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.”
(http://sjm.ministers.treasury.gov.au/speech/009-2016/)
The role of science, research and technology in lifting Australia’s productivity

FINAL REPORT

AUSTRALIAN ACADEMY OF THE HUMANITIES
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Related Papers


- 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

- **Canada**
- **France**
- **Germany**
- **Italy**
Labour Productivity Growth in G7 Countries
Average Annual Rate, OECD Productivity Compendium 2016

Japan

United Kingdom

United States
International Productivity Performance

Labour Productivity Growth
Real GDP per hour worked, annual average

South Korea | Spain | US
New Zealand | OECD* | Australia
Japan | Germany | Sweden
Mexico | Canada | Switzerland
France | UK | Italy
Norway

* 1995–2004 period estimated based on 28 out of 34 countries
Sources: IMF; OECD; RBA

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.”

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.”

Lack of Innovation?


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.

Alvin Hansen’s 1938 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

-5.00 -4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00 4.00 5.00

Agriculture, Forestry and Fishing
Mining
Manufacturing
Electricity, Gas, Water and Waste Services
Construction
Retail Trade
Wholesale Trade
Information, Media and Telecommunications
Accommodation and Food Services
Transport, Postal and Warehousing
Arts and Recreation Services

% 1994-95 to 2003-04
2004-05 to 2014-15

UNSW Australia
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 depreciation 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

- Organisational capital
- Firm-specific human capital
- Brand equity
- Economic competencies
- Innovative Property
- Other product development
- Artistic Originals
- Mineral exploration
- Business R&D
- Computerised Information

Yearly data from 1974-75 to 2012-13.
Plan

1. Productivity
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3. Public Support for R&D
4. Results
5. Conclusions
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


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)

Plan

1. Productivity
2. R&D and other intangibles
3. Public Support for R&D

4. Results

5. Conclusions
Results

Multifactor productivity, market sector, 1974-75 to 2012-13

Index


- 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

- Smoothed MFP growth
- Government spending on research agencies
- Government spending on business enterprise sector
- Government spending on higher education
Estimating Equations

\[
\ln MFP_t = \alpha_o + \sum_{X=L,K,N^{PRV}} d_X \ln X + \varepsilon_{N^{PUB}} \ln N_{t}^{PUB} + \alpha_1 \ln Z_t + \nu_t.
\]

\[
\Delta \ln MFP_t = \alpha_o + \sum_{X=L,K,N^{PRV}} d_X \Delta \ln X + \varepsilon_{N^{PUB}} \Delta \ln N_{t}^{PUB} + \alpha_1 \ln Z_t + \nu_t.
\]
## Spillovers from Intangible Investment

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### Spillovers from Total Public Funding

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<td>(0.143)</td>
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<td>(0.064)</td>
<td>(0.141)</td>
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<td>(0.130)</td>
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Spillover from Public Funding: Research Agencies - breakdown

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<th>$\ln MF P$</th>
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<td>-0.304</td>
<td>0.857***</td>
<td>-0.953</td>
</tr>
<tr>
<td></td>
<td>(0.127)</td>
<td>(0.361)</td>
<td>(0.104)</td>
<td>(0.748)</td>
</tr>
<tr>
<td><strong>Terms of Trade (t-1)</strong></td>
<td>-0.045</td>
<td>-0.002</td>
<td>0.026</td>
<td>0.029</td>
</tr>
<tr>
<td></td>
<td>(0.027)</td>
<td>(0.043)</td>
<td>(0.028)</td>
<td>(0.033)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.99</td>
<td>0.72</td>
<td>0.99</td>
<td>0.84</td>
</tr>
<tr>
<td>Durbin-Watson</td>
<td>1.80</td>
<td>1.27</td>
<td>2.70</td>
<td>1.82</td>
</tr>
<tr>
<td>Jarque-Bera test</td>
<td>0.702</td>
<td>0.777</td>
<td>0.837</td>
<td>0.618</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>19</td>
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### Spillovers from Public Funding: Higher Education

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

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


- 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)”