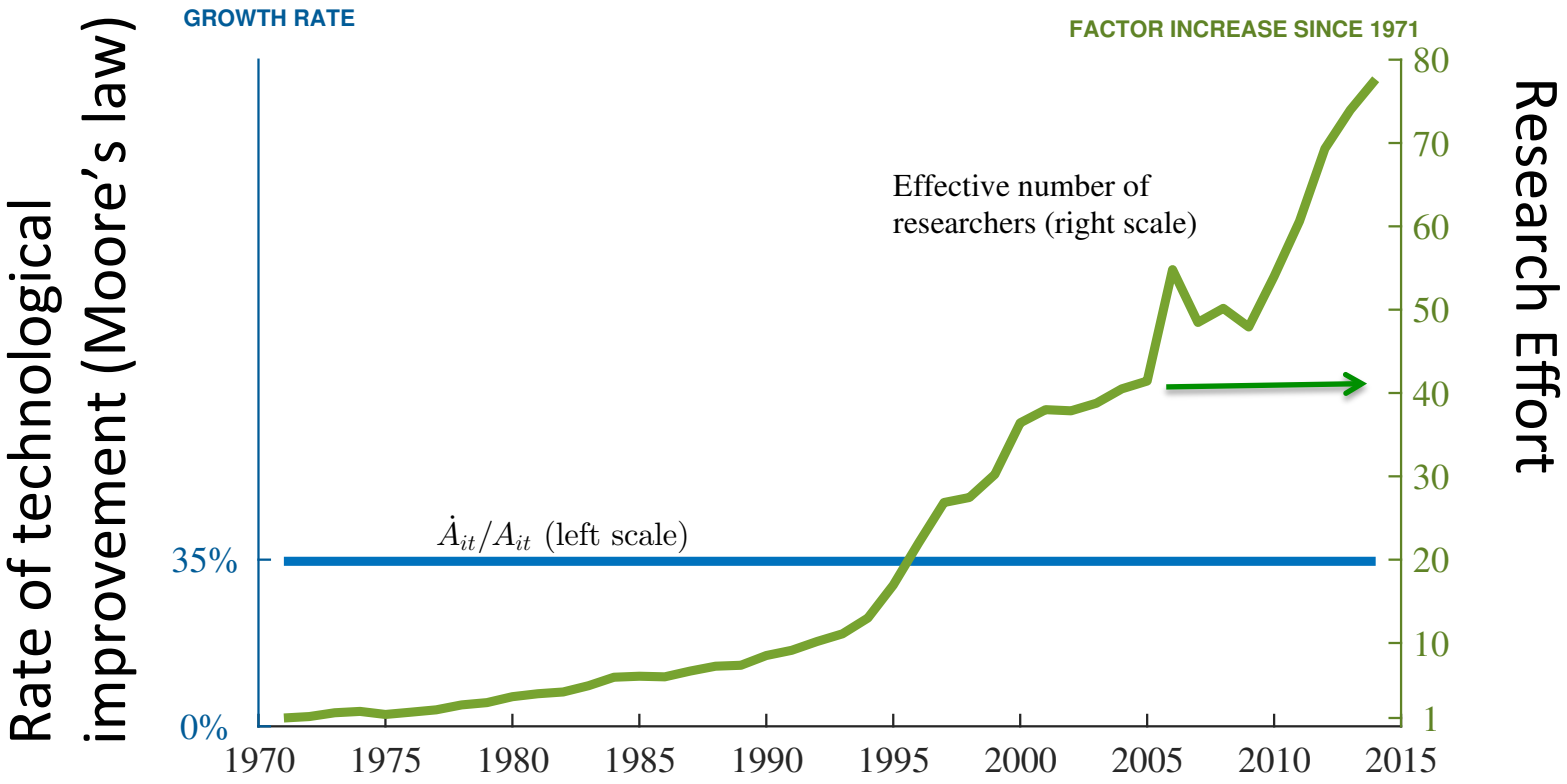


MP944 – microprocessor-based flight control computer for F14 Tomcat - 1970

Ray Holt: http://www.firstmicroprocessor.com

Diminishing returns in the semiconductor industry

Figure 4: Data on Moore's Law

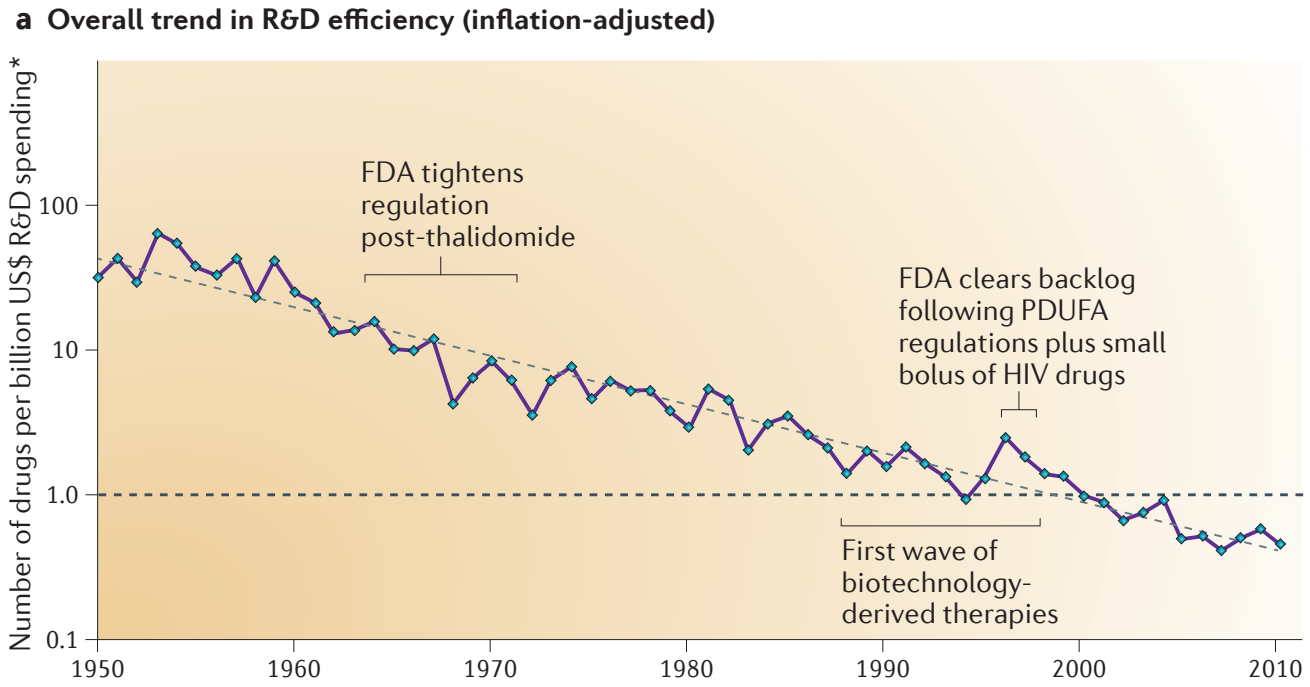


Research effort = total R&D expenditure in semiconductor industry deflated by researcher salaries

From: *Are Ideas Getting Harder to Find?*
Bloom, Jones, van Reenan, Webb, preprint 2017
http://www-leland.stanford.edu/~chadj/IdeaPF.pdf

Innovation in the biological realm

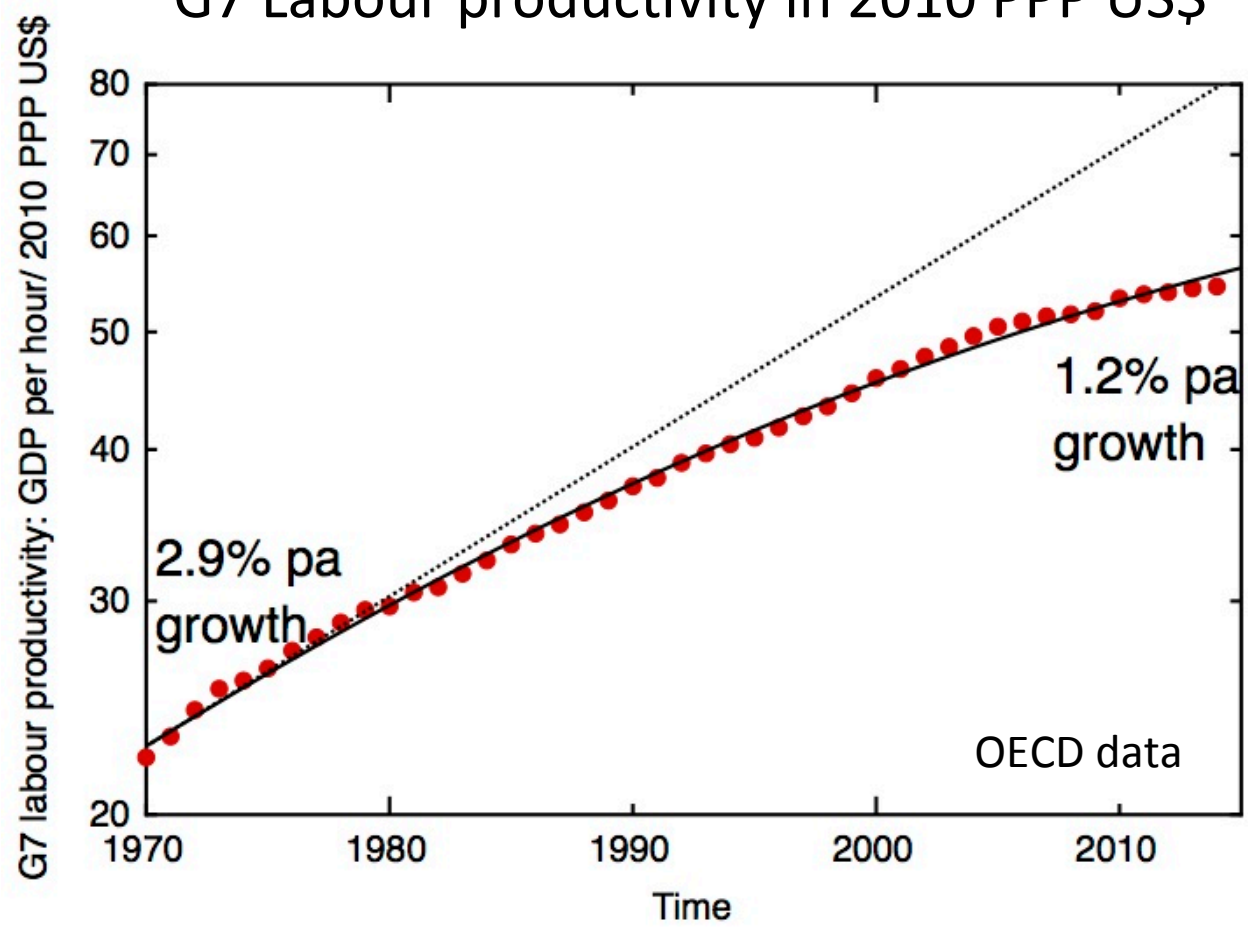
- Organisms have agency of their own
- In some important areas, innovation is slowing down and becoming unaffordable



