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BANKWEST CURTIN ECONOMICS CENTRE

POSITIONED FOR AN IDEAS BOOM?

Productivity and Innovation in Australia

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About the Centre

The Bankwest Curtin Economics Centre is an independent economic and social research organisation located within the Curtin Business School at Curtin University. The centre was established in 2012 through the generous support from Bankwest (a division of the Commonwealth Bank of Australia), with a core mission to examine the key economic and social policy issues that contribute to the sustainability of Western Australia and the wellbeing of WA households.

The Bankwest Curtin Economics Centre is the first research organisation of its kind in Western Australia, and draws great strength and credibility from its partnership with Bankwest, Curtin University and the Western Australian government.

The centre brings a unique philosophy to research on the major economic issues facing the state. By bringing together experts from the research, policy and business communities at all stages of the process – from framing and conceptualising research questions, through the conduct of research, to the communication and implementation of research findings – we ensure that our research is relevant, fit for purpose, and makes a genuine difference to the lives of Australians, both in WA and nationally.

The centre is able to capitalise on Curtin University's reputation for excellence in economic modelling, forecasting, public policy research, trade and industrial economics and spatial sciences. Centre researchers have specific expertise in economic forecasting, quantitative modelling, micro-data analysis and economic and social policy evaluation. The centre also derives great value from its close association with experts from the corporate, business, public and not-for-profit sectors.

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Foreword

Positioned for an Ideas Boom: Productivity and Innovation in Australia is the fourth report in the Bankwest Curtin Economics Centre's Focus on the States series. The report examines an issue of central importance to maintaining economic growth, improving competitiveness and creating jobs – Productivity and Innovation.

The much anticipated National Innovation and Science Agenda launched by Prime Minister Malcolm Turnbull in December 2015 has committed funding of $1.1 billion over four years to twenty eight action areas, which include de-risking start-ups; investing in STEM; attracting and keeping overseas entrepreneurs; and improving university-industry connectedness, amongst others.

These measures are welcome not just because of the commitment of financial support to innovation programmes, but also because of the important signal that promoting a culture of innovation is essential to Australia's economic growth and future prosperity.

So is Australia positioned to capitalise on an ideas boom?

It is more important now than ever for Australia to both learn from, and drive, prosperity through international collaborations. Australia has the people, the resources, the environment, the knowledge and the creativity to thrive in the future, and to contribute to national and global economic growth. But significant barriers remain, specifically in relation to access to research and development funding and venture capital investment, especially to smaller enterprises and at early stages of business expansion.

The National Innovation and Science Agenda provides a credible and coherent prospectus of policies, and significant government funding support, to drive productivity and innovation growth in Australia. The opportunity, and the responsibility, falls on us all – government, families, businesses, universities and research institutions - to bring the ideas boom to reality.

I thank you for your interest in this *Focus on the States* report, and hope the findings are both thought-provoking and illuminating.

Professor Alan Duncan
Director, Bankwest Curtin Economics Centre
Curtin Business School, Curtin University

Executive summary

New sources of growth have become a policy priority for many jurisdictions following the sustained period of slow growth post-Global Financial Crisis (GFC). Governments are trying to grapple with the policy dilemmas of slow productivity growth, disruptive technologies, and population changes. In Australia, we have seen the Government take steps aimed at improving economic growth, prosperity, increased productivity and innovation.

Most recently, these initiatives have emerged through the Government's Industry Innovation and Competitiveness Agenda and the National Innovation and Science Agenda

This fourth report in the Bankwest Curtin Economics Centre's Focus on the States series address an issue of central importance to Australia in maintaining economic growth, improving competitiveness and creating jobs – Productivity and Innovation.

Key findings

Productivity trends in Australia

- Labour productivity is often regarded as an indicator of improvements in living standards.
- With the exception of 1999-2000, Australia has shown a steady year-on-year LP growth over the period 1994 to 2015.
- Capital deepening has been the main contributor to Labour productivity growth, with MFP having a smaller, but positive effect
- Capital input has increased significantly (4.37%), resulting in a capital-labour ratio increase of 3.6 percentage points.
- MFP contributed substantially to output growth between 1995-89, and 2001-02. However, its contribution since 2003-04 has either been negative or positive but relatively small.
- There has been a declining contribution of hours worked to output growth in Australia.
- Changes in the composition of the labour force emphasise the growing importance of 'knowledge workers' to output growth in Australia.

Australia's productivity: international comparisons

- Australia's living standards lie above the OECD average. However, it lags behind USA, France, and Germany, amongst others.
- Australia's LP growth (1.72 per cent) is slightly above the OECD average (1.57 per cent) for the period 1995-2013.
- Post GFC, labour productivity growth has fallen significantly in most OECD countries.

Key findings (continued)

- Increased LP growth does not necessarily imply improvements in competitiveness, and must be looked at in the context of other macroeconomic indicators.
- With the exception of Spain, Italy and Portugal, MFP contributes significantly to LP growth for OCED economies.
- Post-GFC, many OECD countries have experienced a strong decline in the contribution of MFP to LP growth.

Productivity growth by industry sector

- In the fifteen years to 2015, the contribution of the Market 16 industries to output, declined from 76% to 72.4%.
- From 1990 to 2015, Mining's contribution to GVA increased from being the seventh largest contributor to GVA (4.9%) to being the third largest contributor (7.2%).
- Financial and Insurance Services' contribution to GVA increased from third highest (5.8%) in 1990 to being the largest contributor (9.3%) in 2015.
- Professional, Scientific and Technical Services moved from ninth (4.3%) in 1990 to the fifth largest contributor (6.6%) in 2015.
- Agriculture, Forestry and Fishing, which has seen its ranking in contribution to GVA decline from eight position (4.6%) in 1990 to fourteenth position (2.2%) in 2015.
- These movements point towards a transitioning Australian economy – and specifically towards a more knowledge-intensive economy.
- The majority of industry sectors demonstrate positive labour productivity growth, with the exception of Mining and Electricity, Gas, Water and Waste Services.
- For the majority of industries, LP growth has not returned to those levels experienced between 1995 and 2005. However, eleven of the sixteen market sector industries have seen an improvement in LP growth in 2012-11 to 2014-15 compared to the previous interval.

How Innovative is Australia?

- For a business, innovation is "the introduction of a product or process that is new to it".
- 58% of Australian businesses are innovative-active.
- More than 50% of firms in the Wholesale Trade, Retail Trade, Information Media and Telecommunications, and Manufacturing sectors report being innovation-active.
- Small businesses are less likely to introduce productivity enhancing process innovations.
- The Health Care and Social Assistance sector (+26.0%) records the biggest increase in the proportion of innovative active firms over time, followed by Retail Trade and Administrative and Support Services (+17.1%).
- Retail Trade, Arts and Recreation Services, Other Services, Health Care and Social Assistance, and Accommodation and Food Services) have experienced increases above 10% in the proportion of businesses that are innovation-active.

- Australia's larger businesses are more likely to be innovation-active than micro and SMEs and are more likely to produce innovations that are new to the world.
- Firms within the Professional, Scientific and Technical Services report the highest level of 'new to the world' innovations.

Why do businesses innovate?

- The most commonly reported benefit of innovation for micro-businesses is increased revenue, followed by improved customer service.
- Larger firms are most likely to report the benefit of a reduction in costs due to the introduction of an innovation.
- Competition, demand or market drivers are the most significant driver of innovation, with around three-quarters of all firms citing this as a key driver of innovation.

Better together: collaboration and innovation

- Only 7.7 per cent of Australian's innovation active firms are collaborating internationally.
- Innovation active businesses are almost three times as likely to operate in overseas markets.
- Increased collaboration with universities suggests that Australian businesses are increasingly seeking new sources of knowledge.

Getting in the way? Barriers to innovation

- Around one-fifth of Australian businesses report lack of access to additional funds as the greatest barrier to innovation.
- Access to knowledge or technology' is one of the lowest cited barriers to innovation among Australian businesses.
- Government regulations or compliance is seen as a significant barrier to innovation.

Investing in the Ideas Boom

- Over the past two decades, government spending on research and development (R&D) has remained relatively flat at around three to $3.5 billion from 1992-93 to 2013-14.
- Higher education R&D expenditure has had a steady growth trajectory over the last two decades and currently stands at around $10bn.
- Real business R&D expenditure increased from $6.2 billion in 1999-00 to $19.4 billion in 2008-09.
- Business R&D expenditure for WA relative to gross state product, has halved since peaking at $20,000 for every $1m in GSP in 2008-09.
- Victoria and NSW are currently equal first in terms of business R&D spend relative to GSP.
- All states bar NSW have seen a decrease in real business R&D expenditure since the GFC.
- Venture capital and later stage private equity per investee company is the highest in Queensland at $15.6m.

- The proportion of capital devoted to early expansion has almost halved over the last decade, from 30% to 16.1%.

Why proximity matters for innovation

- Larger cities tend to produce more patents per person than smaller cities.
- Countries and states with larger share of population in large cities tend to be more innovative.
- Innovative cities tend to have strong universities, effective business-university relationships and specialised industrial clusters.

How Innovative are Australia's regions?

- Sydney produces the most patents with more than 11 patents per 1,000 workers between 2008 and 2012.
- Suburbs in Brisbane and Sydney perform highly at producing patents.
- Regions with dispersed populations tend to be less innovative.
- Queensland regions perform highly in other innovation indicators and have improved their performance between 2009 and 2014.
- The innovation performance of Australia's regions and suburbs has generally declined between 2009 and 2014.
- Suburbs with universities, close to the city centre or with recent urban growth may be more innovative.

The role of universities: knowledge creation and knowledge flows

- NSW universities have the highest proportion of research income sourced from industry.
- Universities in South Australia and Tasmania have increased their share of research income sourced from industry.
- The ACT has the highest industry research income per capita among all states and territories – $97 per person.

