The Contribution of Research & Innovation to Productivity

Kevin J. Fox

UCL Institute of Education
22 June 2017

"…the need for productivity, innovation and incentive in our economy has never been more important."

Scott Morrison, Federal Treasurer, National Press Club Address, 17 February 2016.

(http://sjm.ministers.treasury.gov.au/speech/009-2016/)

http://www.acola.org.au/index.php/projects/securing-australia-s-future/project-4

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Related Papers

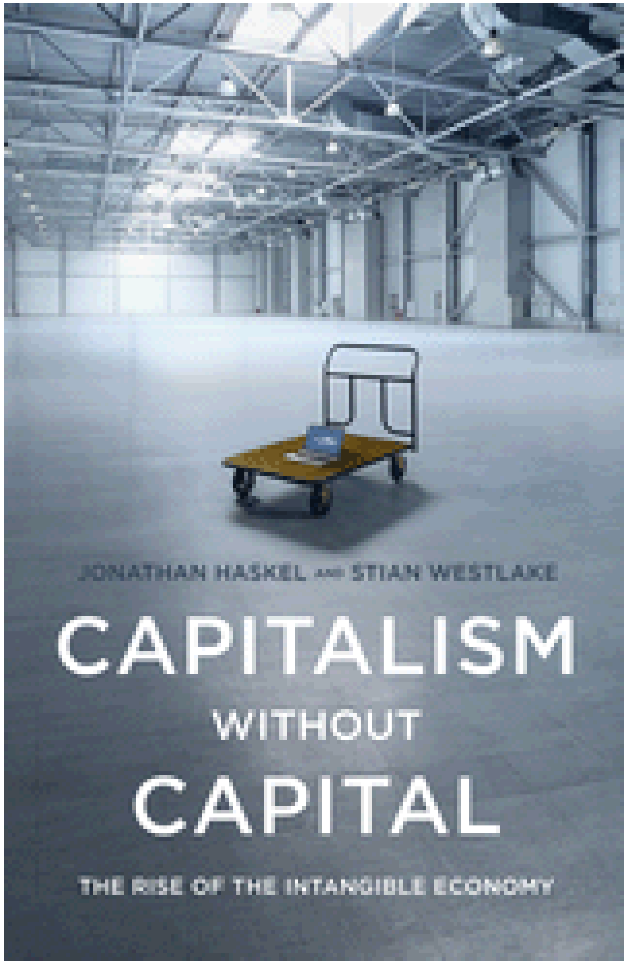
- Elnasri, A. and K.J. Fox (2017), “The Contribution of Research and Innovation to Productivity,” *Journal of Productivity Analysis* 47, 291–308

- Elnasri, A. and K.J. Fox (2015), “R&D, Innovation and Productivity: The Role of Public Support,” *KDI Journal of Economic Policy* 37(1), 73–96

- Fox, K.J. (ed.) (2017), Special Issue of the *Review of Income and Wealth* on “Productivity Measurement, Drivers and Trends,” Series 63, Supplement 1

Haskel and Westlake, October 2017

http://press.princeton.edu/titles/11086.html



Overview

- Productivity, innovation and “technological anxiety”
- Positive relationships between innovation, productivity and economic growth, but can be difficult to quantify.
- Advance understanding of these relationships with Australian data.
- Particular focus on the impact of publically financed R&D on productivity.
- The role of the higher education sector is highlighted.

Plan

1. Productivity

2. R&D and other intangibles

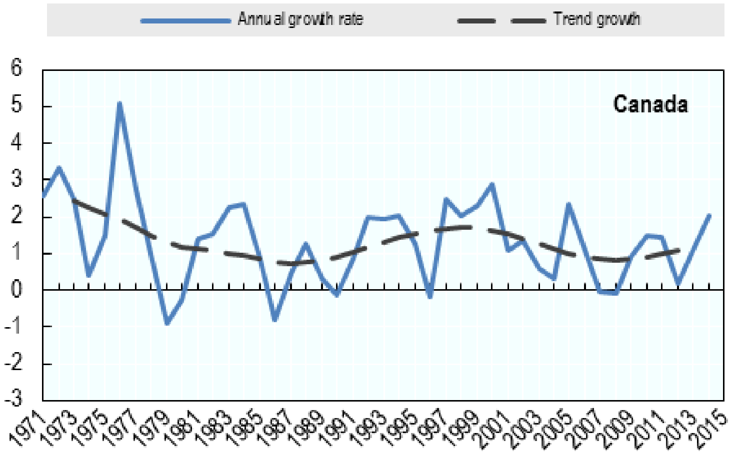
3. Public Support for R&D

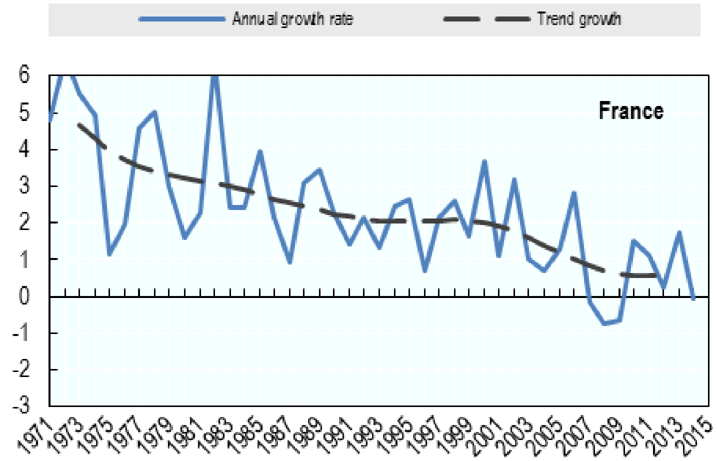
4. Results

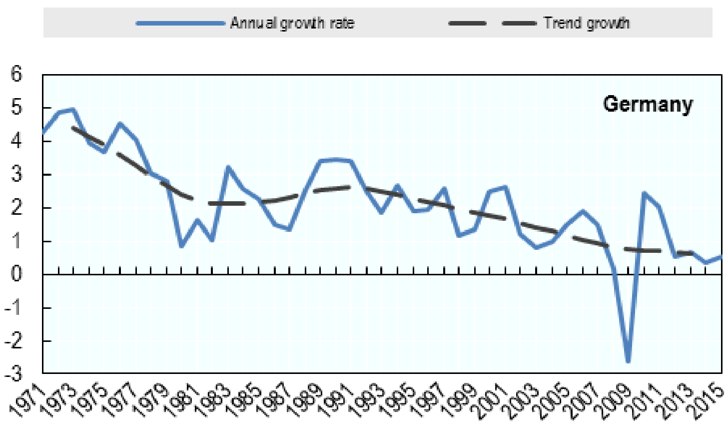
5. Conclusions

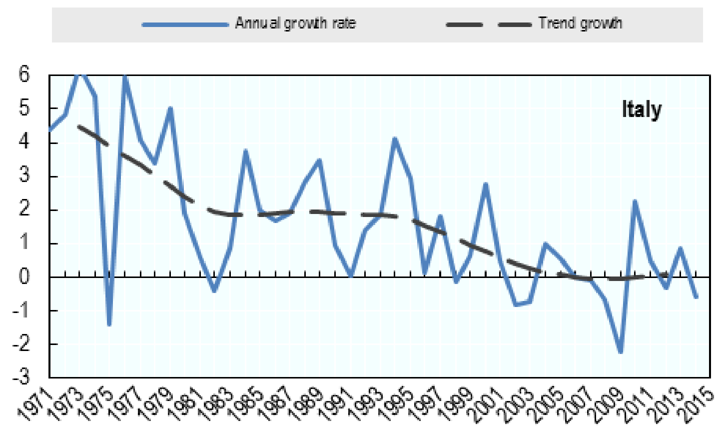
Labour Productivity Growth in G7 Countries