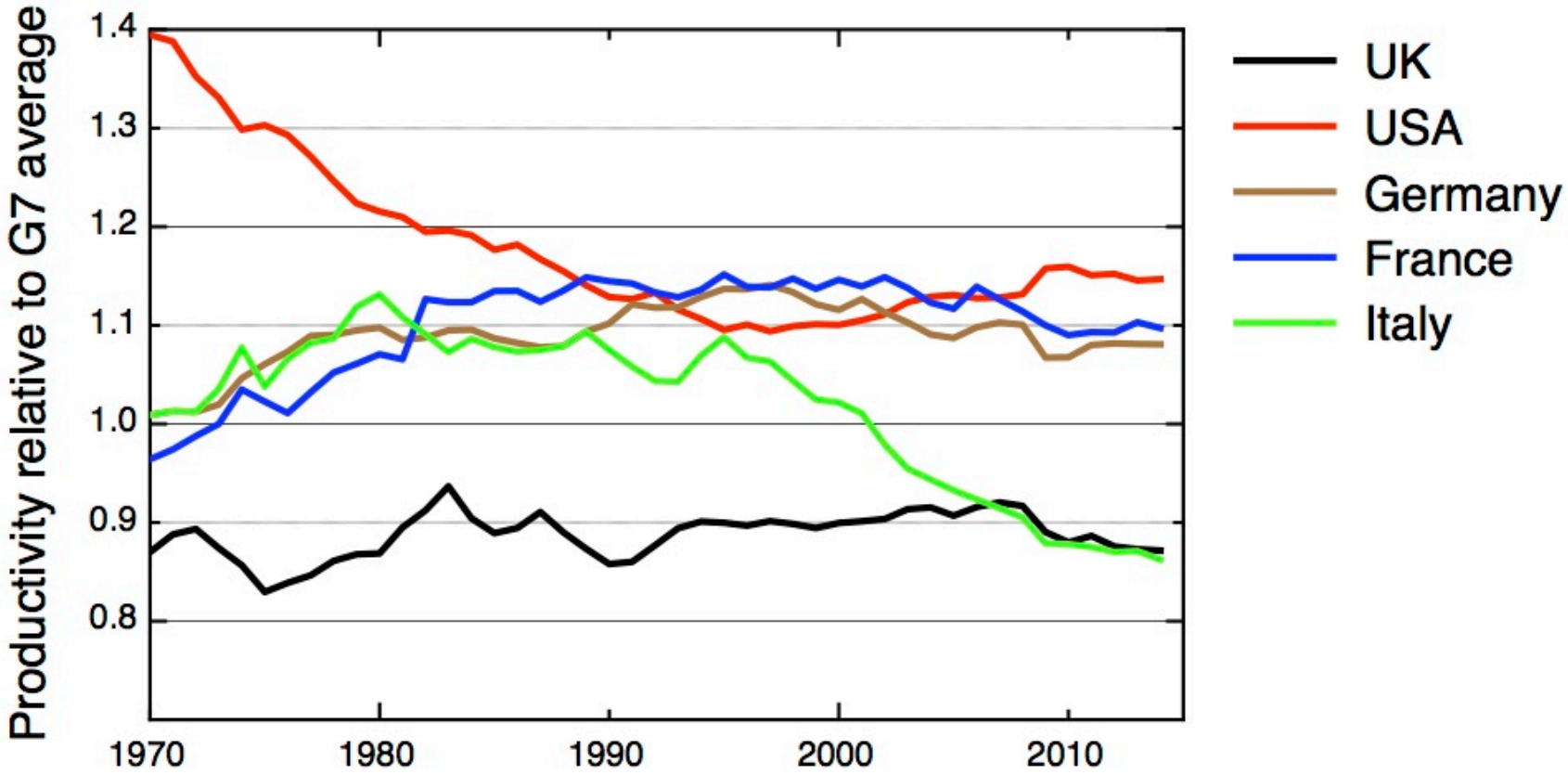
Diagnosing the decline in pharmaceutical R&D efficiency, J.W.Scannell, et al Nature Reviews Drug Discovery, **11** 191 (2012)

UK productivity in developed world context

G7 Labour productivity in 2010 PPP US$



The UK is a chronic underperformer, and has got worse since financial crisis



A phenomenon on this scale doesn't happen for no reason(s)

- How much of this is a UK problem, how much part of a bigger global problem?
- What big changes have happened to the UK economy over the last couple of decades?

The Solow growth model including technological progress

$$Y(t) = F[K(t), L(t), A(t)]$$

Growth Accounting

- Control the measured economic growth for changes in capital stock and labour inputs
- What's left is called *"total factor productivity"*
- Interpreted by economists as a measure of *"innovation"*

Growth accounting for the UK

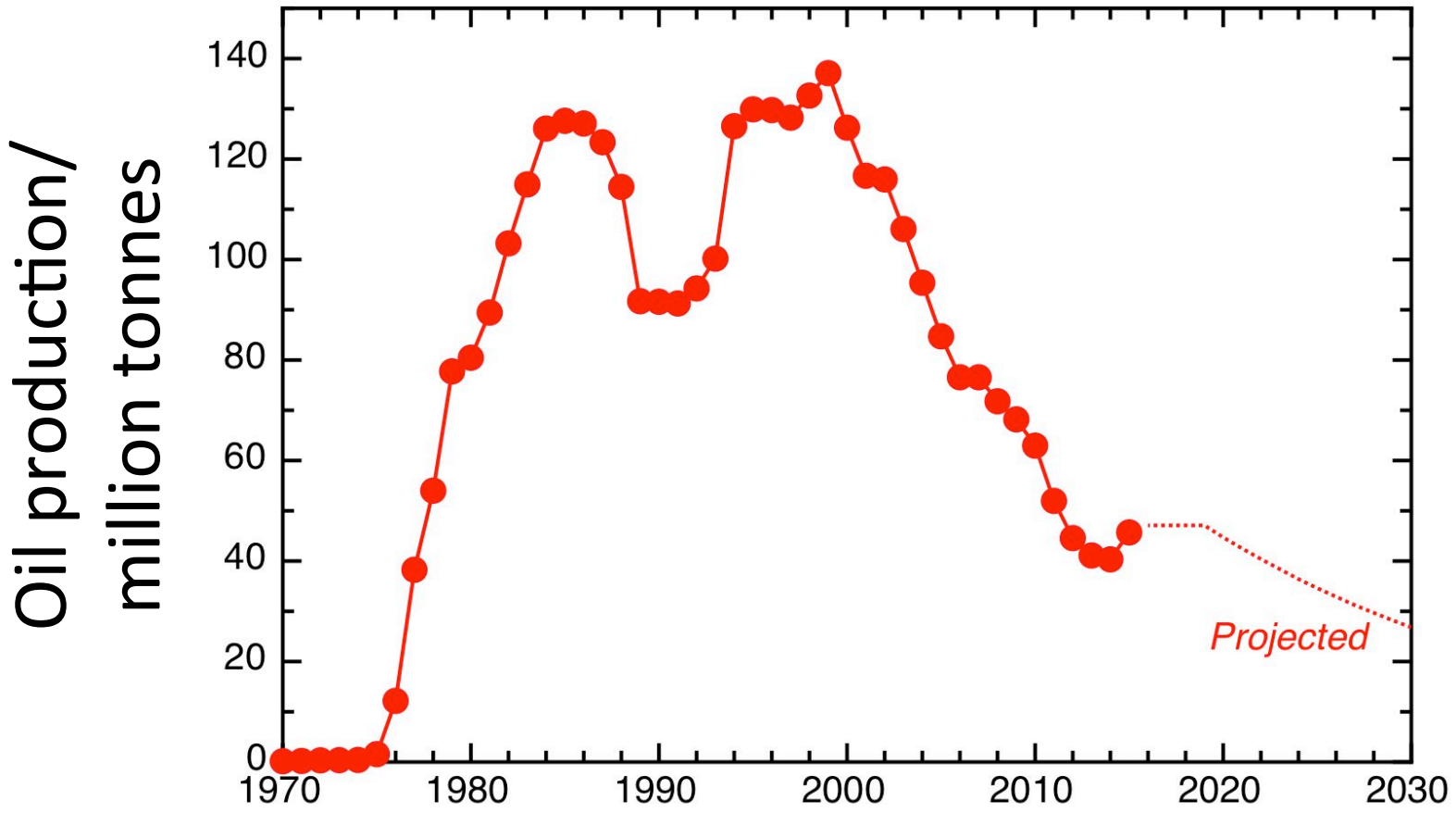
Imperial College London
BUSINESS SCHOOL

Accounting for the UK productivity puzzle:
a decomposition and predictions

Peter Goodridge, Jonathan Haskel, Gavin Wallis

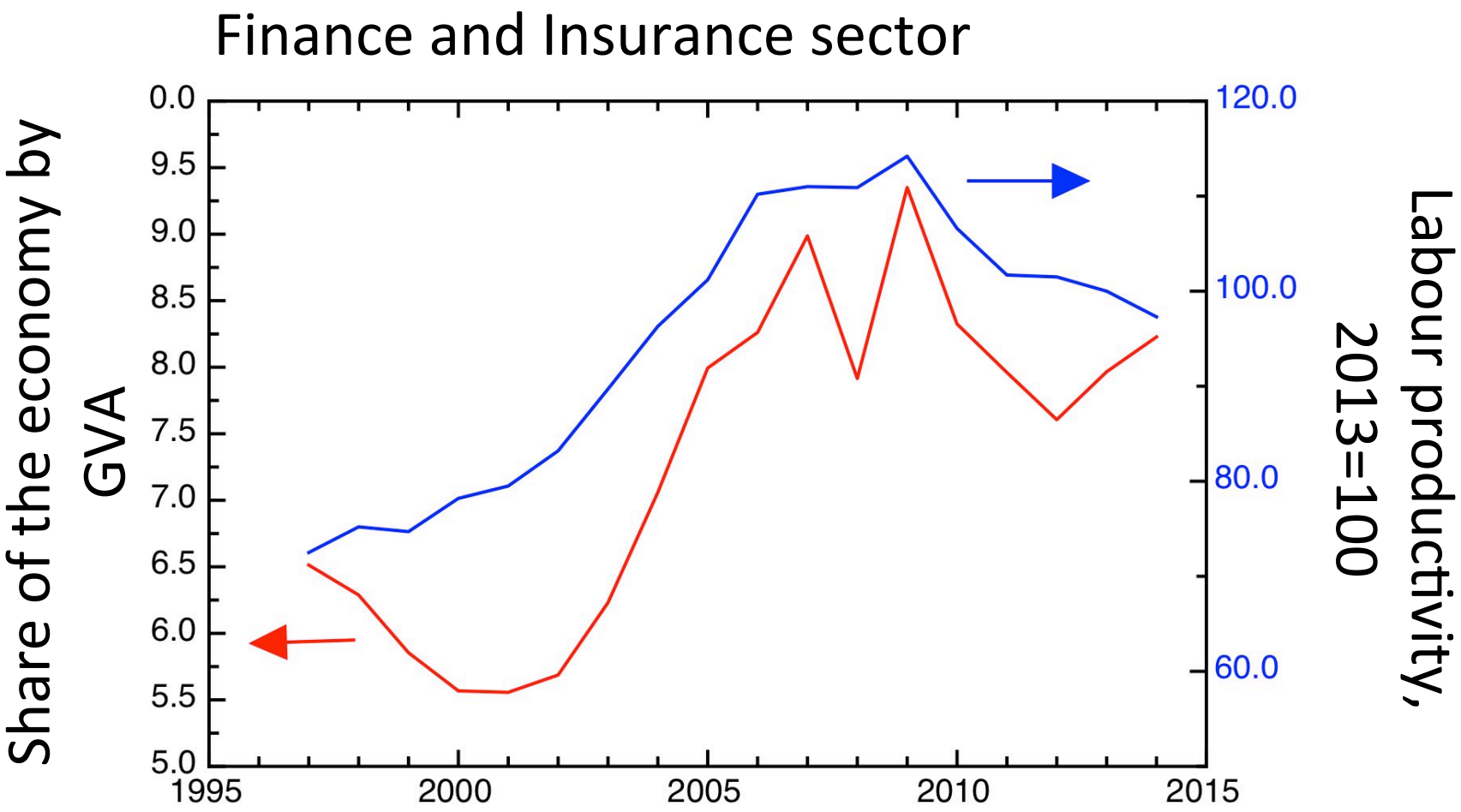
- Key findings:
  - not capital shallowing
  - not shifts from more to less productive sectors
  - A problem of *total factor productivity* – across all sectors
  - 1/3 of the puzzle accounted for by weakness in two sectors
    - Oil and gas
    - Financial Services

Peak Oil UK



Actual and projected production of oil in the UK mainland and continental shelf.
Data: DUKES 2015 and projection: DECC Oil and Gas Projections

Peak Bank UK



Labour productivity in the UK's finance and insurance sector, ONS data.