Introduction

"Virtually all of the economic growth that has occurred since the eighteenth century is ultimately attributable to innovation". William J. Baumol (2002)

Driving productivity and innovation growth has become an essential policy priority for Australia as it seeks to build competitive advantage against a background of challenging global market conditions, slowing productivity growth, disruptive technologies, and population changes.

The National Innovation and Science Agenda launched by Prime Minister Malcolm Turnbull in December 2015 involves a series of measures to drive an "ideas boom" in Australia, with the aim to promote economic growth and prosperity through increased productivity and innovation. Spending commitments of nearly $1.1billion have been made over the next four years to strengthen ties between industry, universities and scientific institutions, and to promote business research, development and innovation.

Economic growth is affected by three main drivers of productivity, participation and population, and this *Focus on the States* report is focussed on the first of these – productivity.

The concept of productivity growth is important, as it is seen as a measure of improved living standards. While productivity growth measures are not without their limitations, they do provide an important benchmark from which we can compare Australia's living standards internationally, and make comparisons at an industry level.

Productivity and innovation are intertwined concepts. Innovation is a key driver for increased competitiveness, productivity growth and job creation, and many business sectors in Australia face with the constant pressure to innovate to maintain market position in what is a fast-changing, technological and globally-based economy.

This research seeks to provide some answers to the question posed in the title to the report. Australia's productivity and innovation trends are examined over time and across industry sectors, and our international standing as a productive nation of innovators is assessed by benchmarking measures of labour productivity and technological progress against those our OECD partners in relation.

The report goes on to explore some of the most common barriers to innovation, and the extent to which Australian businesses collaborate internationally or with university and research partners. We also look at whether research funding and business investment is likely to support an ideas boom. Since knowledge flows play a central role in a national innovation system, this report explores how innovation activity is distributed geographically across Australia's cities and regions through the development of a new small area innovation index for Australia.

Australia's productivity: driving economic growth

Introduction

"We now know that the source of wealth is something specifically human: knowledge. If we apply knowledge to tasks we already know how to do, we call it 'productivity'. If we apply knowledge to tasks that are new and different, we call it 'innovation'. Only knowledge allows us to achieve these two goals." Peter F. Drucker (1993).

Economic growth is usefully considered to be driven by the three broad components of productivity, participation and population – the so-called three Ps. This report is focussed on the first of these – productivity – and the key role that existing knowledge and new innovation plays to enhance our productive capacity and drive economic growth and development.

This section of the report examines Australia's productivity, with a focus on the trajectory of standard measures of productivity over time, across industry sectors, and how Australia compares internationally.

The section begins with a discussion of standard methods for measuring productivity, highlighting some of the key limitations with traditional metrics by which productivity is assessed, before moving to a detailed examination of Australia's productivity profile.

Measuring productivity – a complex business

Productivity sounds straightforward as a concept, but in reality it is anything but. Productivity measures are intended to capture the efficiency of different factors of production - labour, capital, other inputs. Yet many challenges and data limitations exist when attempting to capture underlying productivity in a meaningful way.

Given that this report aims to provide a comprehensive overview of Australia's productivity performance, the most commonly used measures of productivity are used. In particular, these are measures of labour productivity (LP), capital productivity (KP), and multifactor productivity (MFP).

Productivity is broadly defined as the ratio of a volume measure of output to a volume measure of input: specifically, *"that part of output growth that is not accounted for by increases in the amount of inputs being measured"* (ABS, 2015).[1] This report draws on the suite of productivity statistics provided by the Australian Bureau of Statistics (ABS).

Paul Krugman famously notes that productivity *"isn't everything, but in the long run it's nearly everything".*[2] One of the important points in Krugman's quote is that productivity is more reliably measured and compared - over the course of economic growth cycles, in order to distinguish underlying changes in productivity from shorter term business cycle, price and international market effects.

The second implication of Krugman's quote is that the scope of traditional indicators of productivity growth – principally through labour and multifactor productivity measures – is limited. The contribution of other factors of production – commonly including land, transport and infrastructure, sources of energy, as well as organisational processes – are not explicitly captured. This point is well made in Saul Eslake's 2011 report on productivity for the Grattan Institute.

Our capacity to measure productivity is contested, and complex. Traditional labour and multifactor productivity measures are influenced by business cycle effects, the changing price of goods and services on international markets, and the mix of labour and capital inputs into the production process.

It is also important to point out what standard productivity measures fail to capture. Firstly, the value of productive non-market work and caring responsibilities, and the high value of contributions to national output from Australia's community and voluntary sectors, are both obscured in traditional labour and multifactor productivity measures. Nor do they capture the 'latent' potential productivity through a better use of our 'latent' talent pool of people not currently part of the employed workforce.

Despite these limitations an analysis of labour and multifactor productivity provides us with some important insights into Australia's productivity progress over time and across industry sectors, and present some international comparisons with other OECD economies.

> Productivity "isn't everything, but in the long run it's nearly everything" (Krugman, 1990).

1 Refer to the Glossary and Technical Notes of this Report for more comprehensive definitions of productivity measures.
2 Krugman, Paul (1990), *The Age of Diminished Expectations: US Economic Policy in the 1980s*, MIT Press, Cambridge MA.

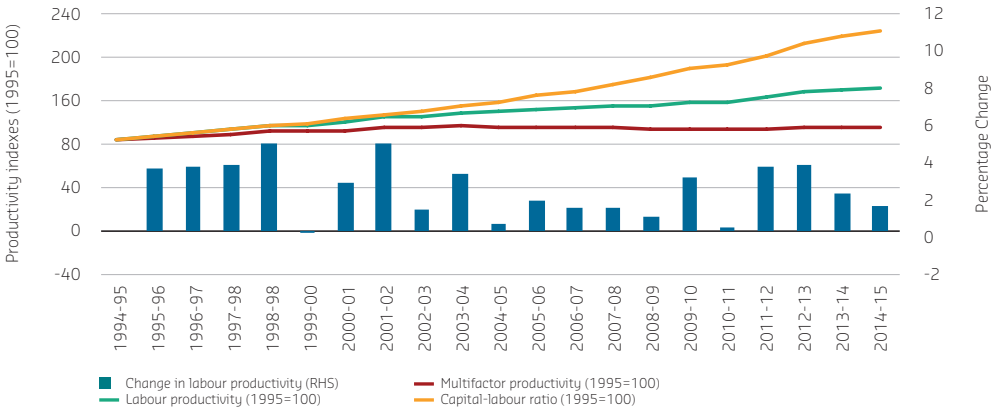
Productivity trends in Australia

Labour productivity is often regarded as an indicator of improvements in living standards.

Australia's productivity performance over the period 1994 to 2015 is presented in Figure 1. Specifically, measures of labour productivity (LP), the capital-labour ratio, and multifactor productivity (MFP), based on a value-added concept of output are presented. The annual percentage change in LP is also reported.

It is important to keep in mind that productivity growth is that part of output growth that is not accounted for by increases in the amount of inputs being measured. In that sense, LP growth reflects two components – MFP growth, plus a component that reflects growth in the capital to labour ratio. LP and KP are both partial productivity measures. That is, they only consider the relationship between output and a single input. In contrast, MFP is a more comprehensive measure of productivity efficiency.

Figure 1 **Labour productivity, multifactor productivity and capital-labour ratio, Market Sector (16) estimates, 1994-95 to 2014-15**



Notes: All indexes have been scaled to 100 in 1994-95. Percentage changes to the ABS labour productivity index are shown in bars and measured against the RHS scale.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from AUSTRALIAN BUREAU OF STATISTICS Cat No 5260.0, Estimates of Industry Multifactor Productivity, Australia, December 2015.

For Australia, productivity estimates by industry sector are only available for the sixteen market sectors of the economy (the 'Market Sector 16'). Productivity measures are not available for the three 'non-market' sectors of the economy – that is, public administration and defence, education and training, and health care and social assistance sectors, which together accounted for just under 28 per cent of Gross Value Added (GVA) in the economy in 2015.

Labour productivity is often regarded as an indicator of improvements in living standards, measured by per capita income, and from this perspective has important policy relevance. As shown in Figure 1, with the exception of 1999-2000, Australia has shown a steady year-on-year LP growth over the period 1994 to 2015. As discussed earlier in this report, the increase in labour productivity is strongly correlated with an

[3] For further information on how MFP estimates are constructed, see ABS (2012a) and OECD (2001).

increase in the capital-labour ratio – that is, the increased concentration of capital in the production process, relative to the size of the workforce employed by businesses. MFP growth has seen a more modest increase, and has in fact had negative growth prior to and during the GFC.

Capital deepening has been the main contributor to labour productivity growth, with MFP having a smaller, but positive effect.

Table 1 Summary of productivity statistics for Market Sector: 1973-2015 (per cent)

	Long term Growth rate	Growth Cycle				Latest Year
	1973-74 to 2014-15	2001-2003	2003-2006	2006-2011	2011-2014	2014-2015
Output (GVA)	3.07	3.55	3.69	2.86	3.11	2.84
Total Inputs	2.29	0.82	0.87	0.95	1.00	2.02
Labour Input	0.76	0.60	1.92	1.55	0.02	0.91
Capital Input	4.37	4.13	6.05	5.79	5.60	3.26
MFP	0.77	1.52	0.10	-0.46	0.71	0.81
Capital Deepening	1.51	0.00	0.00	0.00	0.00	1.05
Labour Productivity	2.30	2.90	1.72	1.28	3.04	1.91
Capital labour ratio	3.60	4.48	4.06	4.19	5.59	2.50

Notes: Divisions A to K and R. Growth Cycles based on calculations by Bankwest Curtin Economics Centre in 'Beyond the Bottom Line: Government Debt in Australia' November, 2015.
Source: BANKWEST CURTIN ECONOMICS CENTRE | AUSTRALIAN BUREAU OF STATISTICS Cat No 5260.0, Estimates of Industry Multifactor Productivity, Australia, December 2015.