Average Annual Rate, OECD Productivity Compendium 2016









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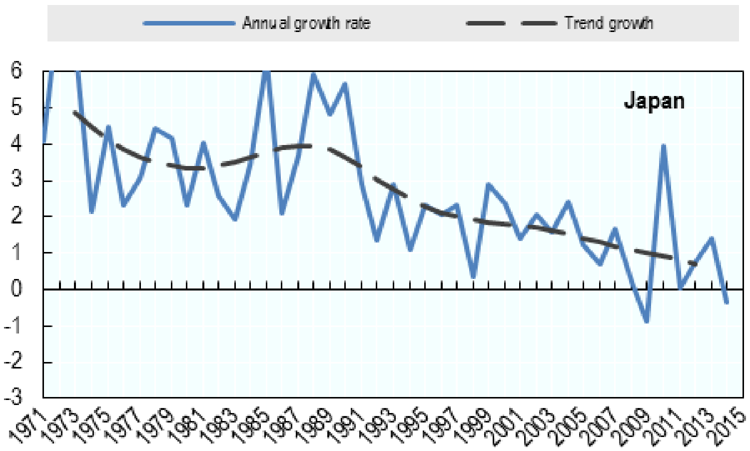
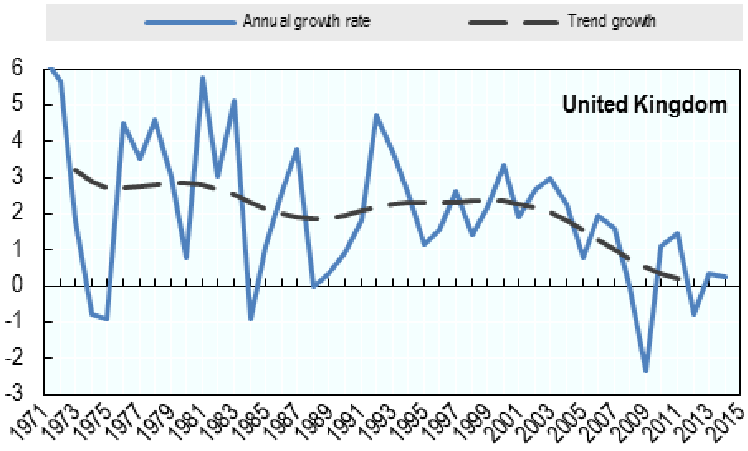
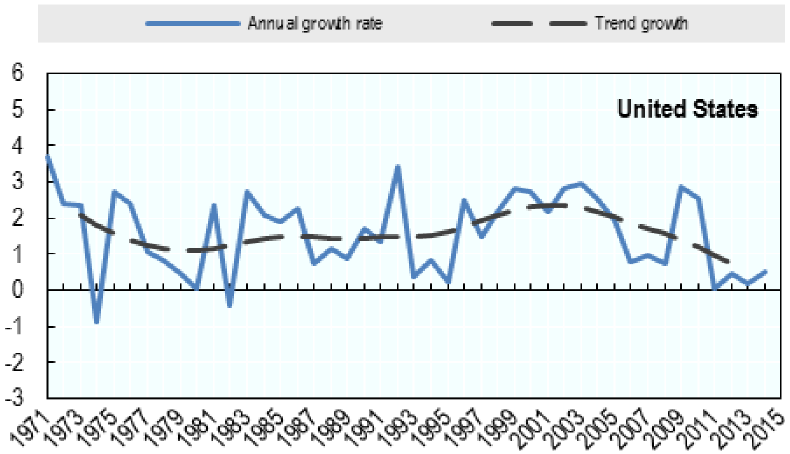
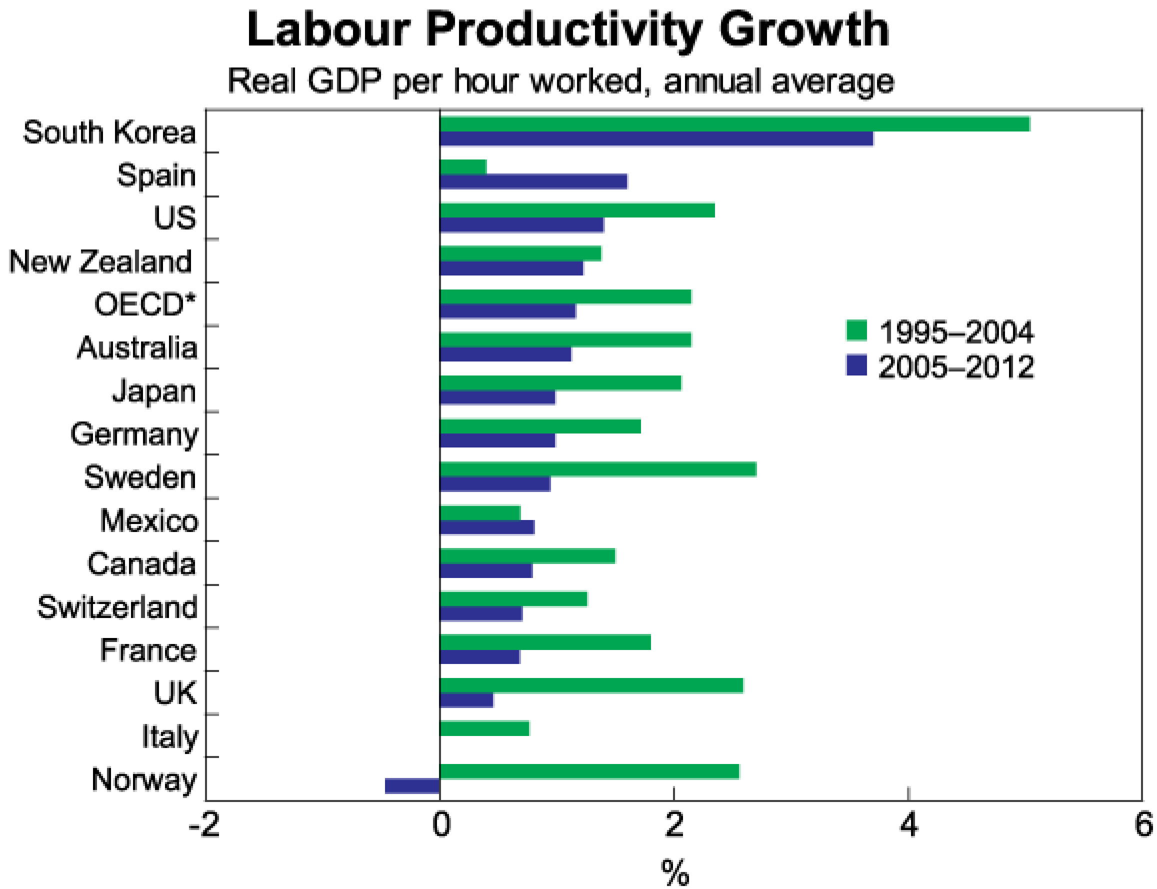






International Productivity Performance



* 1995–2004 period estimated based on 28 out of 34 countries

Sources: IMF; OECD; RBA

From a speech by Dr. Phillip Lowe, Deputy Governor, Reserve Bank of Australia: "Demographics, Productivity and Innovation," The Sydney Institute, Sydney, 12 March 2014. http://www.rba.gov.au/speeches/2014/sp-dg-120314.html

Mismeasurement?

Charlie Bean (2016):

"statistics have failed to keep pace with the impact of digital technology"

Hal Varian (Google):

"There's a lack of appreciation for what's happening in Silicon Valley, because we don't have a good way to measure it."

The Wall Street Journal (2015): Silicon Valley Doesn't Believe U.S. Productivity is Down

Chad Syverson (2016):

"The productivity slowdown has occurred in dozens of countries, and its size is unrelated to measures of the countries' consumption or production intensities of information and communication technologies."

Lack of Innovation?

Innovation is recognised as being key to increasing productivity in the economy.

OECD (2005) defines innovation as follows:

The implementation of a new or significantly improved product (good or service), or process, a new marketing method or a new organisational method in business practices, workplace organisation or external relations.

Lack of Innovation?

- There are several ways to improve productivity, but *knowledge capital* (through innovation leading to new technology, skills, R&D and efficient services and production processes) is a significant factor.

- Research performed by universities enhances the stock of knowledge available to society (Mowery and Sampat, 2010)

- Slowdown in growth of knowledge capital can slowdown growth in productivity.

Lack of Innovation?

“Everything that can be invented has been invented.”

(Attributed to) Charles H. Duell, Commissioner of US patent office, 1899.

Lack of Innovation?

Robert Gordon: “Why Innovation Won’t Save Us” (Wall Street Journal, 22-23 Dec. 2012)

Drying up of big breakthroughs:

Can economic growth be saved by Google’s driverless car?

I am not forecasting an end to innovation, just a decline in the usefulness of future inventions in comparison with the great inventions of the past.

Lack of Innovation?

But what about the evidence of a decline in inventiveness" ....?

*I interpret most of the proffered evidence as reflecting the impact of **reduced aggregate demand and less favourable economic prospects for inventive activity** in the late 1970s, rather than as the result of technological springs running dry.*

Griliches (1988): "Productivity Puzzles and R&D: Another Nonexplanation," *Journal of Economic Perspectives* 2(4), 9 – 21.

"The History of Technological Anxiety and the Future of Economic Growth: Is This Time Different?"

Joel Mokyr, Chris Vickers, and Nicolas L. Ziebarth (2015), *Journal of Economic Perspectives 29(3), 31–50*.