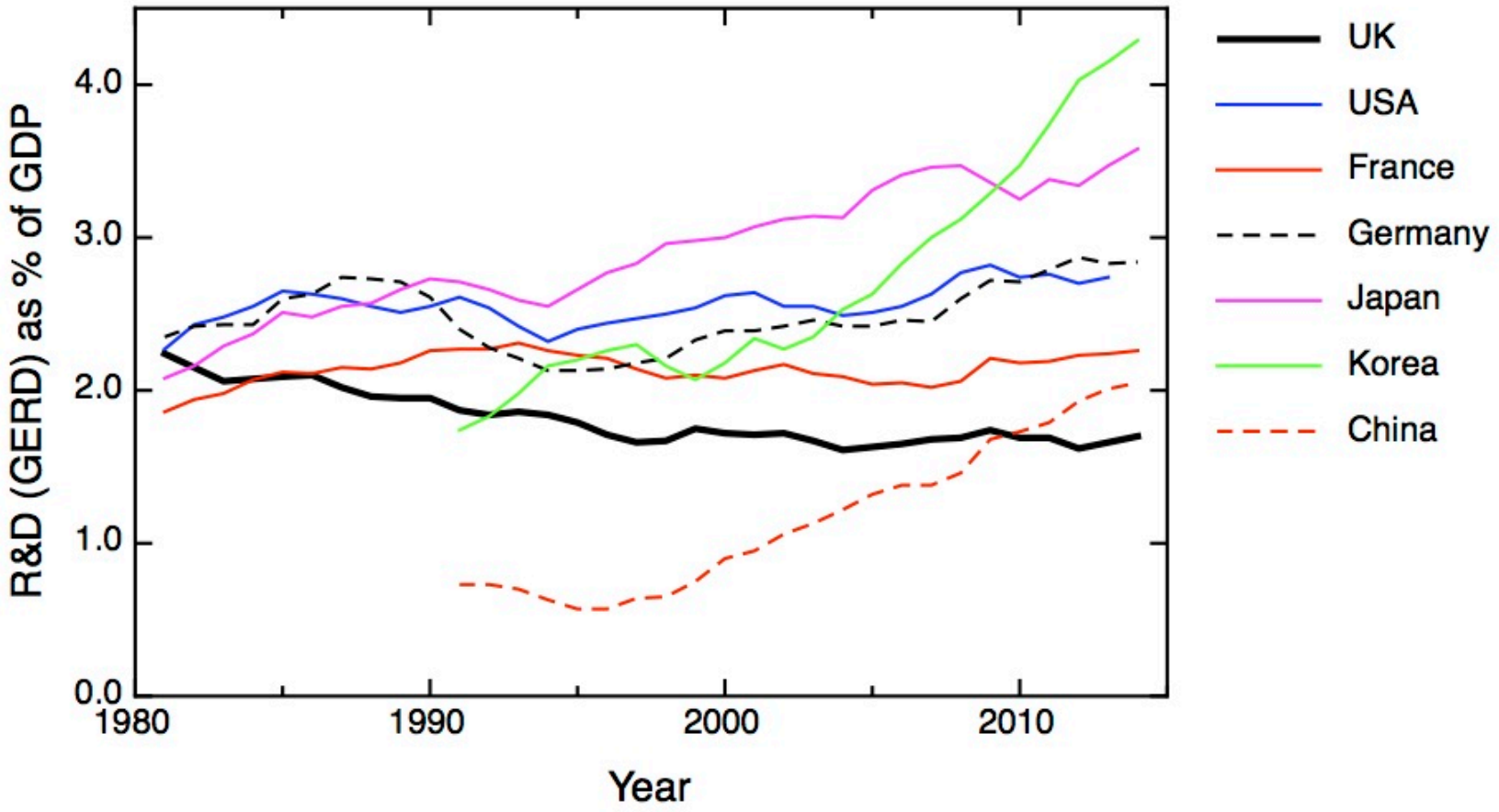
Twin headwinds for the UK economy

- Much productivity growth from 1990-2008 driven by North Sea oil and gas and financial services
- North Sea oil now declining fast – will not be replaced by fracking
- Financial services sector now smaller and more heavily regulated
- Productivity growth in other sectors needs not just to recover to pre-crisis levels, but to achieve a higher level to compensate for these headwinds

So, why might we have an innovation problem?

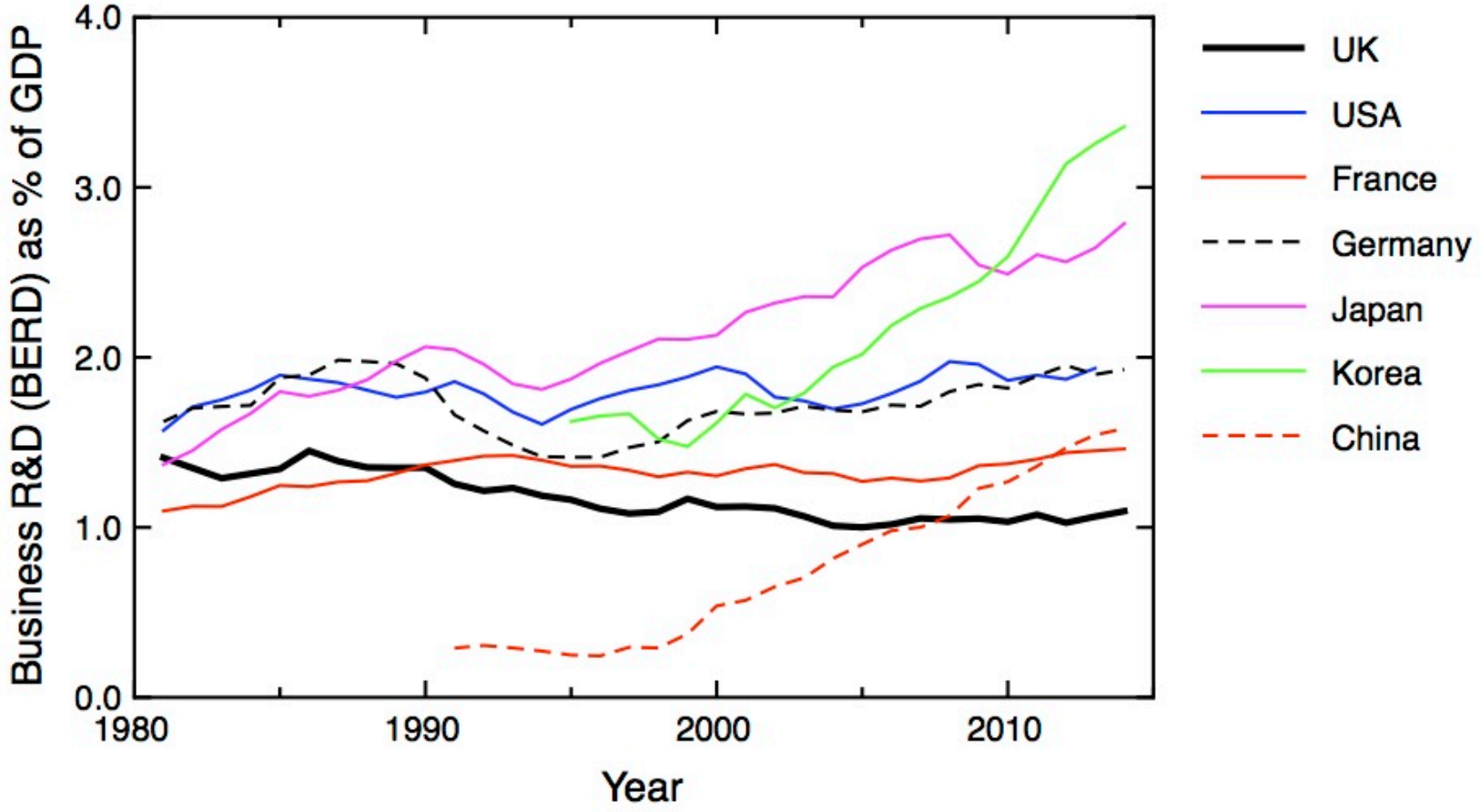
- What economists call *"innovation"* isn't the same as innovation
- And innovation isn't always the result of research and development
- Innovation includes
  - learning from experience,
  - suggestions from users,
  - copying better practices from competitors,
  - transferring new technologies from other sectors
  - more effective ways of organising and distributing work
- Nonetheless…

Our dismal R&D trajectory



- *Research intensity of selected countries, expressed as gross expenditure on research and development as a percentage of GDP. Data: OECD main science and technology indicators, January 2016.*