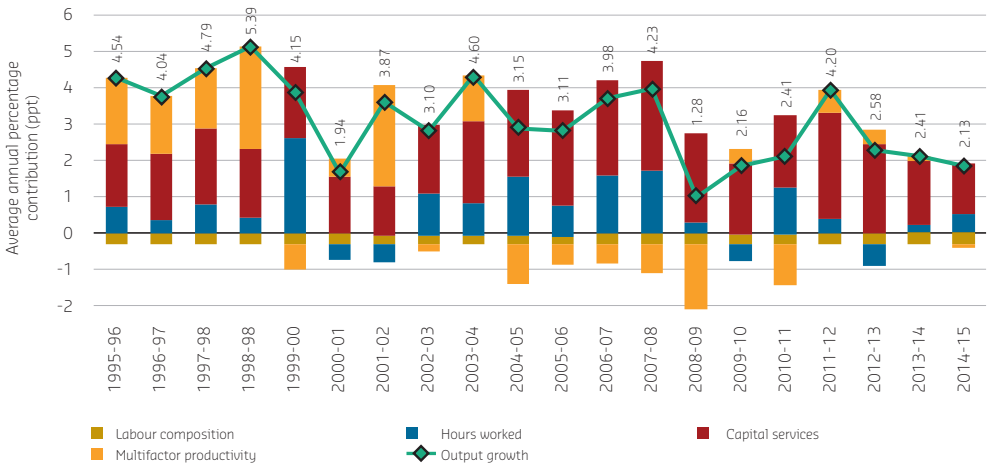
Table 1 shows that over the longer term growth cycle (1973-74 to 2014-15), Gross Value Added (GVA) Output was above three per cent, with LP increasing by 2.30 per cent. Capital input has increased significantly (4.37%), resulting in a capital-labour ratio increase of 3.6 percentage points. Capital deepening has been the main contributor to LP growth, with MFP having a smaller, but positive effect.

Most notable in the 2006-2011 and 2011-2014 growth cycle periods is the continued growth in capital deepening. This is driven by an increase in capital input and a decline in the growth of labour inputs.

MFP declined for the 2006-2011 growth cycle, which coincides with the Global Financial Crisis (GFC). For the most recent growth cycle (2011-2014) MFP has returned to positive growth, and has increased further for the latest year of available data (2014-2015). While caution must be used in drawing conclusions from yearly productivity measures, data for 2014-15 also shows a smaller percentage increase in capital deepening, with MFP having an increased contribution to LP growth.

Capital services have been the main contributor to output growth for the period 1995-96 to 2014-15.

Figure 2 Productivity, labour and capital contributions to output growth: 1995-96 to 2014-15



Notes: Figure reports the 'growth accounting' decomposition of contributions to output growth from number of hours worked, compositional changes to the labour force, capital 'deepening' and multifactor productivity growth.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from AUSTRALIAN BUREAU OF STATISTICS Cat. 5260.0, Estimates of Industry Multifactor Productivity, Australia, December 2015.

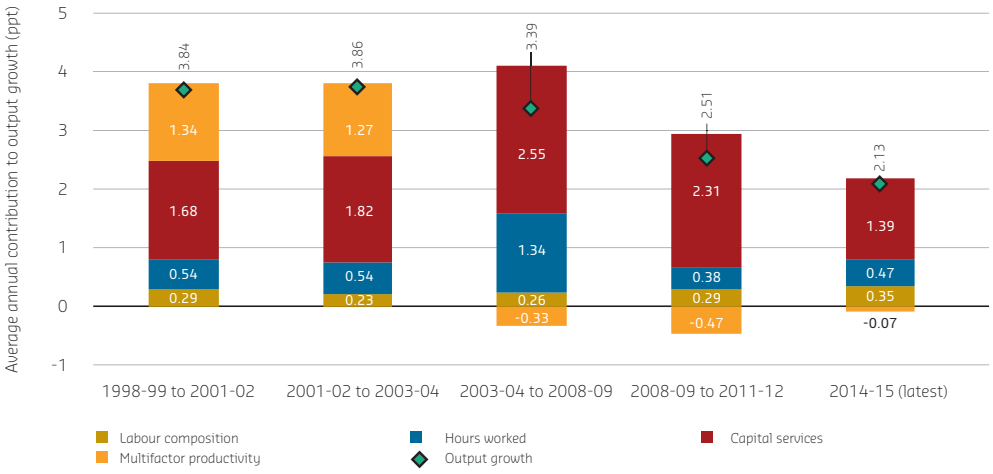
Using growth accounting analysis, Figure 2 decomposes the contributions to Australia's output growth from labour composition, hours worked, capital services and MFP for the period 1995-96 to 2014-15 (refer to Table 7 for detailed growth accounting decomposition data). Over this time period, capital services have been the main contributor to output growth.

MFP contributed substantially to output growth between 1995-89, and 2001-02. However, its contribution since 2003-04 has either been negative or positive but relatively small.

MFP is often referred to as a measure of 'technological progress'. However, given that MFP growth is a 'residual' measure, it also accounts for a range of non-technological factors such as industry and firm level adjustments, economies of scale and cyclical effects. This goes some part in explaining the negative contribution of MFP to output growth, which was particularly evident during the Global Financial Crisis (GFC).

While the contribution of 'hours worked' has improved in the last two years, over the longer time period Figure 2 shows the declining contribution of 'hours worked' to output growth. With an ageing population, and with limited capacity to increase participation rates further amongst the working age population, this finding emphasises the need to enhance workforce skills and productive technologies as a necessary driver of future output growth for Australia.

Figure 3 Productivity, labour and capital contributions to output growth: summary over growth cycles from 1998-99 to 2014-15



Notes: Figure reports the 'growth accounting' decomposition of contributions to output growth from number of hours worked, compositional changes to the labour force, capital 'deepening' and multifactor productivity growth. Growth Cycles based on calculations by Bankwest Curtin Economics Centre in 'Beyond the Bottom Line: Government Debt in Australia' November, 2015.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from AUSTRALIAN BUREAU OF STATISTICS Cat. 5260.0, Estimates of Industry Multifactor Productivity, Australia, December 2015.

Changes in the composition of the labour force emphasise the growing importance of 'knowledge workers' to output growth in Australia.

Productivity measures often show significant short term volatility.[4] To better assess how underlying productivity measures have changed over time, it is good practice to smooth out business cycle effects by comparing average productivity growth over a number of years, rather than quarterly or yearly changes.

Figure 3 shows the contributions to output growth over growth cycles, and reinforces a number of the key points made earlier in this Focus on the States report. First, the importance of capital services to Australia's output growth is significant. Second, there has been a decline in the contribution of MFP to output growth in Australia since 2003-04. Third, increased workforce participation contributed substantially to output growth during Australia's resources boom from 2003 to the onset of the global financial crisis in 2008-09. Wage rates increased over this period due to the high (sometimes excess) labour demand to support growth across many industry sectors.

Compositional changes in the labour force have contributed positively to output growth and at an increasing rate over recent growth cycles. This is a possible indicator of the growing importance of 'knowledge workers' to output growth.

Figure 3 shows a decline in the contribution of multifactor productivity to output growth over the course of the resources boom through to the post-GFC period. For the growth cycles between 1998 and 2004, MFP contributed about one-third of the growth in output. However, the subsequent decline in the contribution of MFP to output growth, while indicative, does highlight the limitations in measuring MFP and its interpretation as a measure of 'technological change'.

[4] This can be due to economic shocks, or as a result of changes in employment that lag changes in output.

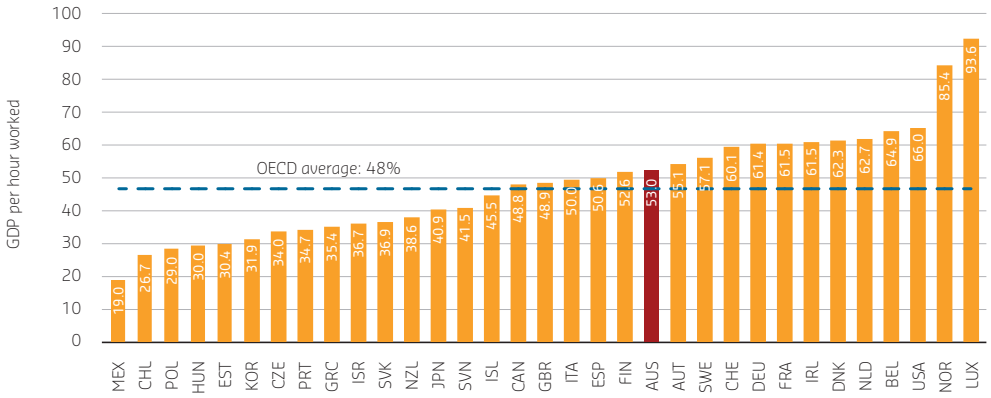
Despite these caveats, the profile and evolution of MFP over time, and the limited degree to which economic growth can be driven by participation and skills enhancement alone, highlights the imperative for Australia to drive future productivity and economic growth through innovation.

Australia's productivity: international comparisons

Figure 4 shows labour productivity (expressed as GDP per hour worked) for OECD economies in 2013, this being the latest data available for international comparisons. While noting that caution must be used in making cross country productivity comparisons[5], Australia's living standards (as measured by LP) lie above the OECD average. Australia compares favourably to our closest neighbour New Zealand (NZL), and to that of Great Britain (GBR) and Canada (CAN), an economy to which our living standards are often compared. With Luxembourg (LUX) and Norway (NOR) being particularly outliers, Australia also lags behind USA (USA), Ireland (IRL), France (FRA), Germany (DEU), and Switzerland (CHE), amongst others.

Australia's living standards lie above the OECD average. However, it lags behind USA, France, and Germany, amongst others.