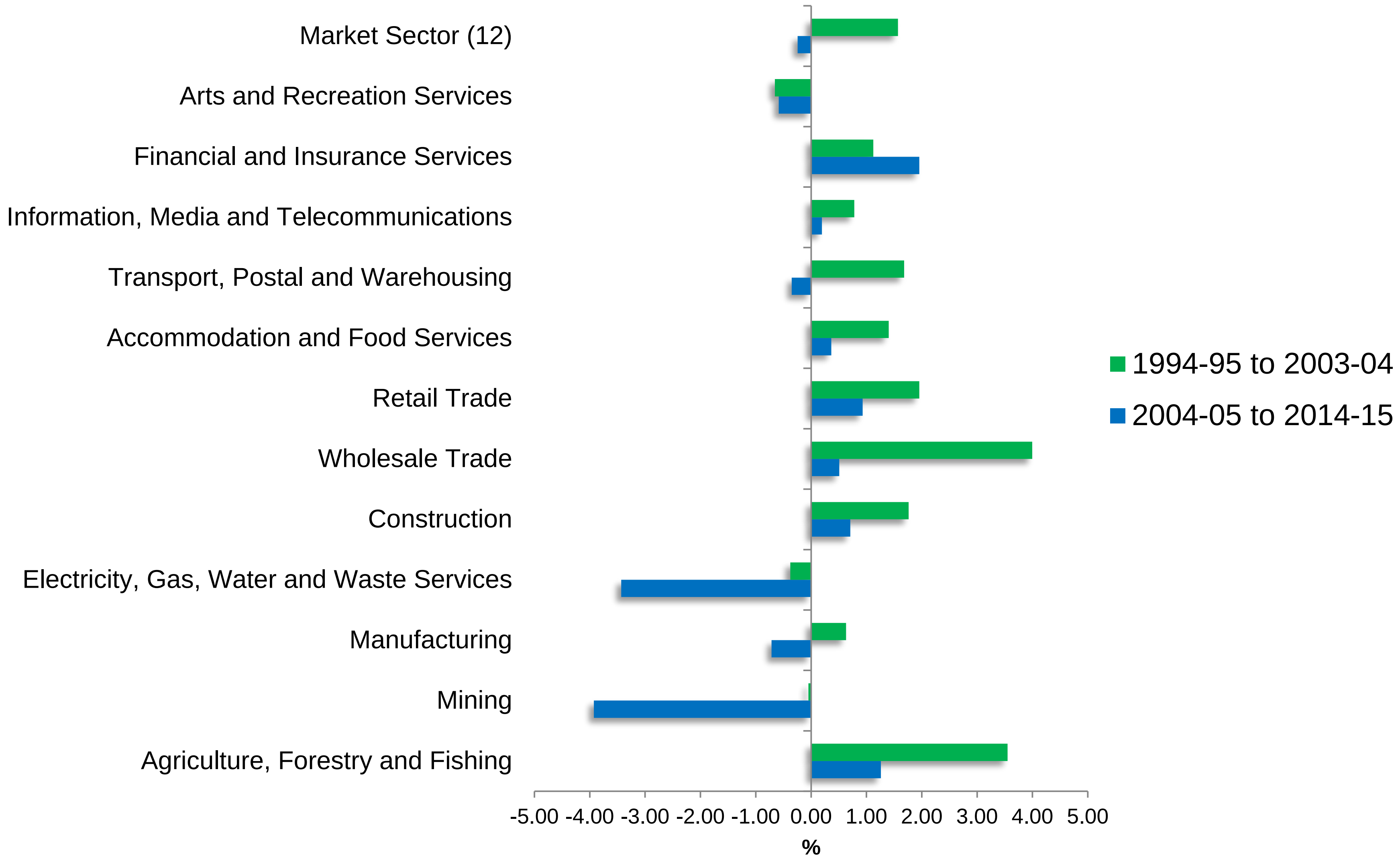
Alvin Hansen's1938 book *Full Recovery or Stagnation?:*

> *"Hansen drew on the macroeconomic ideas of John Maynard Keynes in fearing that economic growth was over, with population growth and technological innovation exhausted."*

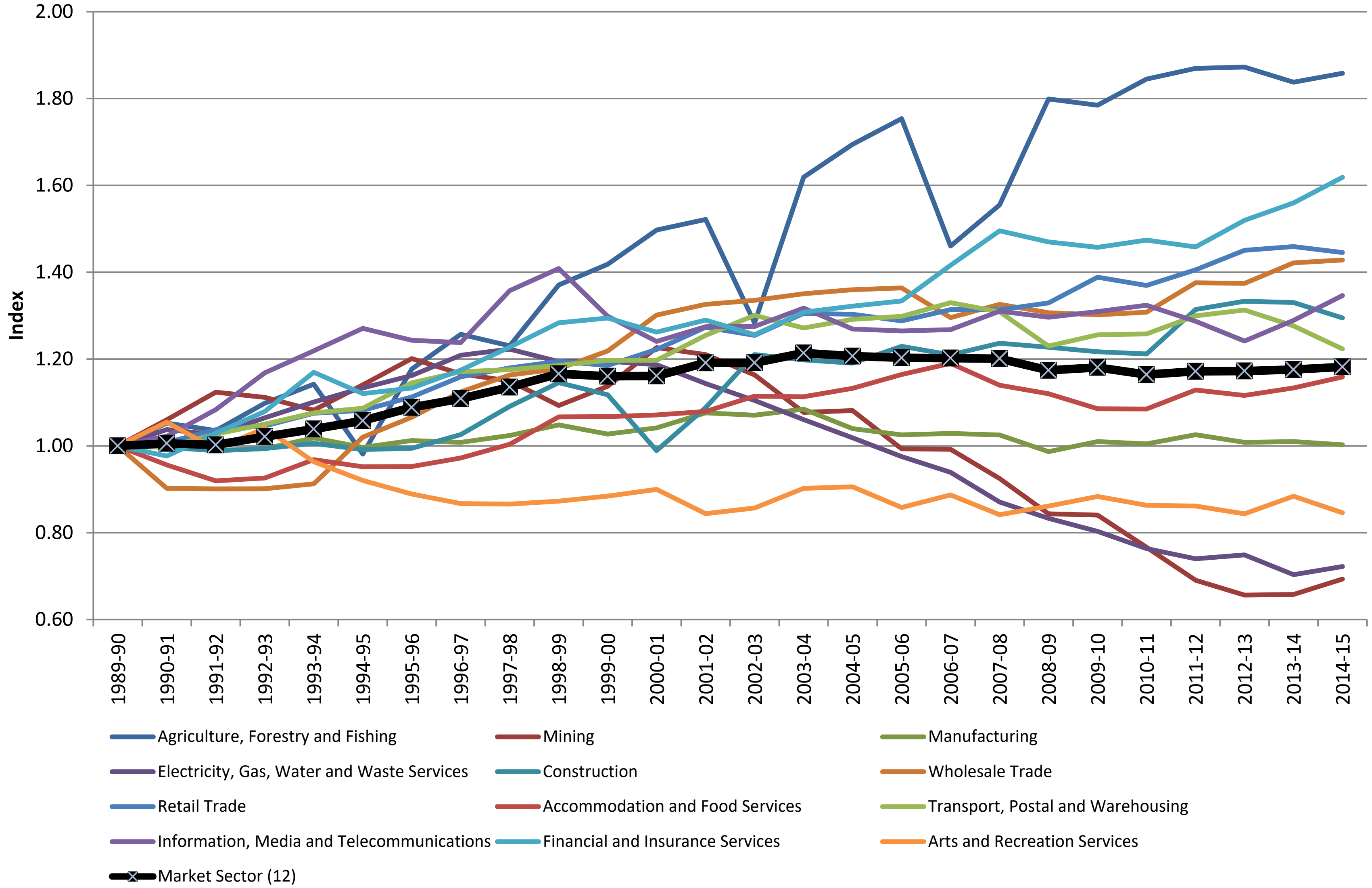
Such "technological anxiety" seems to repeat through history.

Australian Multifactor Productivity Slowdown

Market Sector, Annual Averages



Market Sector Cumulative Multifactor Productivity Indexes



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Plan

1. Productivity

2. R&D and other intangibles

3. Public Support for R&D

4. Unproductive Assets

5. Conclusions

Intangibles

- Thought to be important, but measurement difficult.