Focus on business R&D



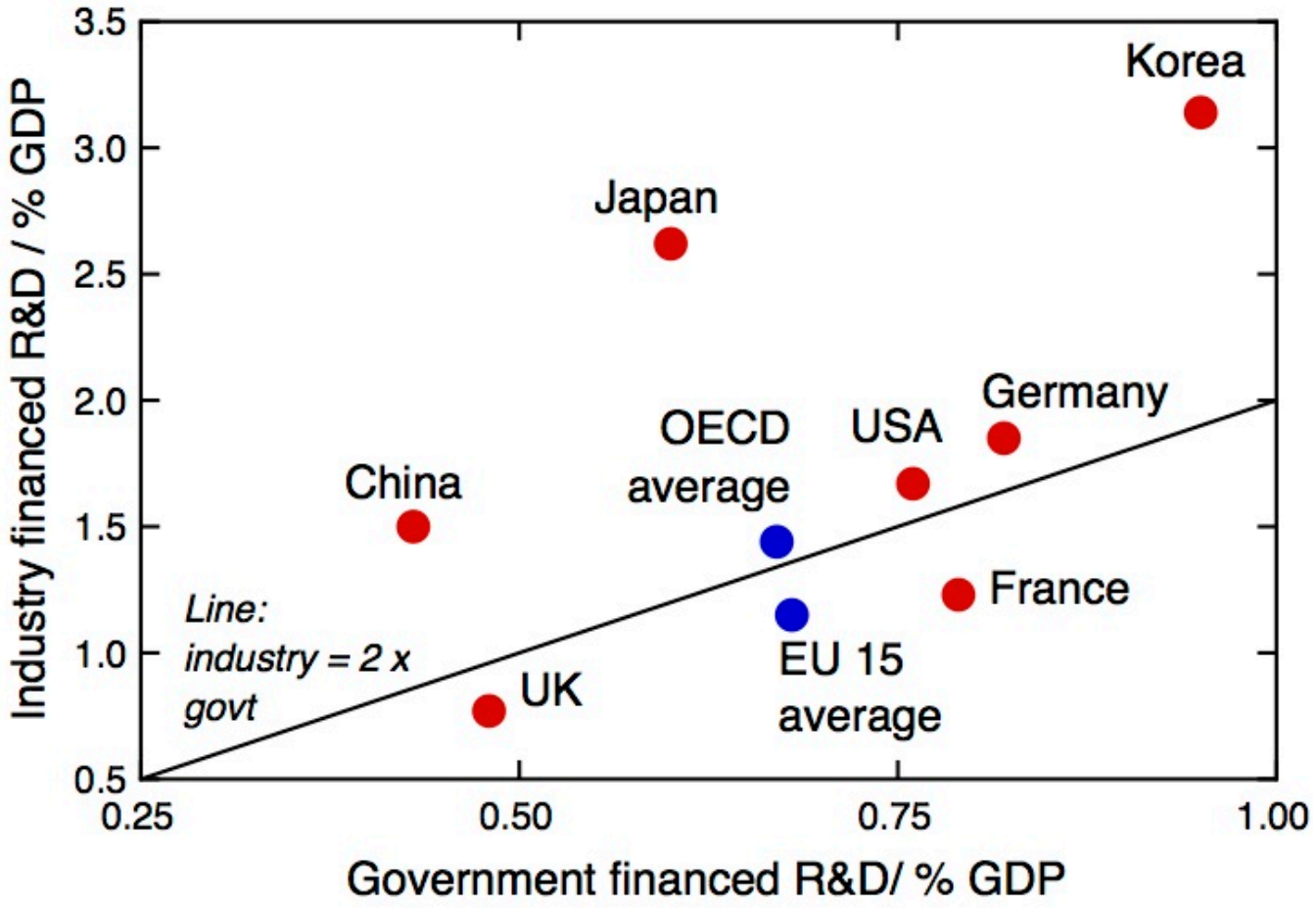
Business enterprise R&D intensity of selected countries, expressed as a percentage of GDP. Data: OECD main science and technology indicators, January 2016.

Is business R&D relevant in a new world of venture capital and nimble start-ups?

- UK business R&D:
  - £20.9 billion
- Venture Capital Technology Investments in UK tech companies at early stage and expansion:
  - £321 million
- VC funds raised from governments:
  - £286 million

2015 figures, ONS BERD and BVCA

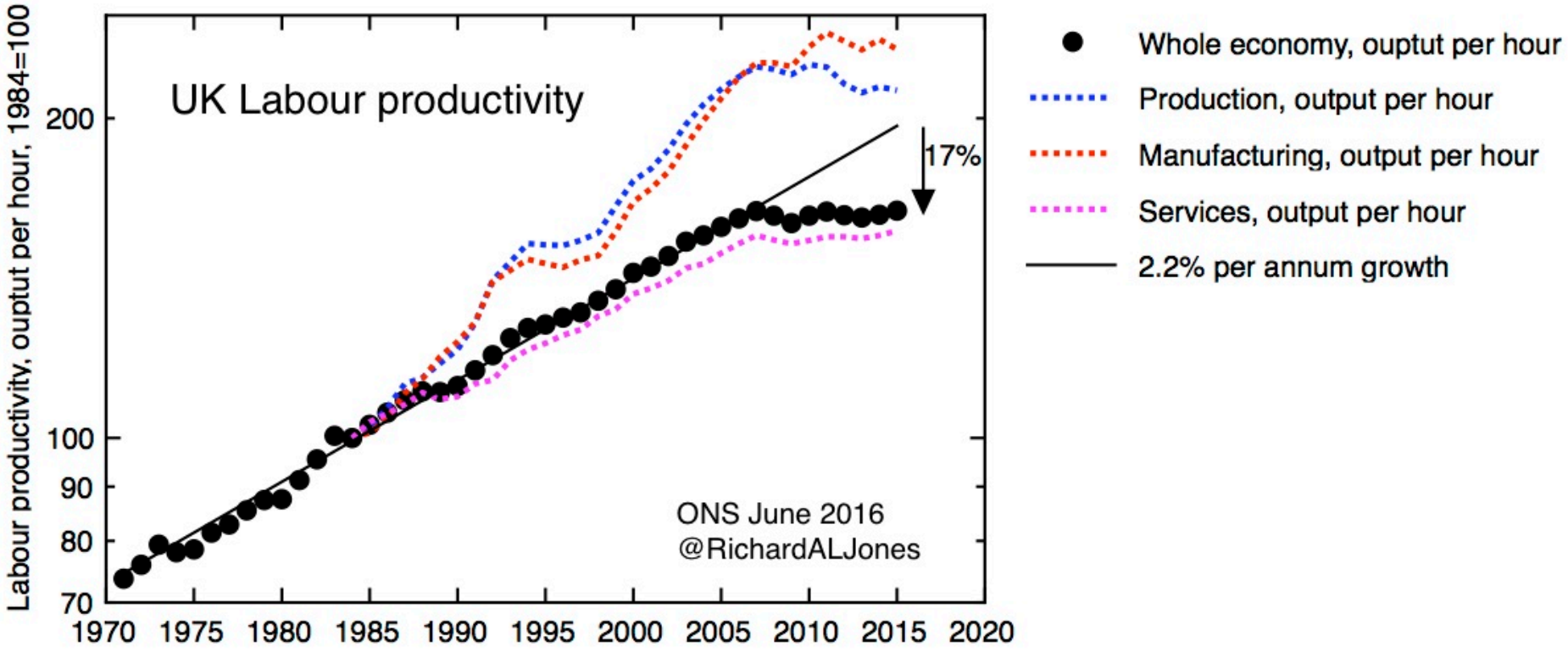
Public R&D “crowds in” business R&D – do we get the business R&D we deserve?



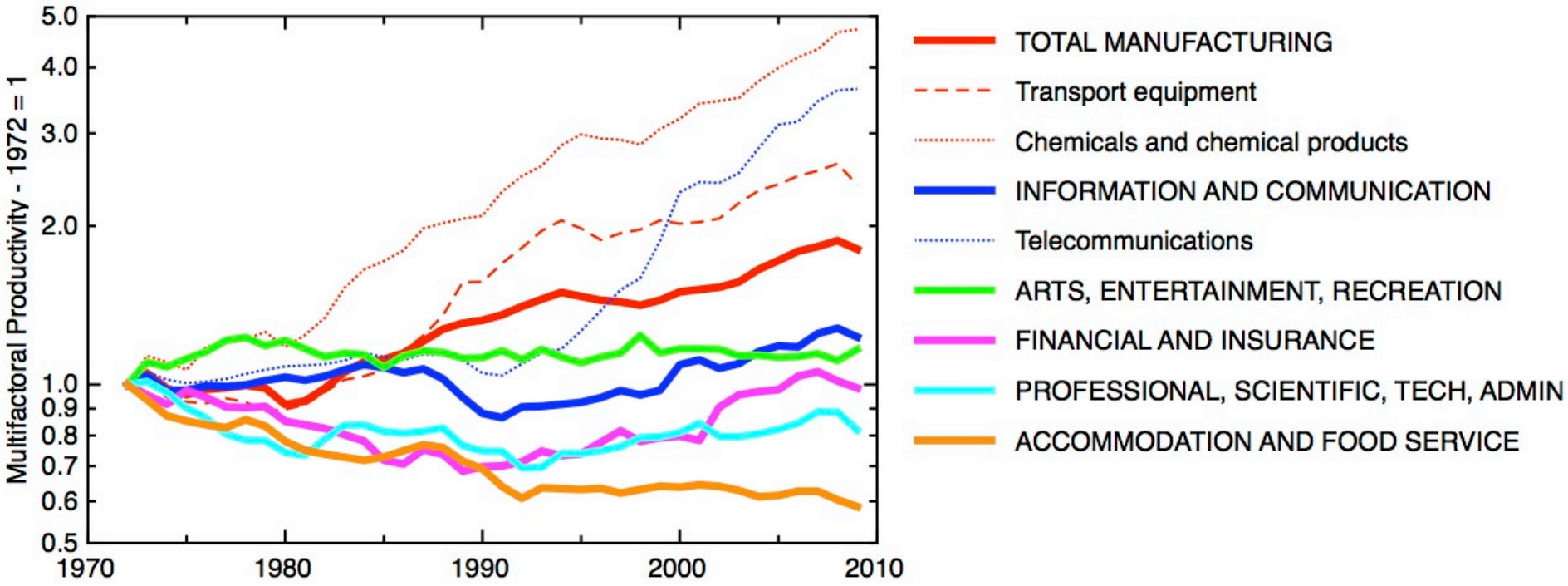
What about sectoral shifts?

- R&D is important for manufacturing and ICT…
- …but does R&D matter in a service based economy?
- …how does one drive productivity growth in the service sectors?
- ...and how important is manufacturing as a driver of productivity growth?

Services productivity growth has lagged production and manufacturing

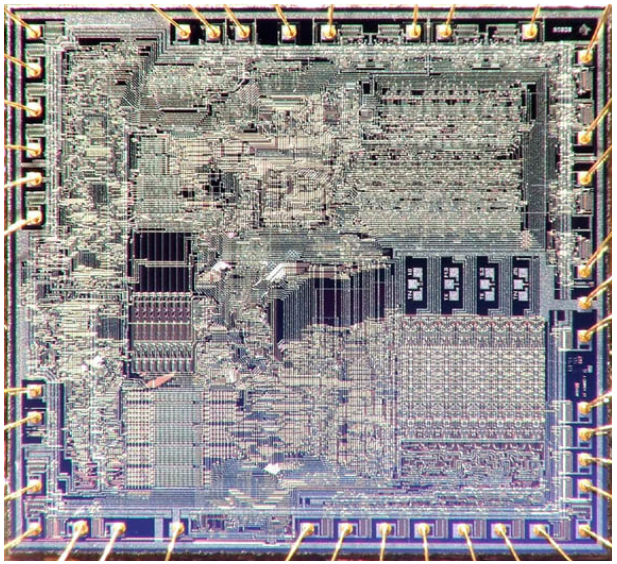


Drivers of UK total factor productivity growth over the medium term



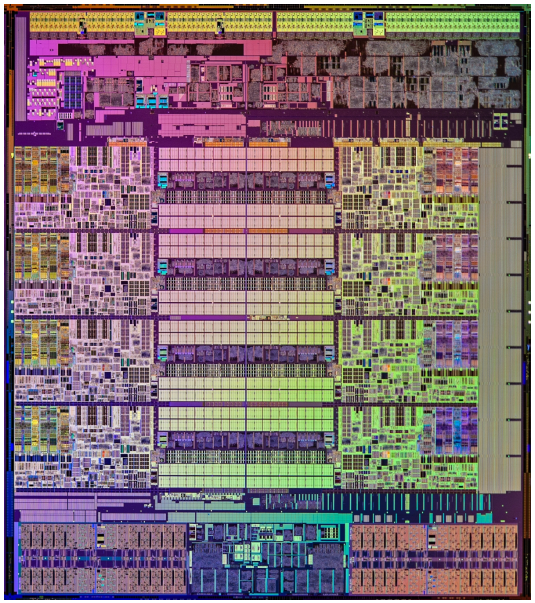
Multifactor productivity growth in selected UK sectors and subsectors since 1972.
Data: EU KLEMS database, rebased to 1972=1.