Figure 4 Labour productivity, OECD country comparisons: 2013



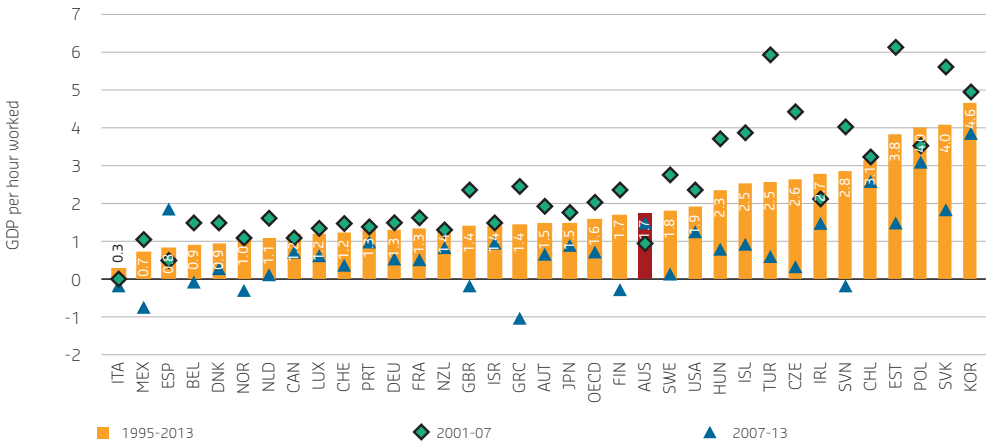
Notes: For each country comparison, labour productivity is defined as GDP (Gross Value Added in market prices based on current PPPs) per hour worked for the total economy, expressed in US dollars.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from OECD Stats, Compendium of Productivity Indicators, 2015.

Taking a more detailed look at LP over time, Figure 5 shows LP growth for OECD economies from 1995 to 2013. Australia's LP growth (1.72 per cent) is slightly above the OECD average (1.57 per cent) for the period 1995-2013.

5 For some countries, the measurement of hours worked suffers from a number of statistical problems that can hinder international comparability.

Post GFC, labour productivity growth has fallen significantly in most OECD countries.

Figure 5 Growth in labour productivity, OECD countries, 1995-2013



Notes: Labour Productivity is defined as GDP (Gross Value Added in market prices based on current PPPs) per hour worked, total economy, US dollars. Percentage change at annual rate.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from OECD Stats, Compendium of Productivity Indicators, 2015.

The period 2001-2007 shows strong LP growth for most economies. However, despite the fact that Australia's 'boom years' fall during the period 2001-2007, Australia did not report strong LP growth during the boom. This is most likely linked to the fact that Australia's 'mining boom' was going through a significant investment phase, with substantial increases in labour and capital input without the large increases in output, which have only recently emerged as the economy has entered the 'production phase'. This also demonstrates the impact individual industry level productivity growth can have on the productivity of the overall economy.

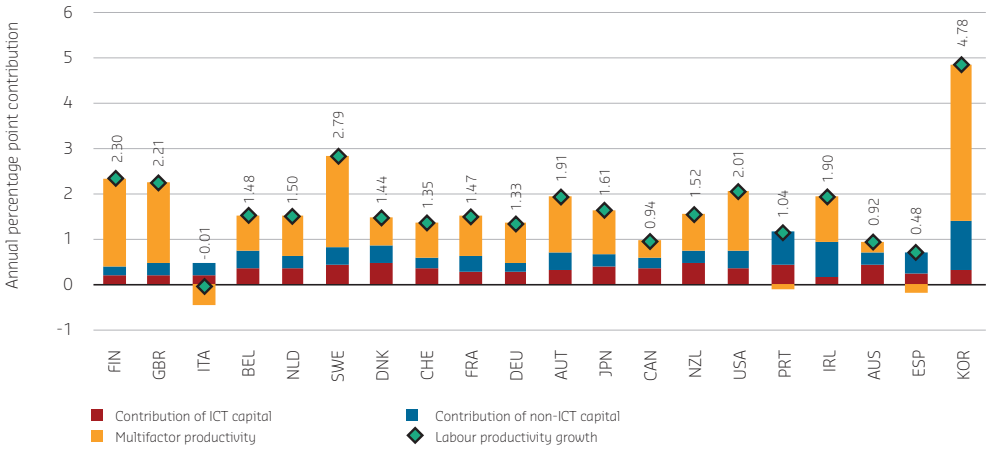
Post GFC, labour productivity growth has fallen significantly in most OECD countries. However, for Australia and Spain (ESP), labour productivity growth picked up in the 2007-2013 period, albeit sometimes coupled with declines in output and labour input. Therefore, increased LP growth does not necessarily imply improvements in competitiveness, and must be looked at in the context of other macroeconomic indicators.

For a selection of OECD economies, Figure 6 and Figure 7 show the contributions of capital (both ICT and non-ICT), and MFP to LP growth for the period 2001-2007 and 2007-2013, respectively. From Figure 6, we can see that, with the exception of Spain, Italy and Portugal, MFP contributes significantly to LP growth for OCED economies.

As previously discussed, Australia's labour productivity growth is largely accounted for by 'capital deepening', with multifactor productivity contributing substantially less to output growth than for other OECD economies. This is an important point, since multifactor productivity is typically used as a measure that most closely aligns with an underlying measure of technical progress, or "the efficiency of producers in producing output using both labour and capital" (Productivity Commission 2015).

As such, multifactor productivity provides some indication of improvements that have taken place in the production process itself – either in relation to the production of goods and services, or in organisational processes of production. As will be clear in the forthcoming analysis, short-run changes in the MFP measure do incorporate the effects of external factors – including business cycle effects, changes in the prices of outputs and inputs into the production process – as well as the influence of broader factors of production.

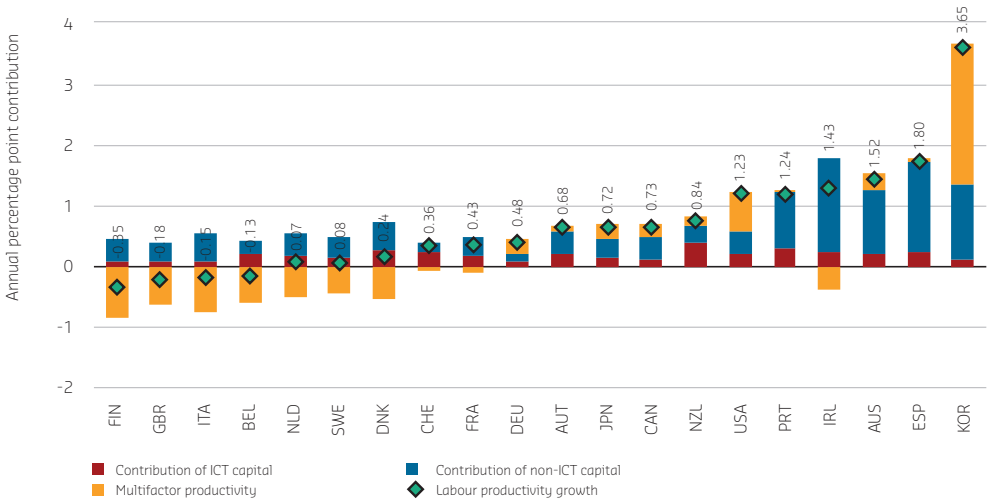
Figure 6 Contributions to labour productivity growth: selected OECD countries, 2001-2007



Notes: Labour Productivity is defined as GDP (Gross Value Added in market prices based on current PPPs) per hour worked, total economy, US dollars. Contributions to labour productivity growth are based on annual percentage point contribution. Countries sorted in rank order of 2007-2013 labour productivity growth.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from OECD Stats, Compendium of Productivity Indicators, 2015.

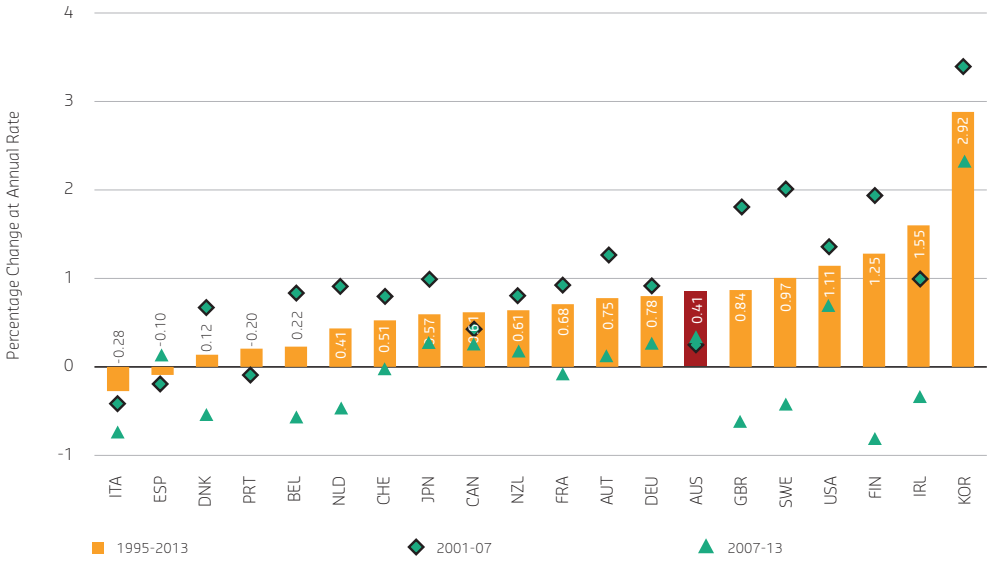
A comparison of Figure 6 with Figure 7 reveals two important findings in relation to productivity – firstly, many OECD economies have experienced a decline in labour productivity post-GFC. Second, the decline is associated with a lower contribution of MFP to labour productivity growth across most OECD countries, coupled with a greater contribution of (particularly non-ICT) capital deepening over the post GFC period. Australia has performed relatively well in terms of overall labour productivity growth, which is attributable mainly to capital deepening but with MFP still a positive contributor.