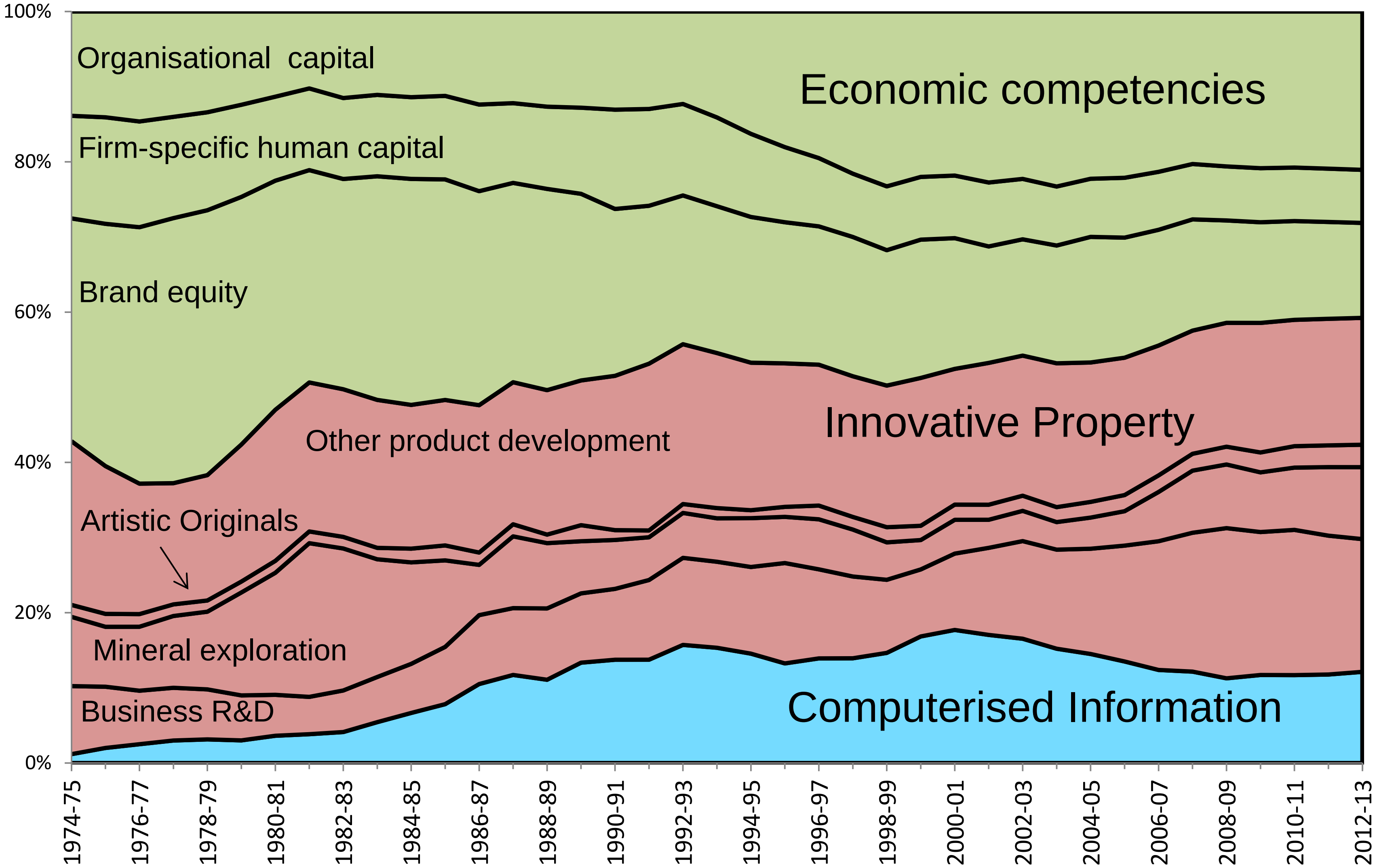
- Excluding investment in intangibles leads to an understatement of output (GDP) and possibly productivity

- Capitalising poses challenges in determining appropriate deprecation rates and asset lives.

- Some intangibles already included in ASNA:
  - Computer software, artistic originals, mineral exploration and R&D (from December 2009)

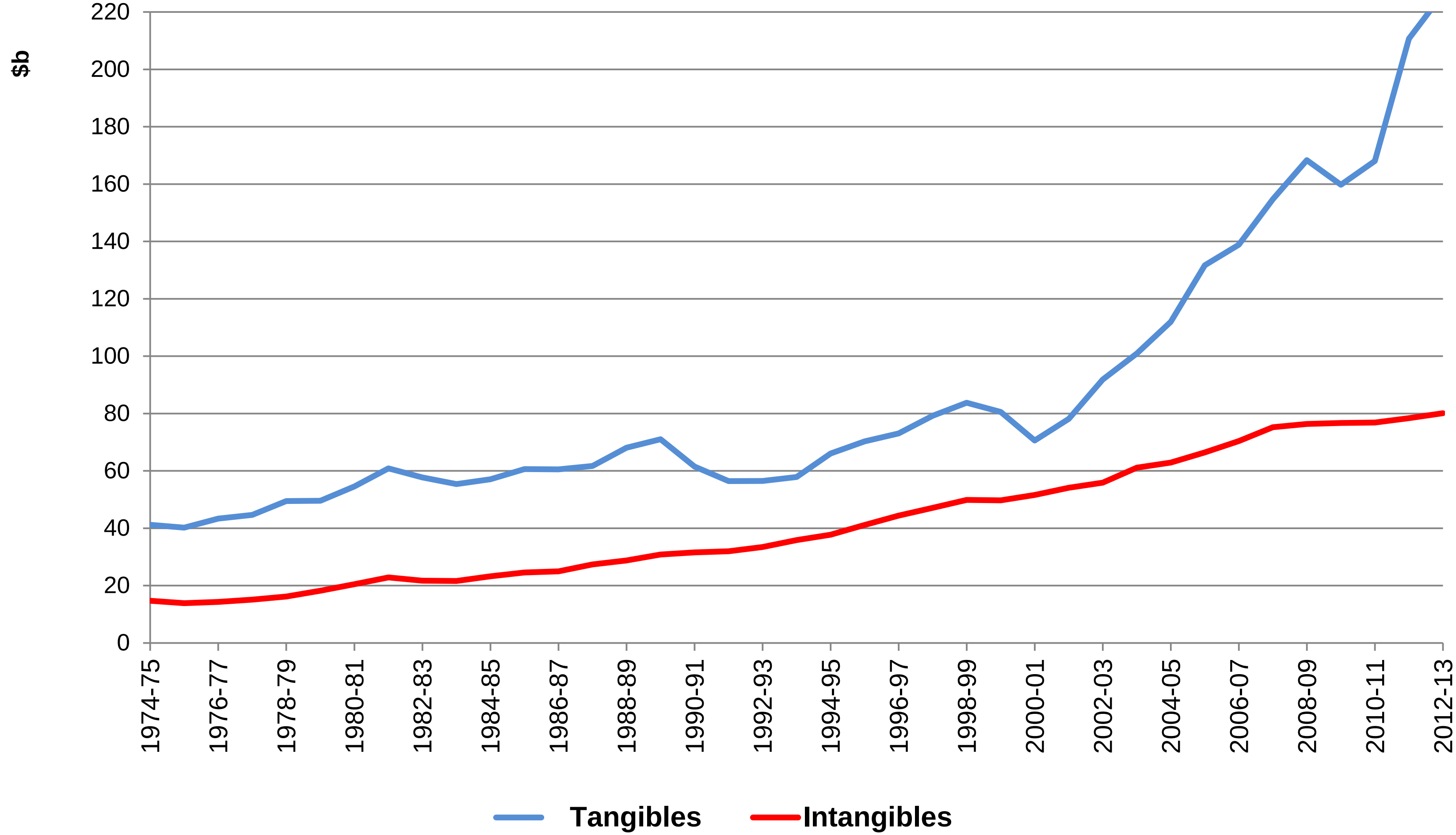
Shares of Nominal Intangible Investment by Asset Type

Corrado, Hulten and Sichel (2005, 2006) approach, Elnasri and Fox (2015)



Market sector real investment

2011-12 dollars, chain volume measures



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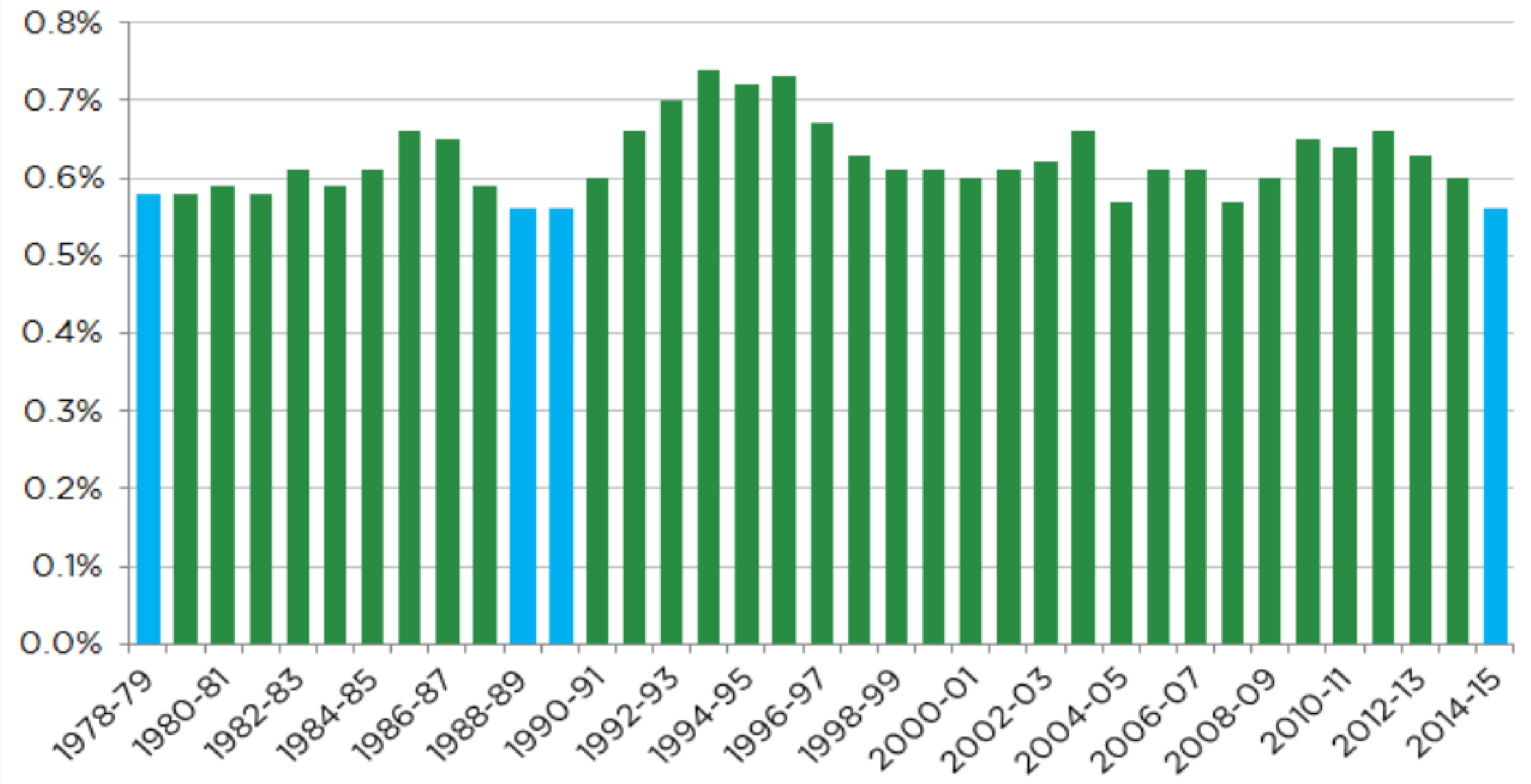
Public Support