Manufacturing innovation sometimes yields very large increases in productivity



1974
Intel 8080
6000 transistors
~$360

2014
Intel Core i7
2.6 billion transistors
~$1,000



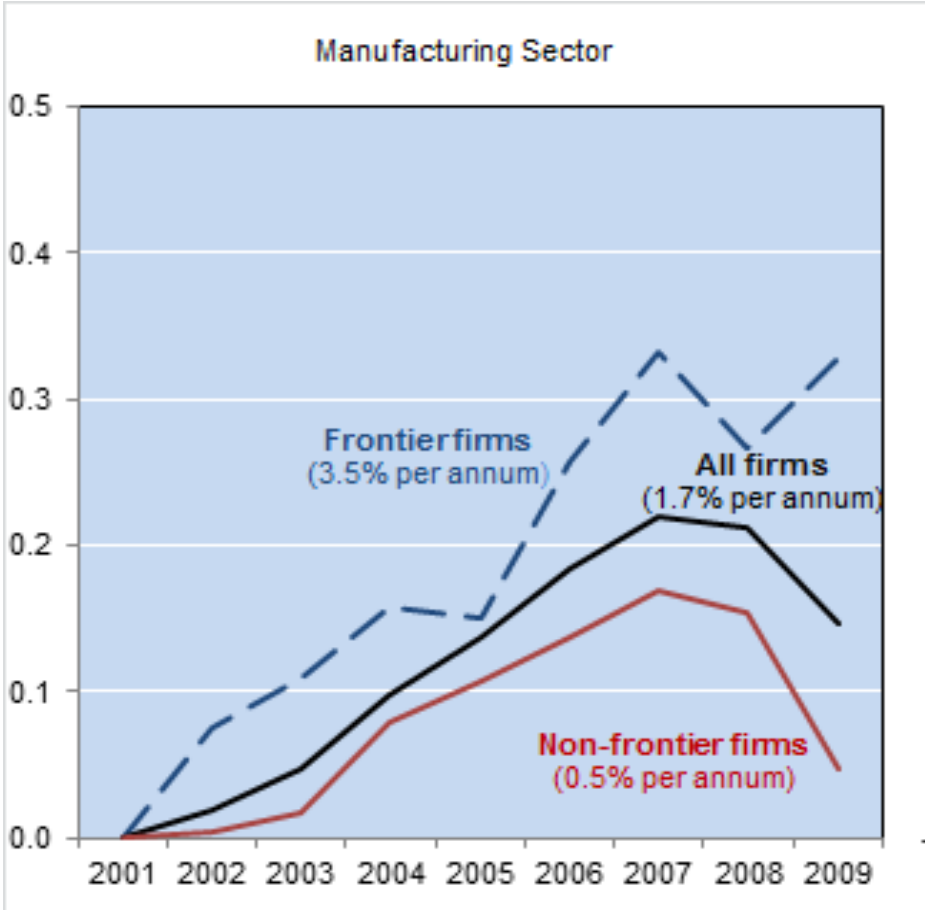
- 40 years of manufacturing innovation
  - performance gain of about 200,000
- Real cost (deflated by CPI) fell from $1760 to $1000
- Cost per unit of computation fell by factor of 350,000

How do you assign utility and value to products subject to rapid technological change?

- The limits of “Hedonic price adjustment”
- Wholesale realignment of relative value of goods and services (Baumol’s cost disease)

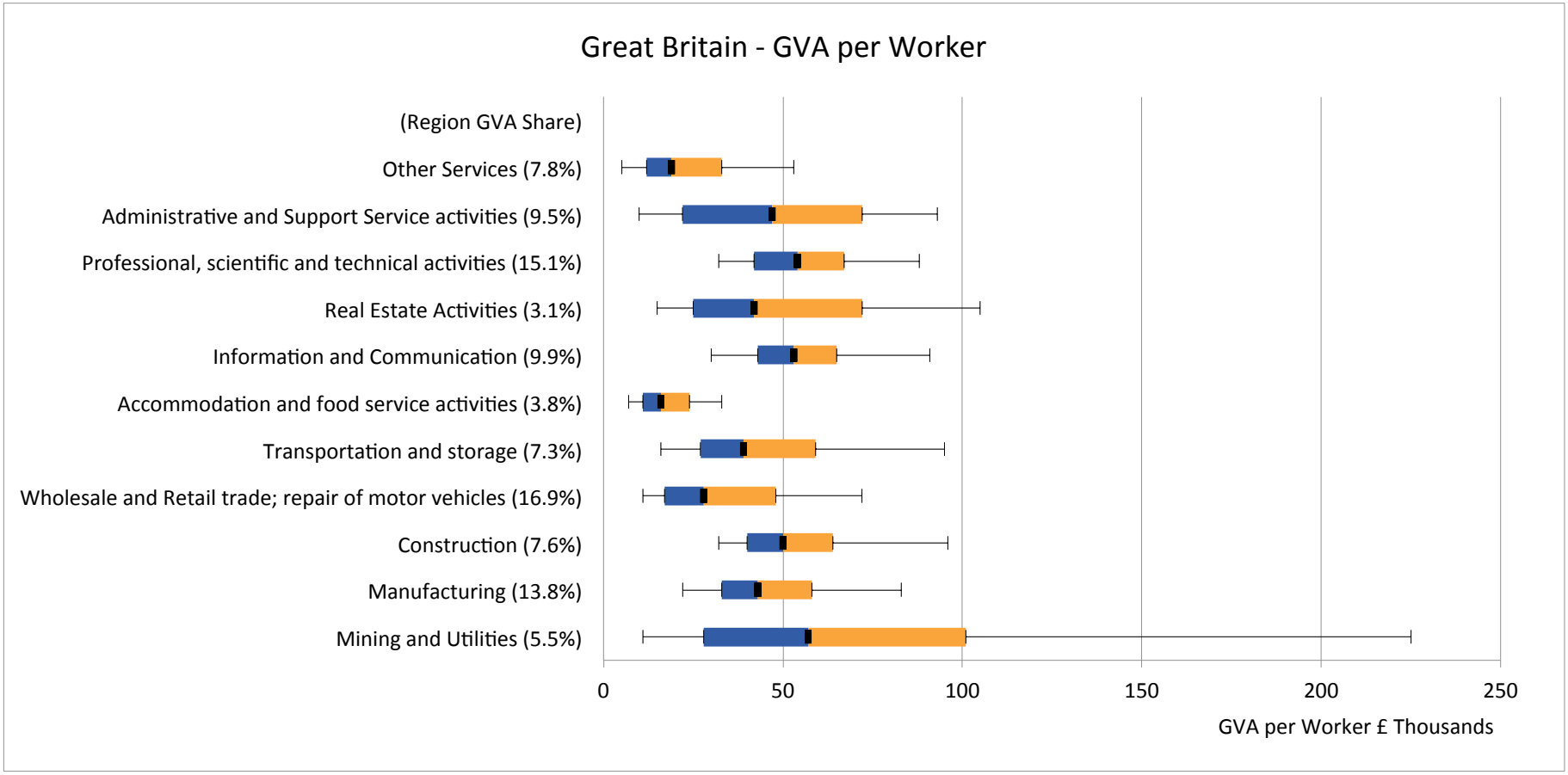
What about dispersion within sectors?

- Globally, a gap has opened up between firms at the technology frontier and the laggards



"Firms at the global productivity frontier are on average 4-5 times more productive than non-frontier firms in terms of MFP, while this difference is more than 10 times with respect to labour productivity"
OECD Future of Productivity Report, 2015

Dispersion within sectors greater than differences between sectors



Lowest decile – first quartile – median – third quartile – top decile

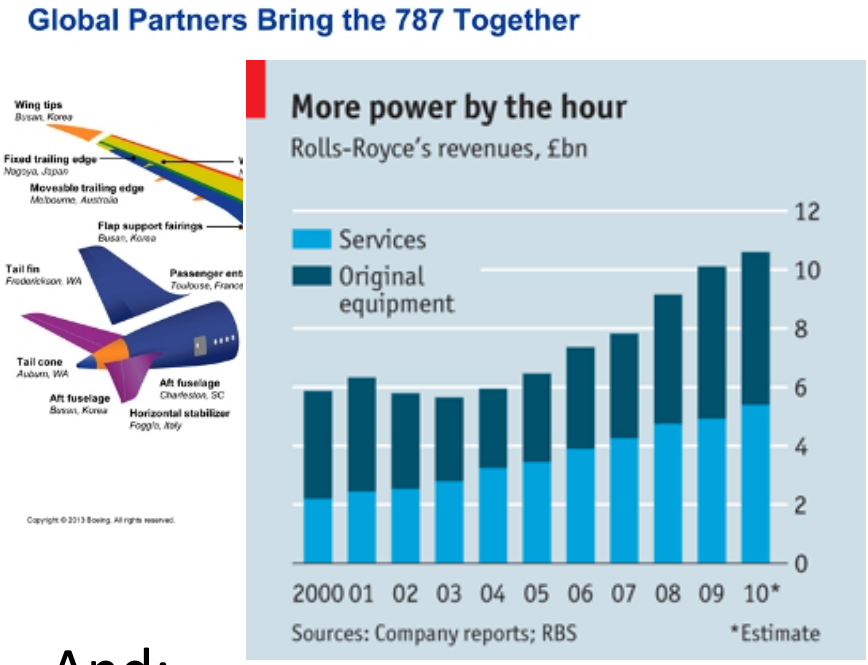
ONS: Regional firm-level productivity analysis for the non-financial business economy: Jan 2017

And what do we actually mean by manufacturing?