Figure 7 Contributions to labour productivity growth: selected OECD countries, 2007-2013



Notes: Labour Productivity is defined as GDP (Gross Value Added in market prices based on current PPPs) per hour worked, total economy, US dollars. Contributions to labour productivity growth are based on annual percentage point contribution. Countries sorted in rank order of 2007-2013 labour productivity growth.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from OECD Stats, Compendium of Productivity Indicators, 2015.

Figure 8 Multifactor productivity growth, OECD country comparisons: 1995-2013



Notes: Multifactor Productivity is derived on a GDP (Gross Value Added in market prices based on current PPPs) per hour worked basis, total economy, US dollars.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from OECD Stats, Compendium of Productivity Indicators, 2015.

Figure 8 shows MFP growth for a selection of OECD economies over the period 1995-2013. The OECD (2015) has noted that "the sharp fall in MFP growth in many countries for the 2007-13 period, leads to a risk that could herald declining longer term trends in labour productivity growth". For Australia, multifactor productivity growth for the period 2007-2013 remains positive and stronger than that reported for many of the OECD economies.

Along with Korea (KOR), USA shows the most consistent MFP growth performance since the start of the millennium. Across the 2001-07 and 2007-13 time periods shown in Figure 8, the USA, often seen as the innovation leader, sees a strong and consistent contribution of MFP to growth in their living standards, with a lower reliance on capital.

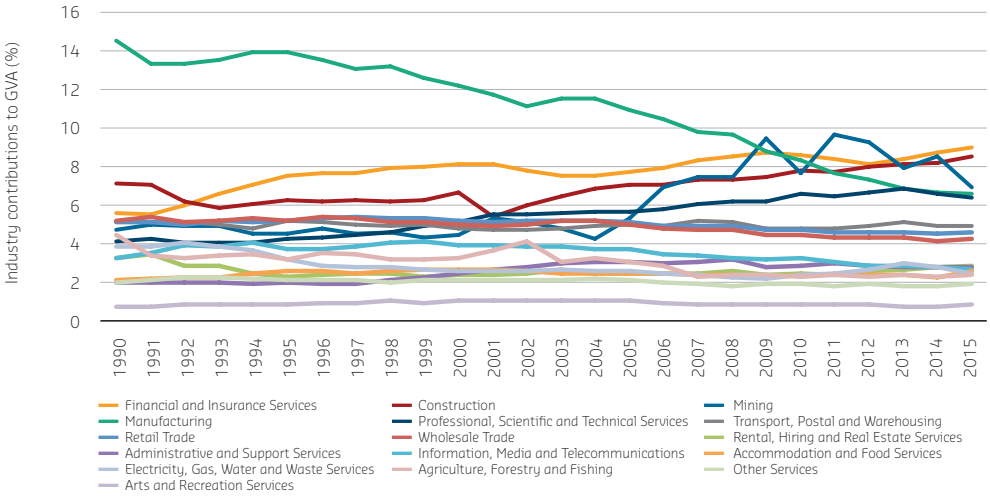
Productivity growth by industry sector

In the fifteen years to 2015, the contribution of the sixteen market sector industries to output declined from 76% to 72.4%.

Given that productivity growth varies across industry sector, this section provides an overview of changes in MFP across the market 16 industry sectors.

Figure 9 shows the percentage contribution of the Market 16 industries to annual GVA for the period 1990 to 2015. During this period, the overall contribution of the Market 16 industries to GVA has declined from 76% to 72.4%.

Figure 9 Industry contributions to Gross Value Added: 1990-2015



Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from AUSTRALIAN BUREAU OF STATISTICS Cat No 5204.0, Australian System of National Accounts, October 2015.

In 1990, the top four industry contributors to GVA were Manufacturing (15%), Construction (7.4%), Financial and Insurance Services (5.8%) and Wholesale Trade (5.4%). Overall, these contributed 33.6% to GVA in 1990. In 2015, the top four industry contributors to GVA accounted for 32.1% and comprised of Financial and Insurance Services (9.3%), Construction (8.8%), Mining (7.2%) and Manufacturing (6.8%).

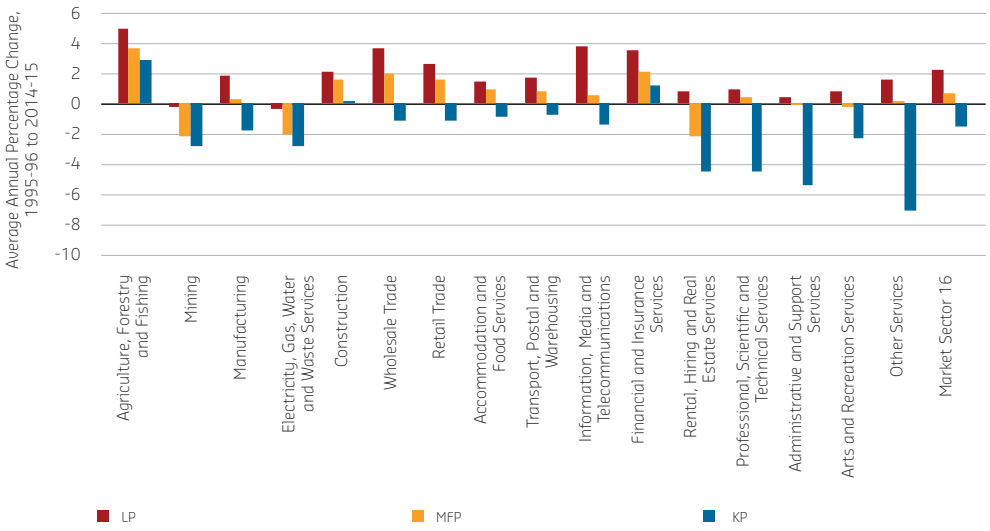
Over the period 1990 to 2015, Mining's contribution to GVA increased from being the seventh largest contributor to GVA (4.9%) to being the third largest contributor (7.2%). Financial and Insurance Services' contribution to GVA increased from third highest (5.8%) in 1990 to being the largest contributor (9.3%) in 2015, while Professional, Scientific and Technical Services moved from ninth (4.3%) in 1990 to the fifth largest contributor (6.6%) in 2015. Manufacturing continues to make a significant contribution to GVA, driven in large part by the sector's transition to 'advanced' manufacturing technologies.

Other industry changes include Agriculture, Forestry and Fishing, which has seen its ranking in contribution to GVA decline from eight position (4.6%) in 1990 to

fourteenth position (2.2%) in 2015, and Electricity, Gas, Water and Waste Services, which has seen a decline in contribution to GVA from tenth position (4.0%) to thirteenth position (2.6%) in 2015.

Overall, these movements point towards a transitioning Australian economy – and specifically towards a more knowledge-intensive economy. Technology-intensive services are playing a more significant role in Australia's growth narrative, in emerging sectors as well as those industries (such as mining) of existing strength.

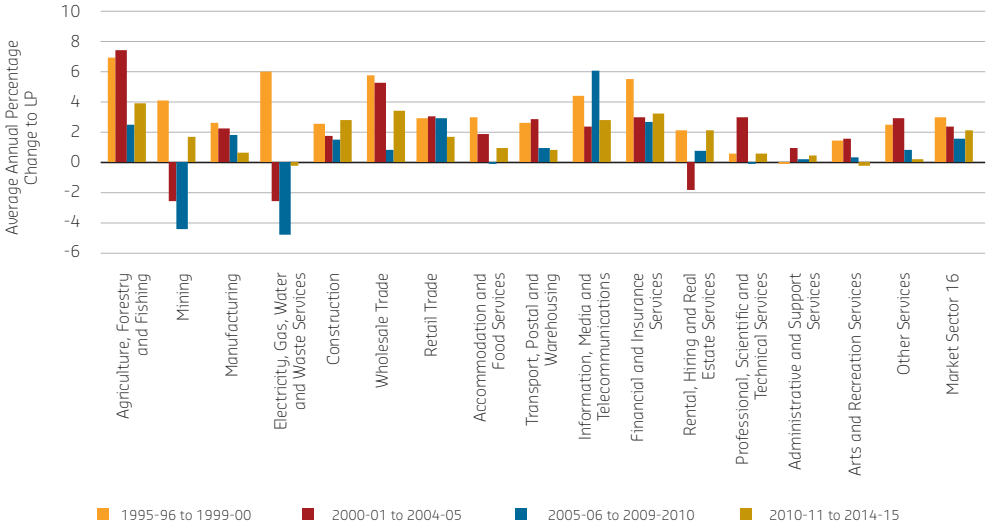
Figure 10 Average annual percentage change in LP, MFP and KP 1995-96 to 2014-15



Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from AUSTRALIAN BUREAU OF STATISTICS Cat No 5260.0, Estimates of Industry Multifactor Productivity, Australia, December 2015.

Figure 10 shows the average annual percentage change in labour (LP) and capital productivity (KP) and multifactor productivity growth (MFP) by industry over the period 1995-96 to 2014-15.Labour productivity growth lies above the Market Sector 16 average for Agriculture, Forestry and Fishing, Wholesale Trade, Retail Trade, Information, Media and Telecommunications and Financial and Insurance Services. The majority of industry sectors demonstrate positive labour productivity growth, with the exception of Mining and Electricity, Gas, Water and Waste Services. The latter industries, together with Rental, Hiring and Real Estate, are the only industries to report negative average annual percentage changes to multifactor productivity. Meanwhile, only Agriculture, Forestry and Fishing, Construction and Financial and Insurance Services report positive changes in capital productivity over this time period.