- The rationale for governmental intervention is the existence of *market failure* associated with research and innovation.
- Typically due to the diffusion of knowledge beyond the control of the inventor.
- The *private rate of return* to research and innovation is *lower than its social return*.
- The amount invested then likely to be below the socially optimal level.
- Thus, there is a potential role for governments to intervene to *eliminate this gap between private and social returns*.

Australian Government Spending on R&D

Percentage of GDP

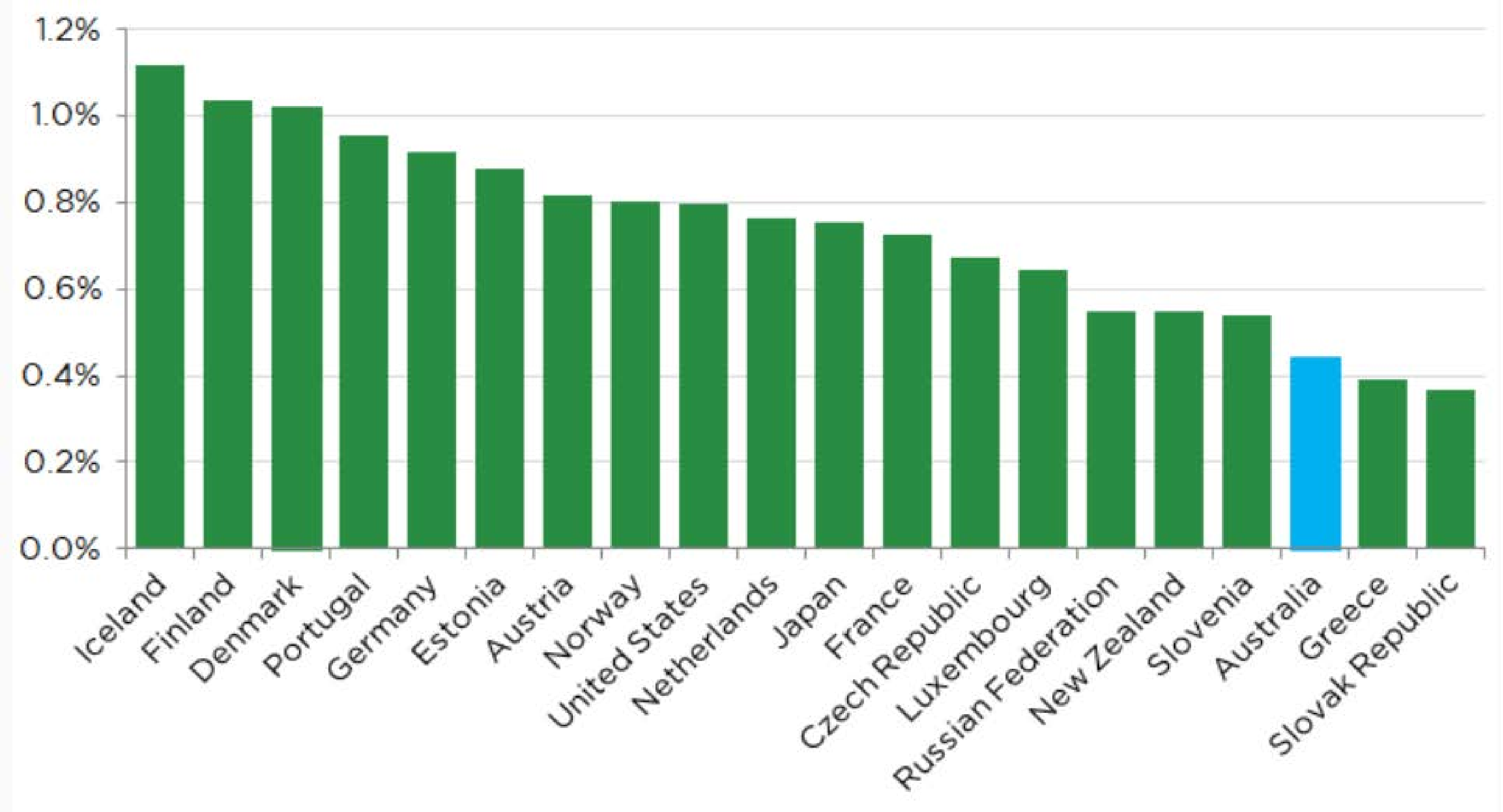


INFOGRAPHIC: Australian government spending on research and development, 1978-79 to 2014-15. Data by Parliamentary Library. (ABC Fact Check)

http://www.abc.net.au/news/2014-10-07/adam-bandt-research-development-spending-claim-checks-out/5789134

Government Spending on R&D

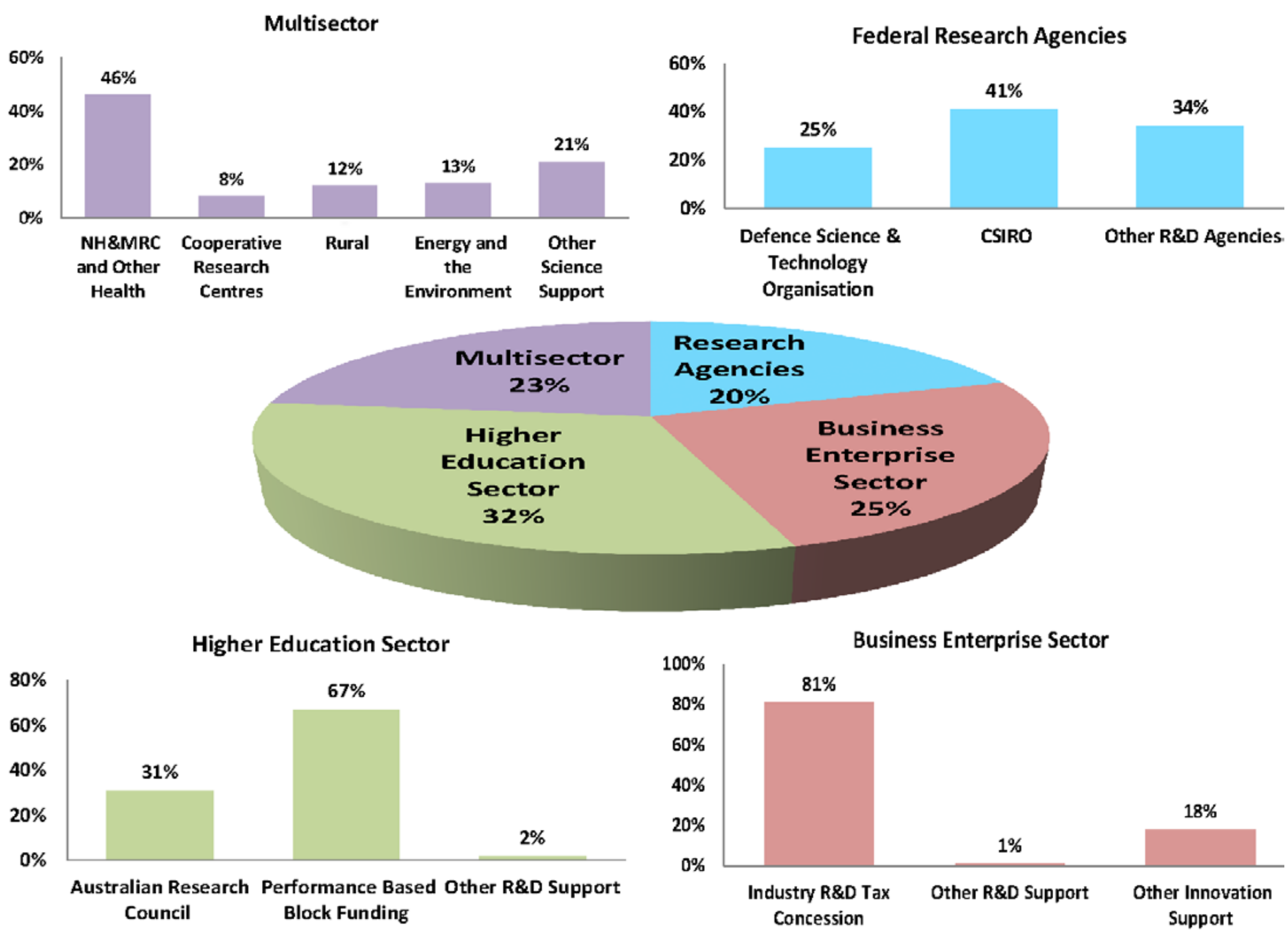
Percentage of GDP, 2013



INFOGRAPHIC: OECD figures on government spending on research and development as a percentage of GDP in 2013. (ABC Fact Check)