From:
Massive vertical integration

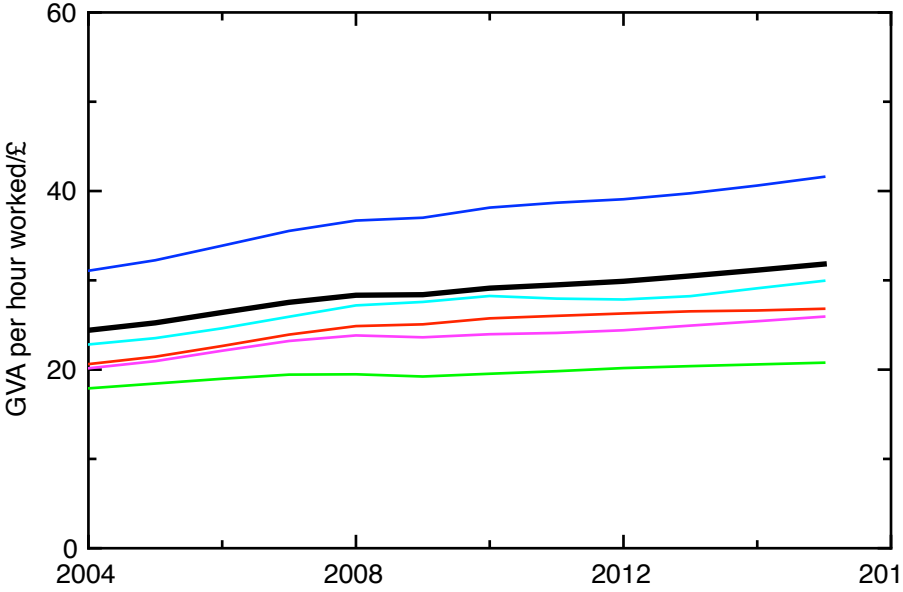
Ford River Rouge Complex, 1927

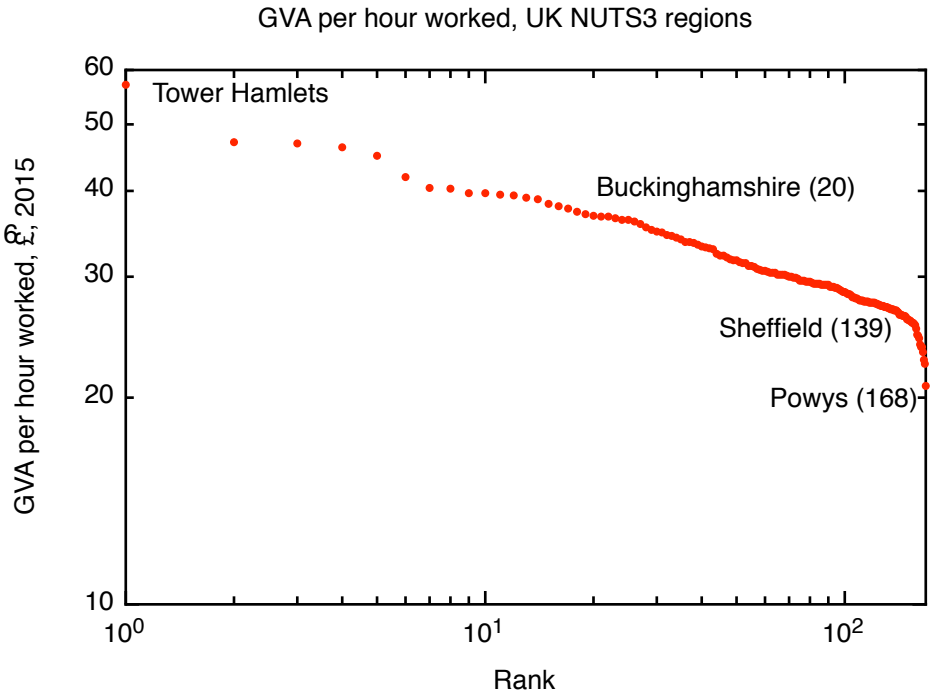
To:
Outsourcing to global supply chains



And:
Servitisation of high value manufacturing

Regional productivity disparities

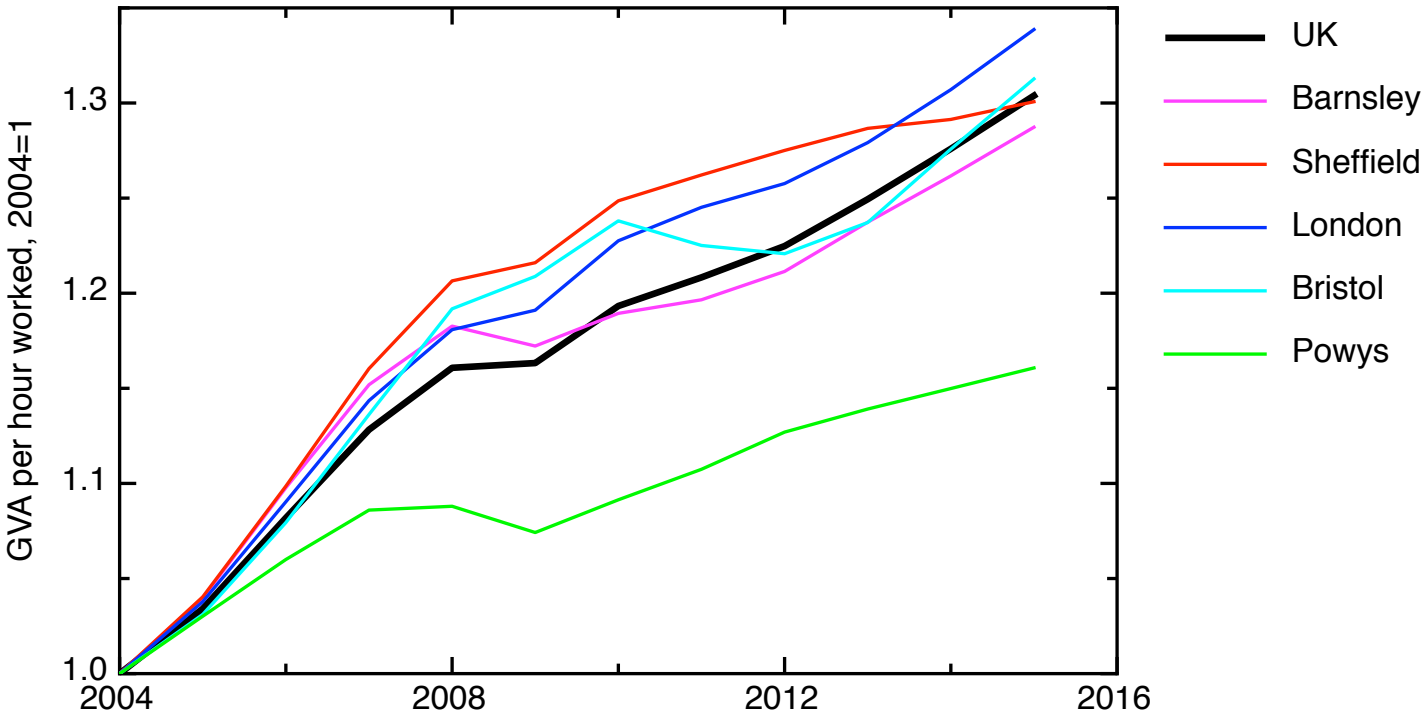




- Most productive region in UK (Tower Hamlets) 2.74 times GVA per hour of least productive (Powys)
- It's not just a long tail, it's a fat tail – most of the UK is below average

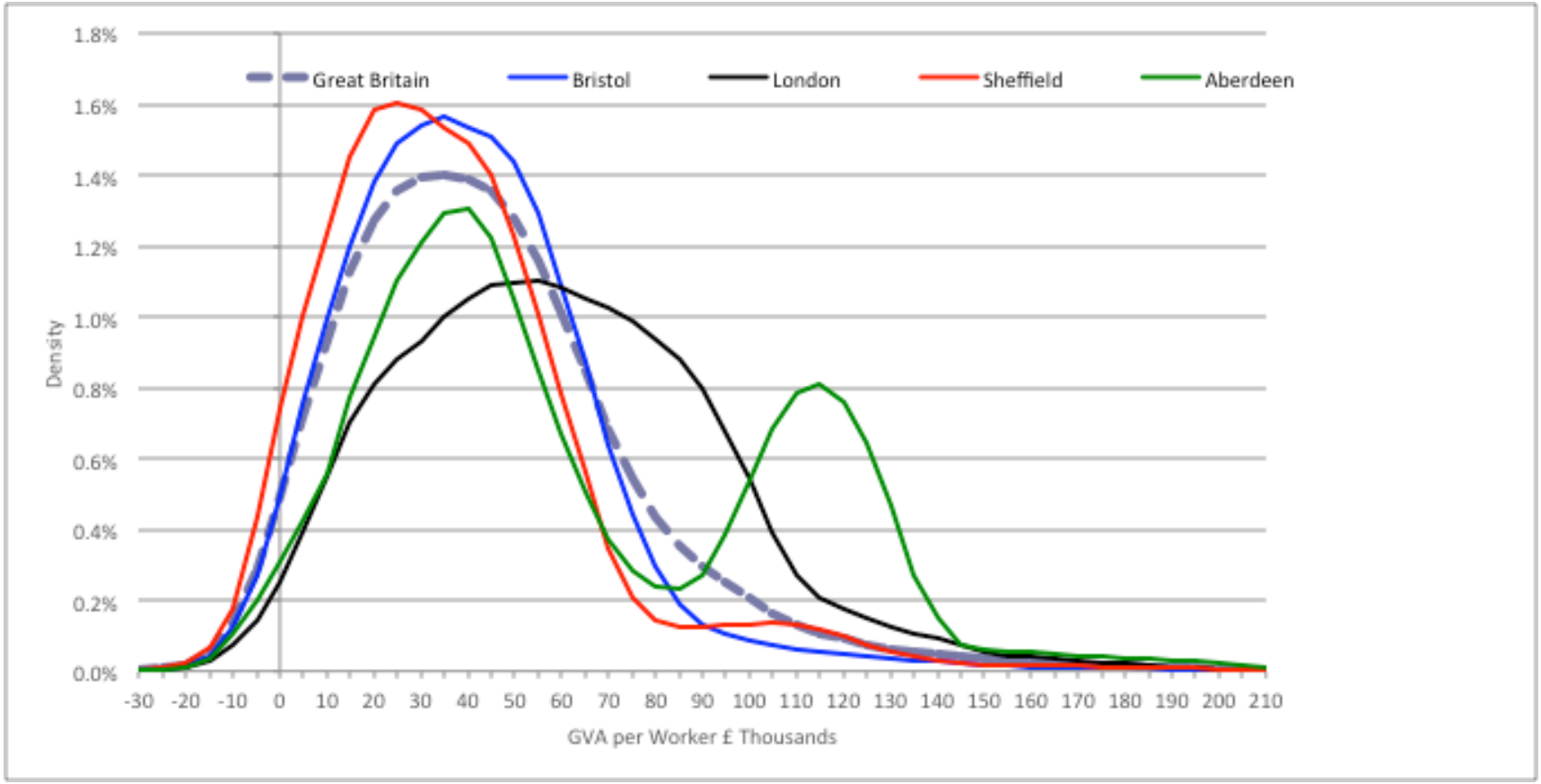
ONS: Regional and sub-regional productivity in the UK: Jan 2017

Regional disparities in relative performance



Distribution of firms

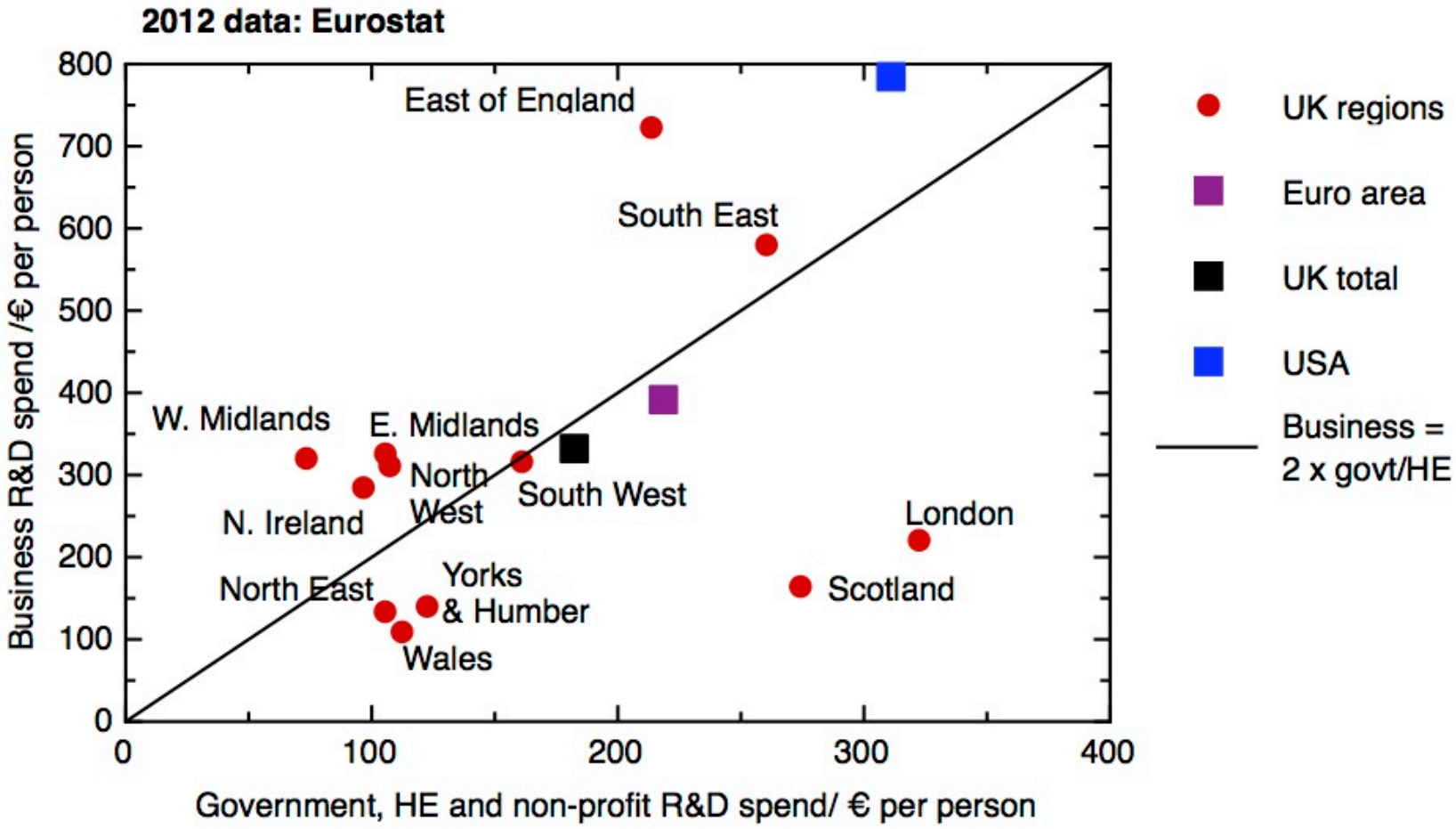
Firm level productivity distributions for selected regions