Figure 11 Annual labour productivity growth by market sector industries: 1995-96 to 2014-15

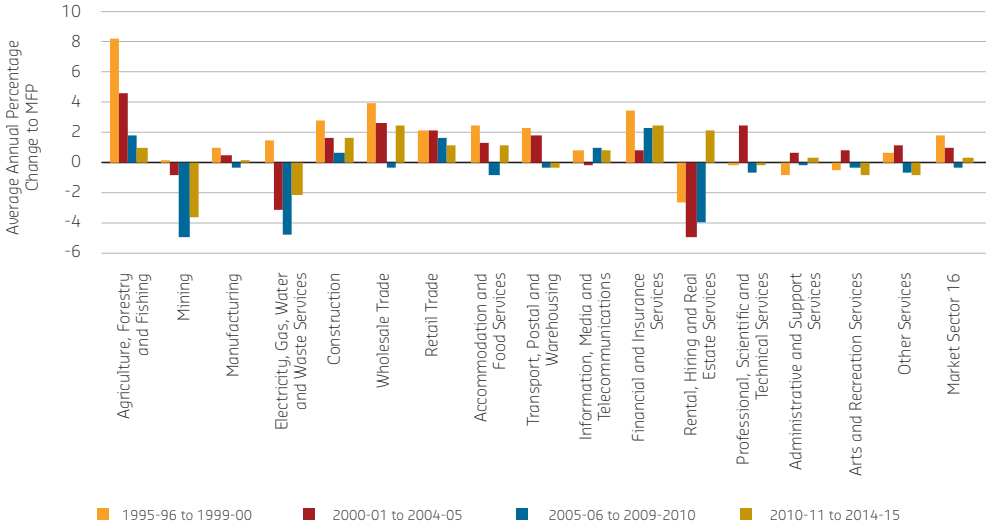


Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from AUSTRALIAN BUREAU OF STATISTICS Cat No 5260.0, Estimates of Industry Multifactor Productivity, Australia, December 2015.

Respectively, Figure 11 and Figure 12 decompose annual LP and MFP growth into five year intervals. For the majority of industries, LP growth has not returned to those levels experienced between 1995 and 2005. However, eleven of the sixteen market sector industries have seen an improvement in LP growth in 2012-11 to 2014-15 compared to the previous interval.

With some exceptions, MFP growth has not returned to those levels shown in the earlier periods.

Figure 12 Annual multifactor productivity growth by market sector industries: 1995-96 to 2014-15



Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from AUSTRALIAN BUREAU OF STATISTICS Cat No 5260.0, Estimates of Industry Multifactor Productivity, Australia, December 2015.

Multifactor Productivity Growth by Industry

Figure 13 presents MFP growth for each of the Market 16 industry sectors between 1994-95 and 2014-15. Each industry is graphed against the Market Sector 16 average MFP growth. Our discussion here focuses on a selection of those industries presented in Figure 13.

Over the period 1994-95 to 2014-15, Agriculture, Forestry and Fishing has seen almost a doubling of MFP growth. This occurred, despite two significant periods of negative MFP growth in the drought years of 2002-03 and 2006-07. This sector has seen significant advancements in technological change, which has led to significant improvements in productivity. That said, these 'technological leaps' have been less evident post GFC (2009).

For mining, recent years suggest that, with projects now reaching their full potential, multifactor productivity is rebounding, reversing much of the decline in previous years. This is in line with what many economists have predicted would occur as Mining shifts from a construction to a production phase, with a reduction in hours worked and capital investment (see for example, Eslake and Walsh, 2011).

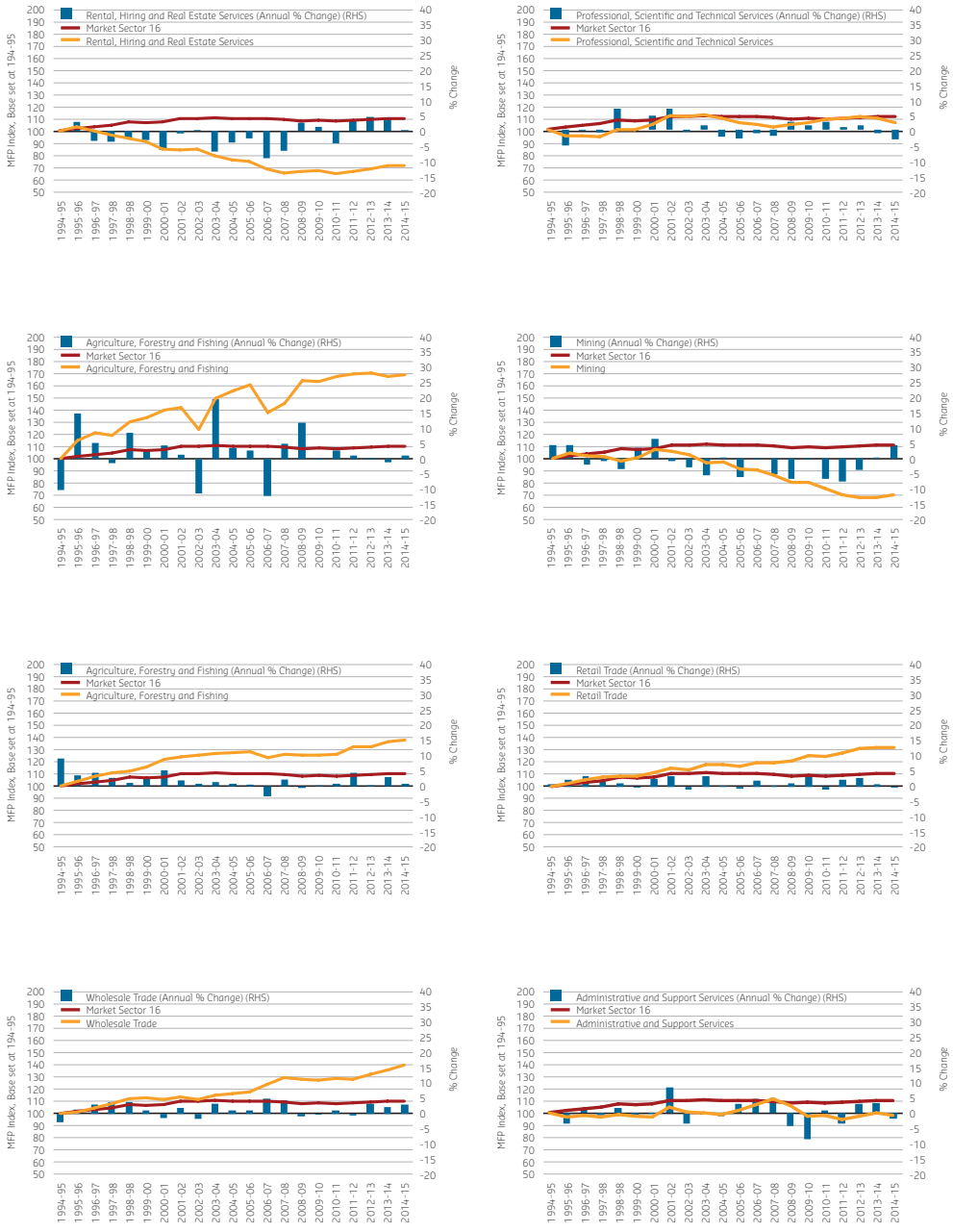
Financial and Insurance Services have seen a significant increase in MFP growth, which coincides with the increased contribution of this sector to overall GVA, as reported previously.

For Manufacturing, MFP has remained reasonably stable, tracking slightly below the market sector 16 trend. Wholesale Trade and Retail Trade have seen substantial improvements to MFP growth over the time period, which is likely to have been impacted by the introduction of on-line trade.

Finally, whilst Rental, Hiring and Real Estate Services have shown a decline in MFP growth, there is a marked improvement in recent years, with MFP growth rates in excess of five percent for the three years prior to 2014-15.

More research is required to fully understand the performance of each individual industries productivity growth, and its overall impact on productivity growth at the macroeconomic level.

Figure 13 Multifactor productivity growth and annual percentage change by industry sector: 1994-95 to 2014-15



Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from AUSTRALIAN BUREAU OF STATISTICS Cat No 5260.0, Estimates of Industry Multifactor Productivity, Australia, December 2015.

Figure 13 continued

Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from AUSTRALIAN BUREAU OF STATISTICS Cat No 5260.0, Estimates of Industry Multifactor Productivity, Australia, December 2015.

Productivity summary

This section of the report has outlined some of the challenges in measuring productivity, with many limitations to providing an accurate and meaningful measure of the concept. The challenge of measuring productivity growth is not unique to Australia, and provides a challenge to economies across the globe.

While noting its limitations, the orthodox measures of productivity growth presented here, provide an insight into some interesting factors affecting productivity growth, with existing measures providing a benchmark for international comparisons.

Australia's living standards (as measured by LP) lie slightly above the OECD average, but lag behind economies such as Germany, France, Ireland and USA. Relative to other OECD economies, over the period 1995-2013, Australia's productivity growth is heavily reliant on capital inputs. For the period 2001-2007, Australia's MFP growth was well below that of its OECD counterparts. However, over the most recent period (2007-2013), Australia's MFP growth compares favourably, with many OECD economies posting negative MFP growth post GFC.

Using growth accounting analysis, Australia's reliance on capital deepening to drive productivity growth is emphasised, with significant increases in the capital-labour ratio since 1994-95. The contribution of hours worked to output growth has decline since the GFC. Prior to 2004-05, the positive contribution of MFP to output growth was significant. However, since 2003-04, the contribution of MFP to output growth has either been negative or has had a relatively small positive contribution. While some consider MFP to be a proxy for 'technological change' we show that it is highly correlated to cyclical shocks and therefore, needs to be interpreted with a degree of caution.

This section has also reported the changing nature of the Australian economy. The percentage contribution of the Market Sector 16 industries to GVA is reported, with Financial and Insurance Services, Mining and Professional, Scientific and Technical Services reporting greater percentage contributions to overall GVA between 1990 and 2015. This coincides with a decline in the contribution of Manufacturing (coinciding with a shift to advanced manufacturing) and Agriculture, Forestry and Fishing to overall GVA. These point to a transitioning Australian economy, towards more knowledge intensive service industries.

Australia can no longer rely upon increases in participation and population for economic growth. Coupled with the likely deterioration in our terms of trade, productivity growth will, in the long run 'mean everything'. However, Australia needs to seek new sources of productivity growth. Economists have long argued that the key source of productivity growth, and hence increases in living standards, is innovation. Therefore, the focus of this report now turns to the economy's ability to increase productivity growth through innovation. That is, we address some of the key factors affecting Australian businesses innovative capacity and the positioning of Australian businesses (existing and new) for an 'ideas boom'.