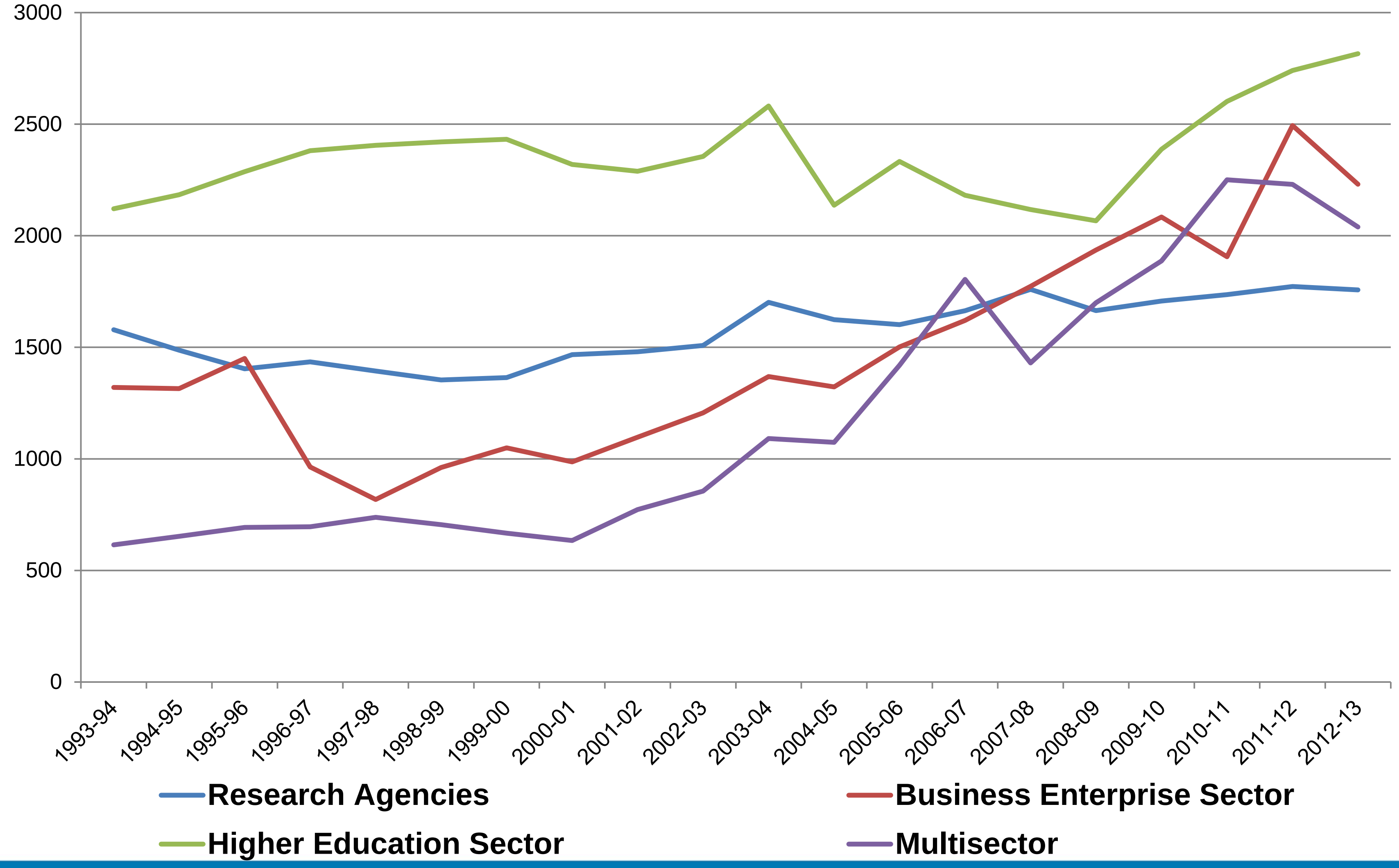
http://www.abc.net.au/news/2014-10-07/adam-bandt-research-development-spending-claim-checks-out/5789134

Australian Government spending on science, research and innovation 2012-13



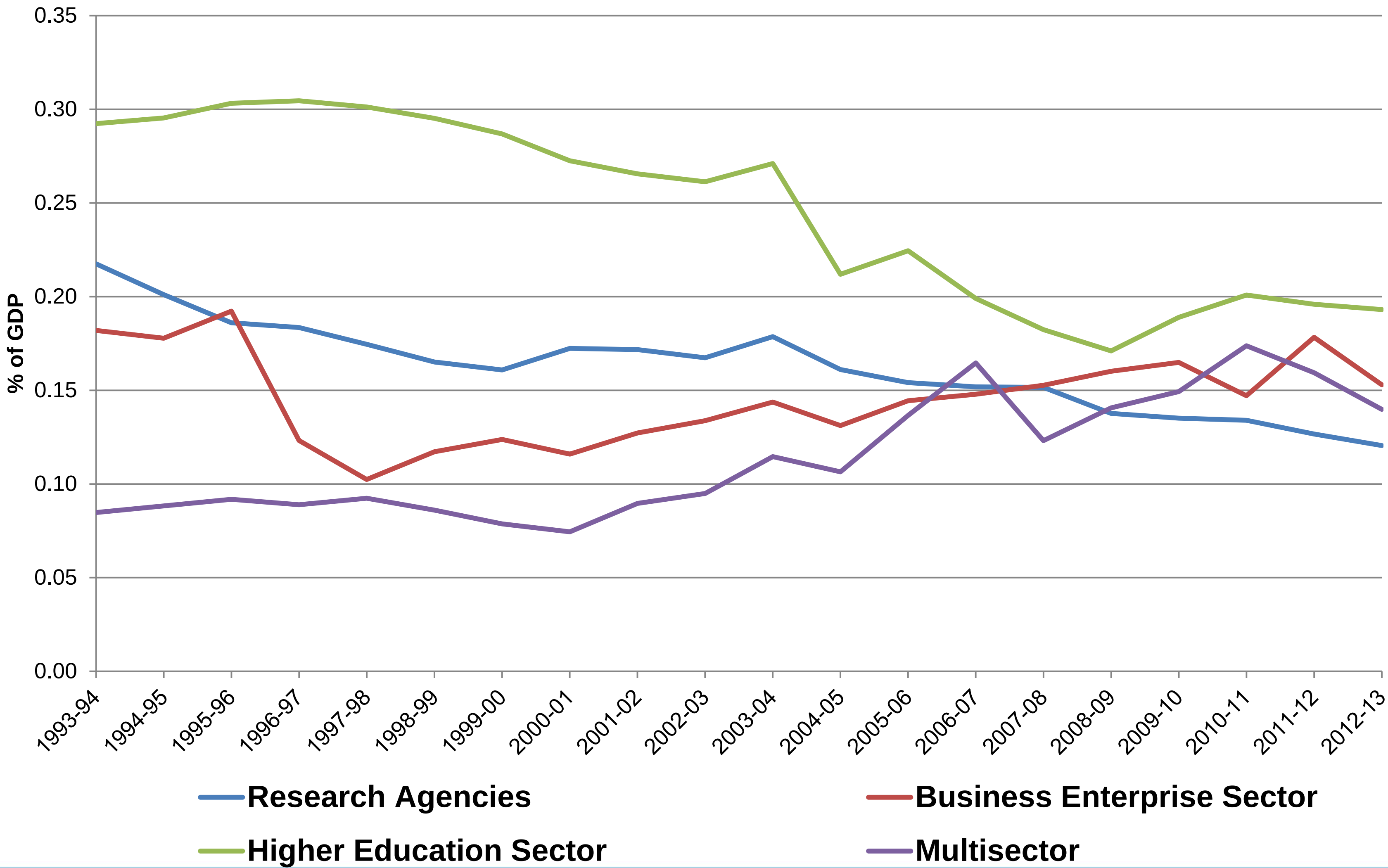
Public funding for science, research and innovation

($m 2011-12)



Public funding for science, research and innovation

(shares of GDP current prices)