Even low productivity regions can have high performing firms

ONS: Regional firm-level productivity analysis for the non-financial business economy: Jan 2017

Regional disparities in public and private sector R&D

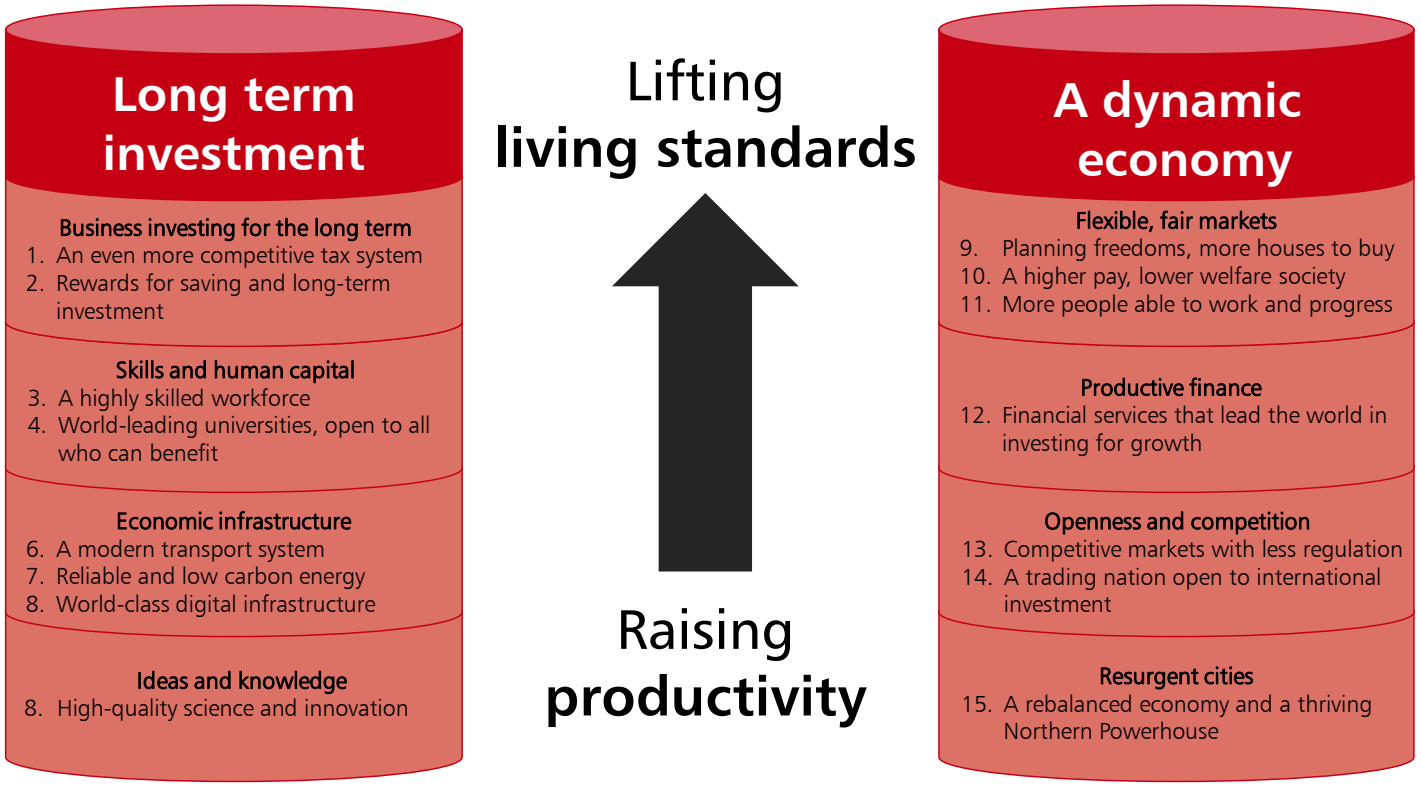


What is to be done?

- Industrial Strategy Green Paper, January 2017
- How much of a departure is this?
- ***Whatever we've done in the past, it hasn't worked***

The 2015 model

Chart iii: A framework for raising productivity



Source: HM Treasury

The Productivity Plan: *"Fixing the Foundations, creating a more prosperous nation"*
HM Treasury, July 2015

HM Government

Industrial Strategy

Government and industry working together in partnership

Britain is already a great place to do business, with world-leading capabilities in engineering, manufacturing, and science and technology. But the world is changing and global competition is increasing.

Government is working in partnership with business to create **more opportunities**, deliver **more jobs** and make the UK **more competitive** so that British businesses can thrive and compete with rising economies.

This new long-term approach will lead to improved opportunities, better jobs, growth and economic prosperity.

October 2014

Industrial Strategy is a long-term, whole-of-government approach to support economic growth

This new partnership between business and all parts of government has identified a range of opportunities to help create growth for the future, from developing new skills and securing critical investment to commercialising our scientific research and inventions.

Industrial Strategy has five main strands:

Skills

Working in partnership with business to **deliver the skills that employers need** through more direct control of how government funding on skills is spent.

Technologies

Investing in **eight great technologies** where the UK has the research expertise and business capability to become a world leader in big data, space, robotics and autonomous systems, synthetic biology, regenerative medicine, agri-science, advanced materials and energy

Access to finance

Creating the **British Business Bank**, to help remove barriers to the supply of business finance, helping smaller businesses grow by investing in people and equipment.

Government procurement

Letting businesses know in advance **what Government is planning to buy** so that they can invest in the right skills and equipment to make the most of these opportunities.

Sectors

Providing support for all sectors of the economy to help increase global competitiveness, support innovation and maximise export potential. Strategic partnerships have been developed in sectors where government and business, working together, believe they can **make the most difference**.

HM TREASURY

dti

department for
education and skills

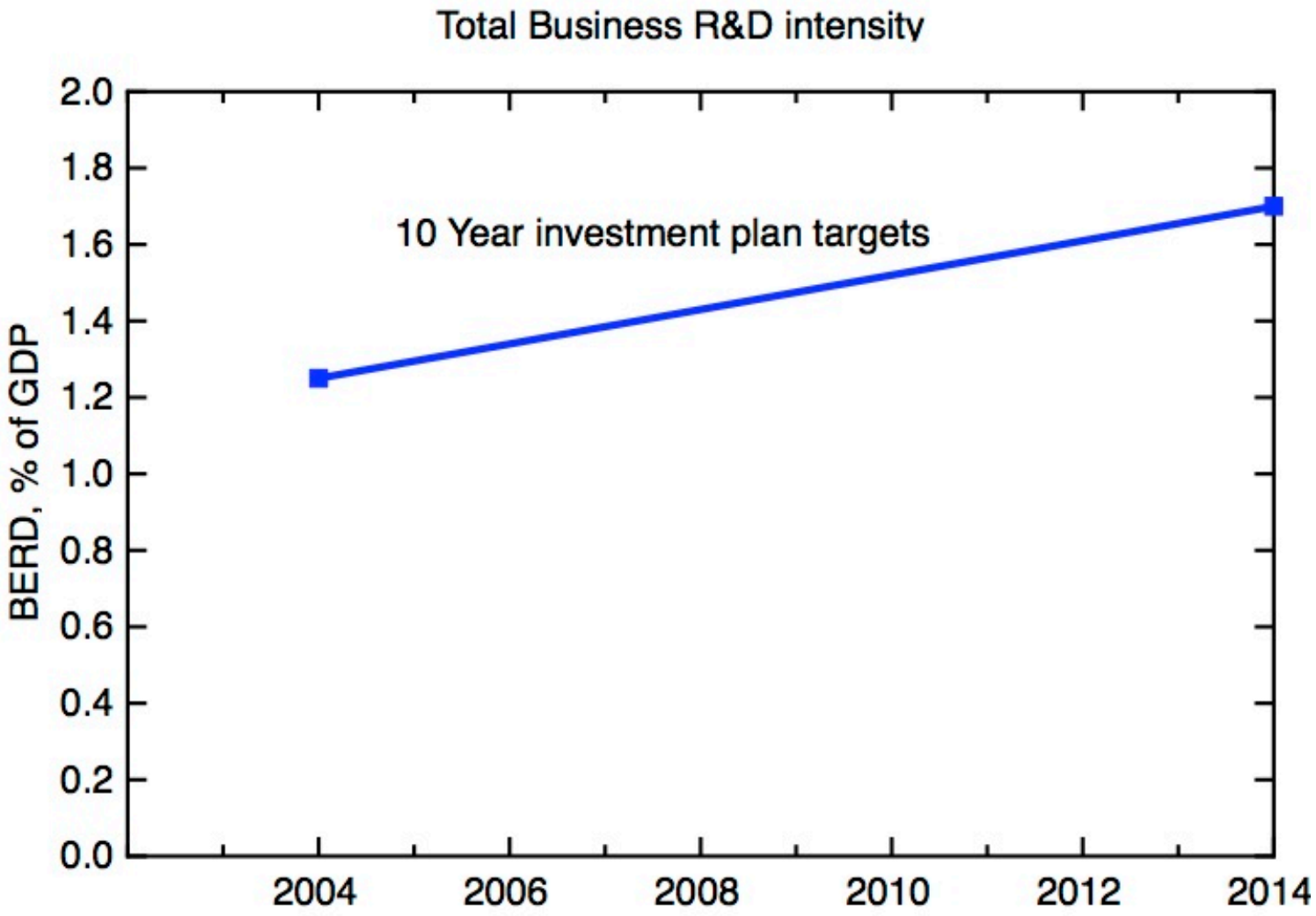
Science & innovation investment framework 2004 - 2014