Innovation

in Australia: supporting an ideas boom

Introduction

"It is reasonable to say not only that innovation has contributed to the growth process, both directly and at second remove, but that without it the process would have been reduced to insignificance". William J. Baumol (2002)

In a fast evolving world it is crucial for firms and business to keep up with the technology and changes in consumer behaviour. Throughout business history there are numerous examples where a lack of innovation has forced firms out of the market. Innovation is not only important for firms or markets; it also plays a significant role in a country's economic prosperity. An innovative country can gain absolute or comparative advantage to produce goods and services. Such advantages can enable countries to smoothly navigate through business cycles and avoid drastic costs during crises.

Australians have had a great history of innovations and inventions that have improved our quality of life and increased our competitiveness in the global market. Australia's geographic isolation is often cited as one of the main factors driving the inventiveness of its citizens, which has seen every day uses such as the hills hoist come to life, to the creation of technological advancements like WiFi and spray-on skin that have global benefits.

This section of the report provides an overview of the current state of innovation amongst Australian businesses. We discuss the drivers and barriers to innovation, as well as the internationalisation and collaboration of Australian businesses and investment towards the delivery of a more innovative Australian economy.

Innovation and knowledge flows

It is important that all stakeholders involved in the development, design and implementation of innovation policy come from a shared understanding of what innovation is. Internationally, the most frequently used definition of innovation is as follows: *"An Innovation is the implementation of a new or significantly improved product (good or service), a new process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations."* (Eurostat/OCED, 2005, p46). This definition is also used by the ABS in their surveys and data collection.

This definition raises two important distinctions. The first distinguishes between product and process innovation. The second concerns the important criterion for 'newness'. For a business, innovation is "*the introduction of a product or process that is new to it*". (Jordan and O'Leary, 2007).

Innovation is not a linear process, but occurs in occurs within a complex 'system', involving interactions and feedback loops with customers, suppliers, competitors, higher educational institutions and innovation supporting agencies.[6]

The role of knowledge – both of an existing stock of knowledge and new knowledge (research) are essential in the innovation process. Therefore, how knowledge, technology and information flows among people, enterprises and institutions is key to driving innovation.

For a business, innovation is "the introduction of a product or process that is new to it". (Jordan and O'Leary, 2007).

How knowledge, technology and information flows among people, enterprises and institutions is key to driving innovation.

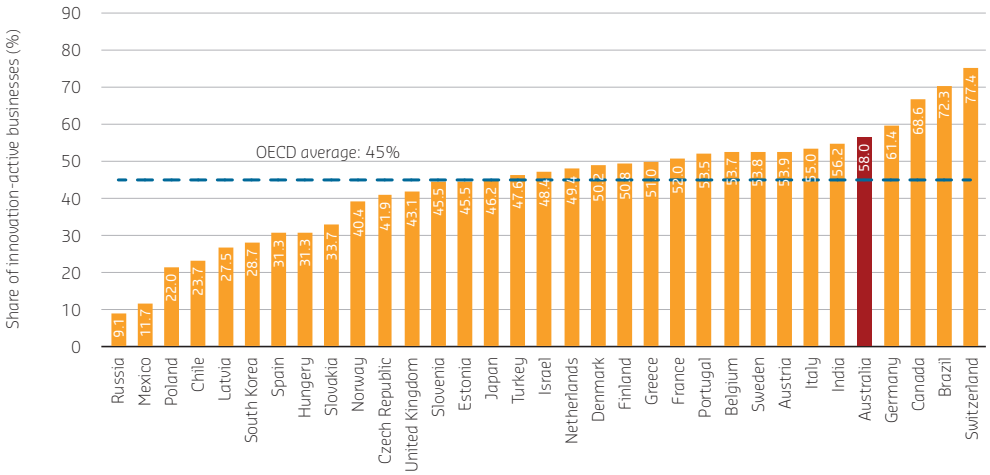
6 For further information on how innovation occurs, see for example Kline and Rosenberg's (1986) 'chain link' model of innovation.

How innovative is Australia?

This section reviews the current state of innovation in Australia. As an important first step, Figure 14 presents the share of innovation-active businesses in Australia, drawing comparisons to other OECD economies in 2012-13. In Australia, 58 percent of businesses are innovation-active. This is above the OECD average of 45 percent and places Australia in fifth position amongst those nations reported here. Australia lies just behind Germany (61.4%), and above Israel (48.4%), and the United Kingdom (43.1%).

However, Australia lags significantly behind the level of innovation-active businesses reported for Canada (68.6%), Brazil (72.3%) and Switzerland (77.4%).

Figure 14 Share of innovation-active firms: OECD comparison, 2012-13



Notes: Figures represent the percentages of firms engaged in some form of product or process innovation, as a share of the total number of firms in each OECD country. Data are drawn from country-specific national innovation surveys. For Australia, data come from the Business Characteristics Survey (BCS) and refer to financial year 2012/13.
Source: BANKWEST CURTIN ECONOMICS CENTRE | OECD Innovation Indicators, June 2015.

The prevalence of innovation activity is not equally distributed across Australian industries. As reported in the first column of Table 2, Wholesale Trade, Retail Trade, Information Media and Telecommunications and Manufacturing sectors report the highest number of innovation-active firms (50% or above). Transport, Postal and Warehousing, Construction, Agriculture, Forestry and Fishing, and Rental, Hiring and Real Estate sectors report the lowest level of innovation-active firms for 2012-13.

The prevalence of innovation activity is not equally distributed across Australian industries.

Table 2 **Innovation and Gross Value Added (GVA) by industry sector: 2012-13 and change since 2008-09**

Industry	2012-13				Change between 2008-09 and 2012-13			
	% Innovation active firms	GVA ($ millions)	% contribution to GDP	No. of businesses	% Innovation active firms	% change in real $ GVA value	% Innovation active firms	% Innovation active firms
Agriculture, Forestry and Fishing	35.1% 14	35,382 15	39.4% 15	55,000	(na)	(na)	(na)	(na)
Mining	42.0% 10	119,067 3	30.2% 3	4,000	14.8% 4	28.9% 1	16.3% 1	33.3% 1
Manufacturing	50.4% 4	103,011 4	2.8% 4	48,000	3.9% 11	-2.4% 15	-12.0% 15	-5.9% 13
Electricity, Gas, Water and Waste Services	37.1% 12	44,316 10	4.4% 10	3,000	3.9% 10	5.5% 10	-4.9% 10	0.0% 8
Construction	30.6% 15	120,166 2	5.0% 2	128,000	-0.6% 12	16.4% 4	5.0% 4	0.8% 7
Wholesale Trade	53.0% 1	64,955 9	15.6% 9	39,000	4.1% 9	12.6% 7	1.6% 7	-4.9% 11
Retail Trade	51.3% 2	68,860 8	1.4% 8	74,000	17.7% 2	10.2% 8	-0.7% 8	-5.1% 12
Accommodation and Food Services	41.4% 11	36,301 14	1.2% 14	58,000	4.5% 8	4.6% 12	-5.7% 12	11.5% 2
Transport, Postal and Warehousing	28.3% 16	75,538 7	57.7% 7	38,000	-10.2% 14	13.2% 6	2.1% 6	-7.3% 14
Information Media and Telecommunications	51.1% 3	41,983 12	$75.8 12	7,000	7.8% 6	4.6% 11	-5.7% 11	0.0% 8
Financial and Insurance Services	43.9% 8	127,053 1	5.1% 1	21,000	-4.8% 13	9.2% 9	-1.5% 9	-8.7% 15
Rental, Hiring and Real Estate Services	35.5% 13	39,736 13	3.7% 13	31,000	-10.4% 15	18.3% 3	6.7% 3	3.3% 5
Professional, Scientific and Technical Services	47.2% 6	101,149 5	3.1% 5	111,000	7.8% 7	25.1% 2	12.8% 2	0.9% 6
Administrative and Support Services	43.1% 9	42,007 11	2.5% 11	36,000	17.1% 3	-0.8% 14	-10.6% 14	-2.7% 10
Health Care and Social Assistance	44.6% 7	95,982 6	6.6% 6	55,000	26.0% 1	16.1% 5	4.7% 5	7.8% 4
Arts and Recreation Services	49.6% 5	12,146 16	2.9% 16	13,000	12.5% 5	4.3% 13	-5.9% 13	8.3% 3

Notes: GVA (Gross Value Added) can be considered the gross product for each industry. For 2008-09, data were unavailable for Agriculture, Forestry and Fishing.
Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 8158.0, 8165.0, 5204.0.