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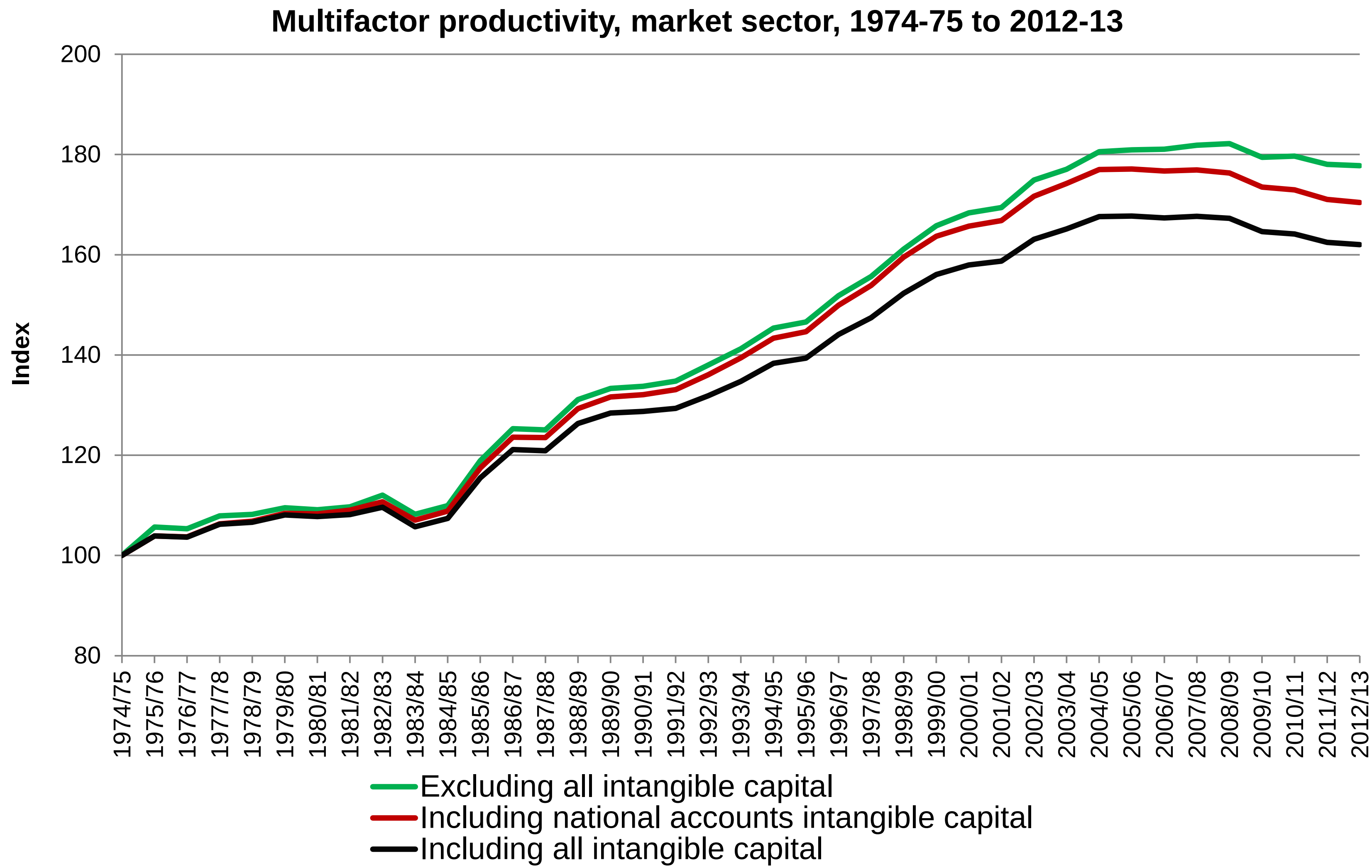
Results


Multifactor productivity, market sector, 1974-75 to 2012-13
Index
200
180
160
140
120
100
80
1974/75
1975/76
1976/77
1977/78
1978/79
1979/80
1980/81
1981/82
1982/83
1983/84
1984/85
1985/86
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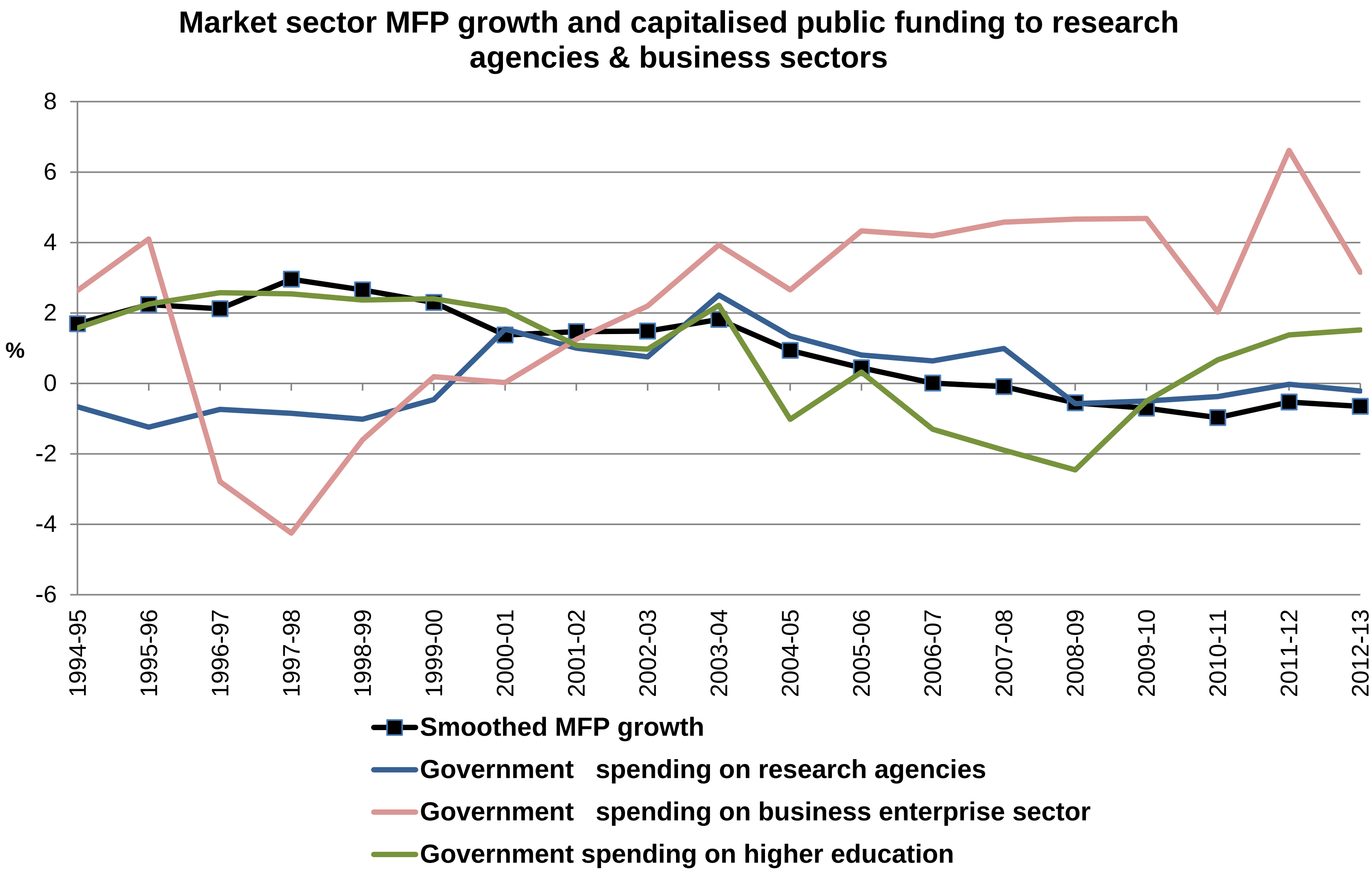
2011/12
2012/13
Excluding all intangible capital
Including national accounts intangible capital
Including all intangible capital

Results



Market sector MFP growth and capitalised public funding to research agencies & business sectors
8
6
4
2
0
-2
-4
-6
%
1994-95
1995-96
1996-97
1997-98
1998-99
1999-00
2000-01
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
Smoothed MFP growth
Government spending on research agencies
Government spending on business enterprise sector
Government spending on higher education

Estimating Equations

$$\ln MFP_t = \alpha_0 + \sum_{X=L,K,N^{PRV}} d_X \ln X + \varepsilon_{N^{PUB}} \ln N_t^{PUB} + \alpha_1 \ln Z_t + \upsilon_t.$$

$$\Delta \ln MFP_t = \alpha_0 + \sum_{X=L,K,N^{PRV}} d_X \Delta \ln X + \varepsilon_{N^{PUB}} \Delta \ln N_t^{PUB} + \alpha_1 \ln Z_t + \upsilon_t.$$

Spillovers from Intangible Investment

	$\ln MFP$	$\Delta \ln MFP^a$	$\ln MFP$	$\Delta \ln MFP^a$
Tangible capital	-0.175	-0.434**	-0.129*	-0.024
	(0.165)	(0.137)	(0.068)	(0.105)
Labour	-0.663***	-0.136	-0.579***	-0.098
	(0.137)	(0.096)	(0.074)	(0.057)
Intangible capital	0.579***	0.329		
	(0.062)	(0.226)		
Software			0.134***	0.100
			(0.007)	(0.059)
Innovative property			0.117*	-0.107
			(0.055)	(0.112)
Economic competencies			0.112***	0.256***
			(0.028)	(0.026)
Business cycle	0.734***	-0.094	0.826***	-0.026
	(0.181)	(0.122	(0.118)	(0.041)
Public infrastructure	0.194	-0.149	0.038	-0.140
	(0.216)	(0.302)	(0.123)	(0.149)
Openness	0.012**	-0.001	0-.001	0.006*
	(0.005)	(0.001)	(0.000)	(0.003)
Terms of Trade (t-1)	-0.106**	-0.022	-0.022*	-0.022
	(0.044)	(0.050)	(0.011)	(0.050)
$\bar{R}^2$	0.99	0.85	0.99	0.74
Durbin-Watson	1.66	1.15	2.73	3.03
Jarque-Bera test	0.624	0.285	0.467	0.083
Number of Observations	19	18	19	18