The 2004 target for business R&D

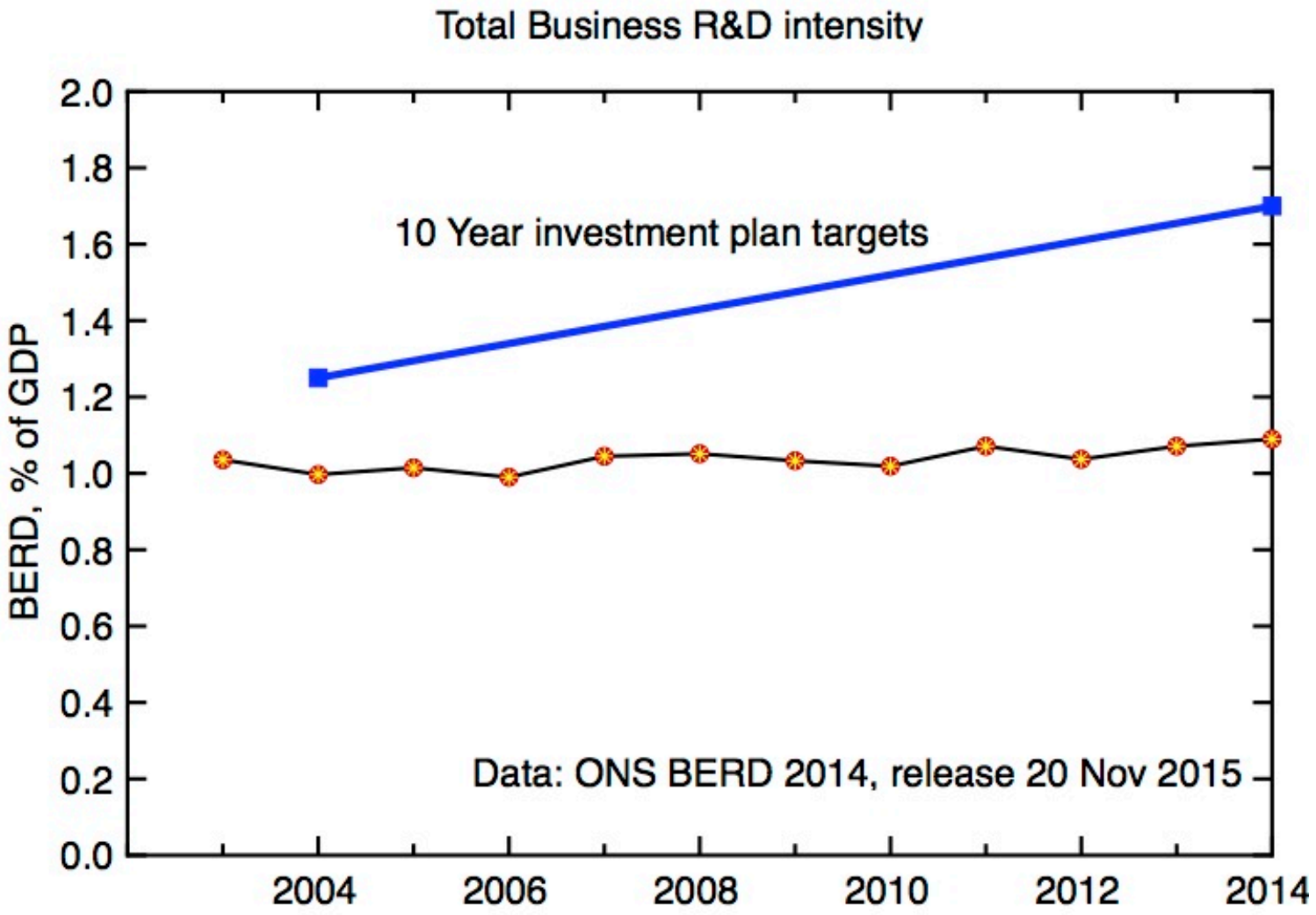
Increased business investment in R&D, and increased business engagement in drawing on the UK science base for ideas and talent:

- Increase business investment in R&D as a share of GDP from 1¼ per cent towards goal of 1.7 per cent over the decade
- Narrow the gap in business R&D intensity and business innovation performance between the UK and leading EU and US performance in each sector, reflecting the size distribution of companies in the UK

The 10 year investment plan target



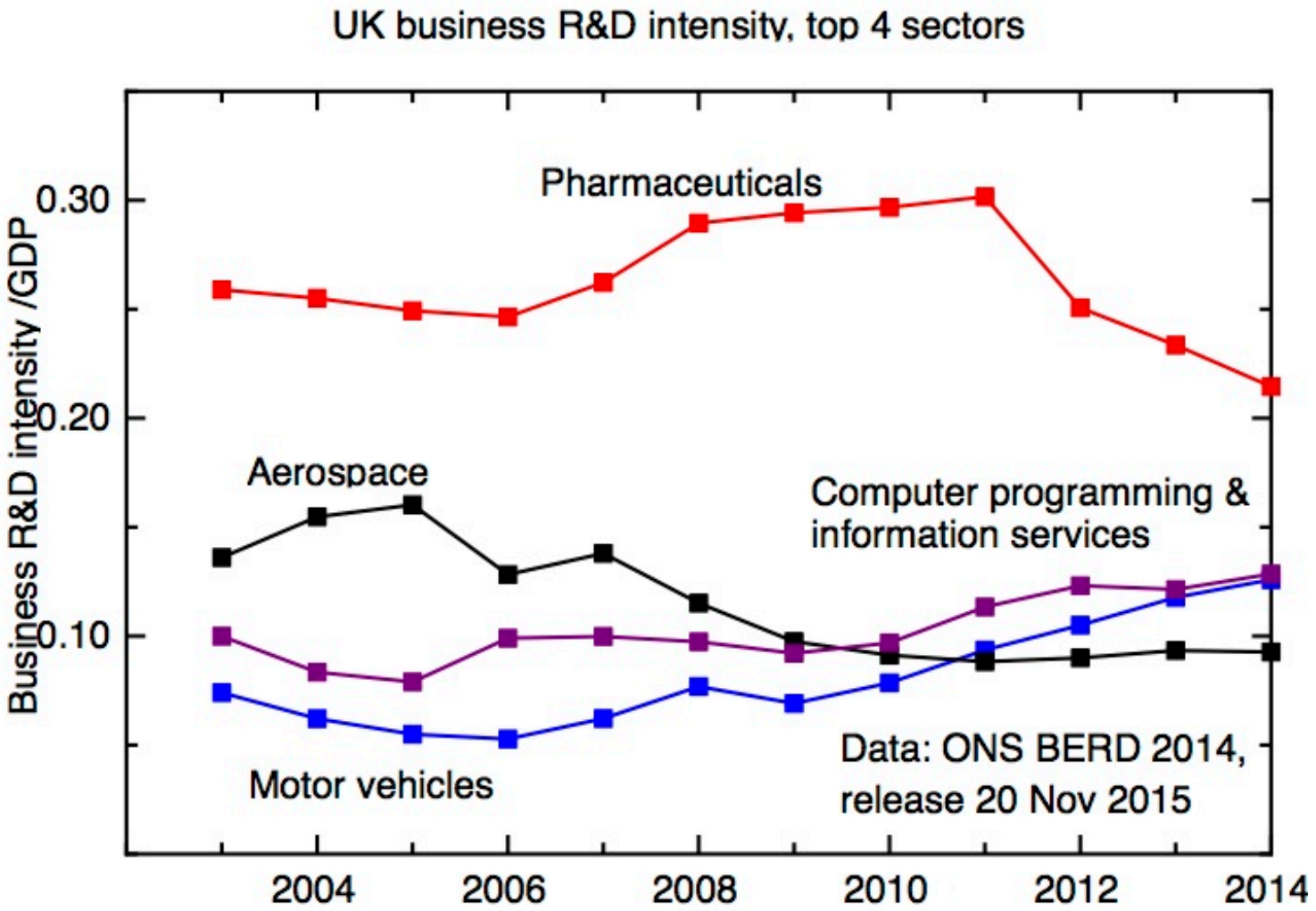
A decade of flat BERD



Relatively constant overall industry R&D intensity conceals some big sector movements

- **Pharmaceuticals**, 22% of R&D
  - **Down 15%** since 2008 in real terms
- **Aerospace**, 9% of R&D
  - **Down 14%** since 2008
- **Computer programming & info**, 10.9% of R&D
  - **Up 24%** since 2008
- **Automotive,** 11% of R&D
  - **Up 60%** since 2008

Sectoral shifts in BERD



Supply side innovation policy

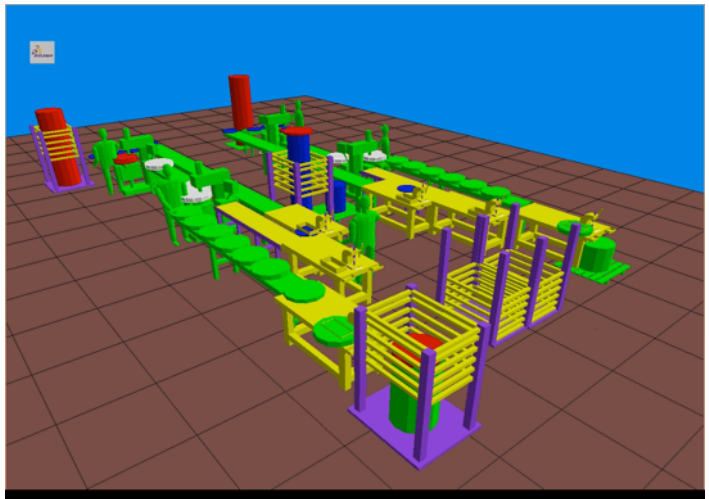
- More than a decade of innovation policy has focused on the *supply side*
  - Strong basic science base
  - Supply of well-trained people
  - Encouragement of business-university links
  - Better commercialisation of University IP
  - Generalised incentives for business R&D through R&D tax credits (to correct market failure)
- All good – but is it enough?

Building innovation capacity and speeding up the diffusion of technologies

- Key role of translational research facilities
  - Academia, Large firms at the tech frontier, SMEs (typically in supply chains) as equal partners
  - Focus on know-how, learning by doing and process improvement, as much as protectable IP
  - Translational research at industrial scale
  - Responsibility for skills development at all levels as well as innovation
- O'seas models include Fraunhofers, Taiwan's ITRI etc
- UK's Catapults should have this as an aspiration

The University of Sheffield's Advanced Manufacturing Research Centre with Boeing

The digital future of manufacturing



Flexible
Reconfigurable
Customisable

Driven by data analytics
Using new materials & manufacturing techniques
Heavy use of automation and robotics

User involvement in design
Capturing more of the value chain

"Industrie 4.0"

Focus of Sheffield/Lancashire Science and Innovation Audit

Creating the demand for innovation

- Where does the UK Government most urgently need innovation to happen to control public expenditure and meet policy objectives?
  - Energy
  - Healthcare Technology
- Government needs to be much more active in procuring not just innovative products, but innovation itself

Further reading…

- Two working papers by RAL Jones from Sheffield Political Economy Research Institute:

  The UK's innovation deficit and how to repair it
  http://speri.dept.shef.ac.uk/2013/10/30/speri-paper-no-6-the-uks-innovation-deficit-repair-it/

  Innovation, research, and the UK's productivity crisis
  http://speri.dept.shef.ac.uk/2016/04/14/new-speri-paper-innovation-research-and-the-uks-productivity-crisis/

- My blog: http://www.softmachines.org
  (also includes more about Transhumanism than you probably want to know)

  @RichardALJones