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Spillovers from Total Public Funding

	$\ln MFP$	$\Delta \ln MFP^a$	$\ln MFP$	$\Delta \ln MFP^a$
Tangible capital	-0.423**	-0.523**	-0.168	-0.223*
	(0.173)	(0.179)	(0.118)	(0.103)
Labour	-0.758***	-0.025	-0.547***	-0.008
	(0.159)	(0.108)	(0.117)	(0.094)
Intangible capital	0.461***	0.328	0.440***	0.339*
	(0.066)	(0.217)	(0.067)	(0.166)
Total public support	0.399**	-0.235		
	(0.143)	(0.243)		
Research agencies			0.349***	0.007
			(0.064)	(0.141)
Higher education			0.175*	0.324*
			(0.076)	(0.157)
Business enterprise			-0.056	-0.056
			(0.060)	(0.066)
Multisector			-0.032	-0.021
			(0.035)	(0.051)
Business cycle	1.188***	-0.073	0.876***	0.083
	(0.202)	(0.119)	(0.156)	(0.134)
Public infrastructure	0.521**	-0.328	0.308	-0.432
	(0.222)	(0.319)	(0.211)	(0.404)
Terms of Trade (t-1)	-0.106**	-0.018	-0.037	-0.009
	(0.044)	(0.050)	(0.027)	(0.022)
$\bar{R}^2$	0.99	0.75	0.99	0.87
Durbin-Watson	1.41	1.42	2.33	2.33
Jarque-Bera test	0.732	0.514	0.167	0.320
Number of Observations	19	18	19	18

Spillovers from Public Funding: Research Agencies

	$\ln MFP$	$\Delta \ln MFP^a$	$\ln MFP$	$\Delta \ln MFP^a$
Tangible capital	-0.381***	-0.586***	-0.419***	-0.505**
	(0.111)	(0.163)	(0.120)	(0.130)
Labour	-0.789***	-0.043	-0.845***	-0.007
	(0.097)	(0.103)	(0.133)	(0.121)
Intangible capital	0.477***	0.289	0.449***	0.078
	(0.038)	(0.276)	(0.053)	(0.268)
Research agencies	0.295***	-0.1376		
	(0.052)	(0.193)		
Research agencies (t-1)			0.358***	-0.490*
			(0.048)	(0.163)
Business cycle	1.163***	-0.006	1.274***	-0.033
	(0.130)	(0.135)	(0.182)	(0.086)
Public infrastructure	0.778***	-0.373	1.025***	-1.023**
	(0.197)	(0.365)	(0.249)	(0.388)
Terms of Trade (t-1)	-0.066**	-0.003	-0.092**	0.022
	(0.034)	(0.050)	(0.038)	(0.032)
$\bar{R}^2$	0.99	0.75	0.99	0.85
Durbin-Watson	2.02	1.42	2.17	1.85
Jarque-Bera test	0.656	0.514	0.876	0.517
Number of Observations	19	18	19	18

Spillover from Public Funding: Research Agencies - breakdown

	$\ln MFP$	$\Delta \ln MFP^a$	$\ln MFP$	$\Delta \ln MFP^a$
Tangible capital	-0.347***	-0.543**	-0.390***	-0.509***
	(0.072)	(0.217)	(0.063)	(0.147)
Labour	-0.696***	-0.007	-0.527***	0.027
	(0.097)	(0.143)	(0.110)	(0.119)
Intangible capital	0.414***	0.308	0.224***	0.095
	(0.053)	(0.263)	(0.027)	(0.293)
Research agencies (x defence)	0.256***	-0.038		
	(0.040)	(0.145)		
Defence	-0.065	-0.140		
	(0.075)	(0.196)		
Research agencies (x defence) (t-1)			0.295***	-0.339
			(0.031)	(0.204)
Defence (t-1)			-0.417	-0.176
			(0.073)	(0.178)
Business cycle	1.120***	-0.024	1.206***	-0.028
	(0.107)	(0.145)	(0.097)	(0.108)
Public infrastructure	0.698***	-0.304	0.857***	-0.953
	(0.127)	(0.361)	(0.104)	(0.748)
Terms of Trade (t-1)	-0.045	-0.002	0.026	0.029
	(0.027)	(0.043)	(0.028)	(0.033)
$\bar{R}^2$	0.99	0.72	0.99	0.84
Durbin-Watson	1.80	1.27	2.70	1.82
Jarque-Bera test	0.702	0.777	0.837	0.618
Number of Observations	19	18	19	18

Spillovers from Public Funding: Higher Education

	$\ln MFP$	$\Delta \ln MFP^a$	$\ln MFP$	$\Delta \ln MFP^a$
Tangible capital	-0.162	-0.263**	-0.074	-0.254**
	(0.197)	(0.115)	(0.155)	(0.177)
Labour	-0.375	-0.046	-0.426***	-0.044
	(0.221)	(0.093)	(0.101)	(0.064)
Intangible capital	0.535***	0.357**	0.412***	0.460***
	(0.061)	(0.127)	(0.062)	(0.097)
Higher education	0.305**	0.409***		
	(0.120)	(0.123)		
Higher education (t-1)			0.352***	0.378***
			(0.068)	(0.116)
Business cycle	0.519***	0.148**	0.594***	0.075
	(0.230)	(0.076)	(0.075)	(0.070)
Public infrastructure	-0.288	-0.378	-0.098	-0.170
	(0.362)	(0.324)	(0.184)	(0.262)
Terms of Trade (t-1)	-0.019	0.002	-0.045	-0.015
	(0.044)	(0.022)	(0.025)	(0.028)
$\bar{R}^2$	0.99	0.89	0.99	0.89
Durbin-Watson	1.10	2.44	1.92	2.54
Jarque-Bera test	0.656	0.422	0.534	0.810
Number of Observations	19	18	19	18

Spillovers from Public Funding: Business Enterprise

	$\ln MFP$	$\Delta \ln MFP^a$	$\ln MFP$	$\Delta \ln MFP^a$
Tangible capital	-0.445***	-0.306**	-0.259	-0.480**
	(0.218)	(0.129)	(0.197)	(0.158)
Labour	-0.795***	0.078	-0.522***	-0.018
	(0.205)	(0.090)	(0.154)	(0.118)
Intangible capital	0.604***	0.228	0.589***	0.328*
	(0.050)	(0.166)	(0.063)	(0.097)
Business enterprise	0.108	-0.179**		
	(0.073)	(0.061)		
Business enterprise (t-1)			-0.077	-0.150*
			(0.052)	(0.068)
Business cycle	1.100***	-0.106	0.684***	-0.062
	(0.257)	(0.090)	(0.168)	(0.099)
Public infrastructure	0.558	-0.534	0.199	-0.205
	(0.330)	(0.377)	(0.282)	(0.338)
Terms of Trade (t-1)	-0.087	-0.033	-0.071	0.015
	(0.058)	(0.026)	(0.063)	(0.036)
$\bar{R}^2$	0.99	0.84	0.99	0.82
Durbin-Watson	1.26	1.84	1.23	1.87
Jarque-Bera test	0.896	0.396	0.564	0.888
Number of Observations	19	18	19	18

Conclusions

- Treating investment in intangible assets as capital considerably affects the level of MFP.

- Evidence of market sector spillovers from intangibles.

- Similar to Haskel and Wallis (2013) for the UK, find *evidence of spillovers from public R&D spending on research agencies and higher education*, but not from the other types of public support.

Further Evidence on Role of the High Education Sector

- Burgio-Ficca (2004) finds evidence of a positive relationship between higher education R&D and gross state product.

- Evidence of the positive impacts of universities and research agencies on firm productivity, through the development of skilled labour and positive externalities (Malecki 1997; Medda *et al.* 2005).

- Adams (2002) found evidence of academic spillovers from U.S. R&D laboratories that induce the clustering of firms with universities and research agencies.

Further Evidence on Role of the High Education Sector

- Woodward *et al.* (2006) found that R&D intense production tends to be located close to universities.

- Jaffe (1989) found that patented inventions at the state level in the U.S. depend significantly on university research.

- Yaşar and Morrison Paul (2012) found more patent activity and higher productivity in Chinese firms with university and research institution connections.

Further Evidence on Role of the High Education Sector

- Bakhtiari and Breunig (2017), Australian Department of Industry, Innovation and Science:
  - higher education R&D expenditure has a positive influence on firm-level R&D expenditure in Australia.

- 2016 Review of the R&D Tax Incentive (chaired by the Chief Scientist and the Secretary of the Treasury)
  - Six recommendations, including:

  “*A premium rate of up to 20 per cent for collaborative R&D projects with publicly-funded research organisations (such as universities)*”