There is no obvious relationship between the proportion of innovation-active businesses and the change in the number of businesses within a sector over time (Table 2). An interesting point to note is that in 2012-13, Australia's three largest-industry contributors to gross value added (GVA) were ranked at the lower end of the proportion of innovation-active businesses. For example the top three sectors in terms of GVA – Financial and Insurance Services, Construction and Mining, rank

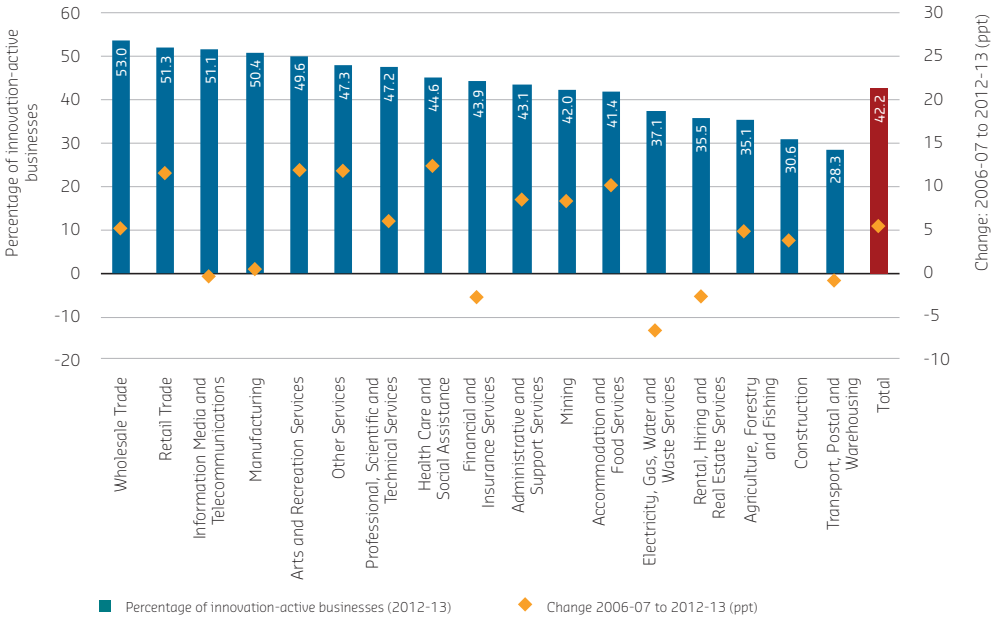
8th, 15th and 10th respectively when assessing the proportion of firms within those sectors that are innovation active businesses.

However, when assessing changes between 2008-09 and 2012-13, the mining sector stands out across all measures included in the Table 2. It has the largest increase in GVA, the sector's contribution to GDP and the number of businesses operating within the sector, and is ranked fourth in terms of the increase in the proportion of innovation-active firms within the sector. The Health Care and Social Assistance sector (+26.0%) records the biggest increase in the proportion of innovation-active firms over time, followed by Retail Trade and Administrative and Support Services (+17.1%).

Changes in the degree of innovation activity over time are highlighted in Figure 15, with the proportion of innovation-active firms plotted alongside the percentage point change in the degree of innovation activity over time.

Five industries (Retail Trade, Arts and Recreation Services, Other Services, Health Care and Social Assistance, and Accommodation and Food Services) have seen their share of innovation-active businesses increase by 10 per cent or more. Five industry sectors have also shown a decline in the percentage of innovation-active business during this period. These include Information, Media and Telecommunications, Financial and Insurance Services, and Electricity, Gas, Water and Waste Services, along with Rental, Hiring and Real estate Services and Transport, Postal and Warehousing. The Electricity, Gas, Water and Waste Services has seen the biggest decrease in the proportion of firms engaged in innovative activities – a decrease of 6.3 percentage points between 2006-07 and 2012-13.

Figure 15 Share of innovation-active businesses by industry sector: 2012-13 and change from 2006-07



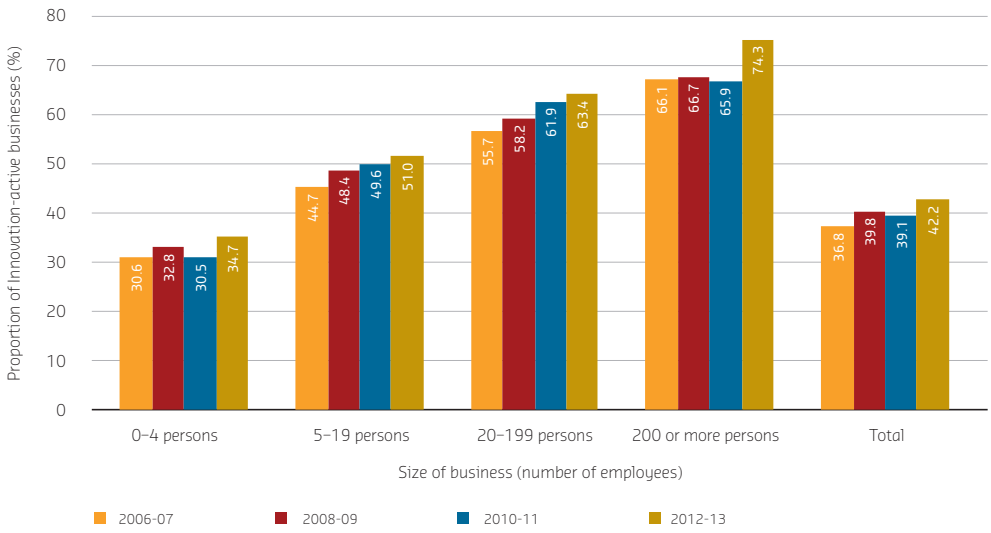
Notes: Figures denote the proportion of businesses in each industry sector that report any innovative activity. Changes are expressed as percentage point differences between 2006-07 and 2012-13 for all industry sectors bar agriculture, forestry and fishing (reported between 2010-11 and 2012-13).).
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from ABS Cat No 8158D001 (Summary of innovative activity, Table 1).

Figure 16 shows the share of innovation-active businesses by employment size for the periods between 2006-07 and 2012-13. It is evident from this figure, that larger businesses (by number of employees) are more likely to be innovation-active, with micro businesses (0-4 employees) the least likely to be innovation-active. Micro-businesses and SMEs make up a significant proportion of all businesses in the Australian economy, constituting one-third of all businesses in Australia (Cassells et al. 2015).

Australia's larger businesses are more likely to be innovation-active.

A further point to note is that all business sizes have shown an improvement in the proportion that report being innovation-active between 2006-07 and 2012-13. The largest increase is observed for large businesses (200+ employees) where in 2006-07 two-thirds reported being innovation-active. By 2012-13, this had increased to almost three-quarters.

Figure 16 Share of innovation-active businesses by firms' employment size: 2006-07 to 2012-13



Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from ABS Cat No 8158D001 (Summary of innovative activity, Table 1).

The incidence and novelty of product and process innovation by firm size is presented in Figure 17.

In the case of product innovation, large firms employing 200 or more persons clearly outperform smaller firms. The former are significantly more likely to offer innovations that are 'new to Australia' compared to smaller firms. At 5.8 per cent, the share of businesses employing 200 or more persons that introduce product innovations which are 'new to Australia' is more than twice the share of businesses with 20-199 persons and more than five times the share of businesses with 0-4 persons that offer product innovations in this category. Moreover, firms employing 200 or more persons are marginally more likely to introduce product innovations that are 'new to the world' (2.6 per cent compared to 2-2.3 per cent of firms with less than 200 persons).

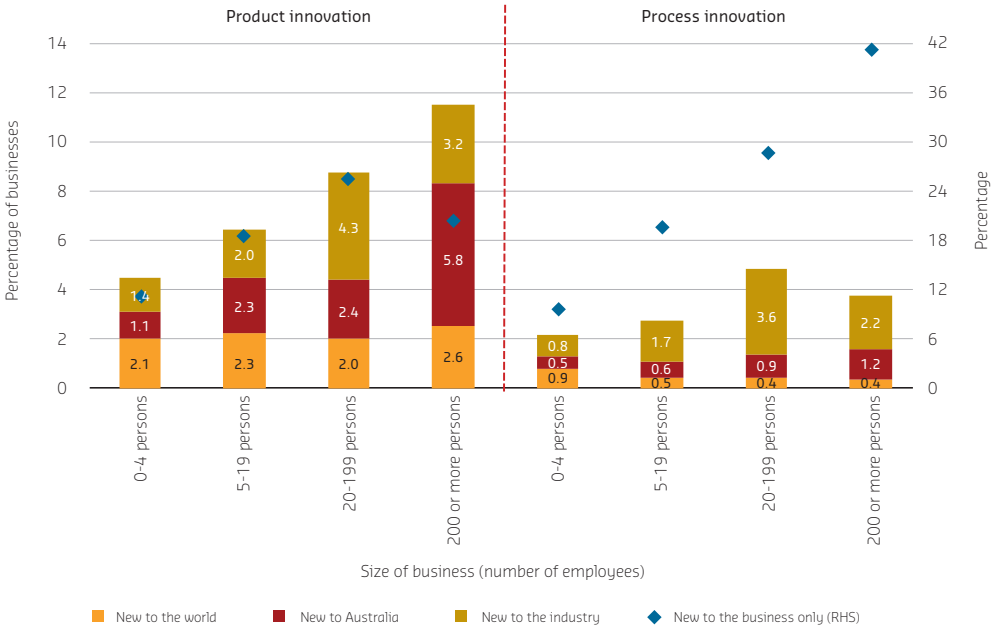
Small businesses are less likely to introduce productivity-enhancing product and process innovations than larger businesses.

Australian businesses are less likely to introduce innovations in processes compared to products. 9 per cent of Australian businesses introduced product innovations that were 'new to the world' in 2012-13, but only 2.2 per cent introduced process innovations that were 'new to the world' in the same year. In addition, 11.6 per cent of businesses introduced product innovations that were 'new to Australia', over three times the share of businesses that introduced process innovations.

Another noteworthy finding is that whereas the largest firms (200 or more persons) are most likely to introduce product innovations, it is firms with 20-199 employees that are most likely to report process innovations. This is mainly due to the fact that businesses employing 20-199 persons are much more likely to introduce process innovations that are 'new to the industry' (at 3.6 per cent) than businesses of other sizes.

Overall, Figure 17 reveals a stark difference between the percentage of small firms that introduce innovative products or processes, compared to larger Australian businesses. Among firms with 0-4 persons, less than 5 per cent introduced product innovations in 2012-13 and less than 3 per cent introduced process innovations that can otherwise lead to significant productivity improvements. These proportions are relatively low compared to larger firms. It may be the case that small businesses face greater barriers to innovations than larger businesses, and these barriers are discussed in greater detail later in this section.

Figure 17 Incidence and novelty of product and process innovation by firm size: 2012-13



Notes: The overall height of each bar represent the share of businesses in each industry sector that introduced an innovation that is at least new to the industry. Separate shades within each bar represent the degree of novelty of innovation. The diamond markers (RHS scale) show the share of businesses that introduced an innovation new to the business only.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from ABS Cat No 8158D003 (Operational process innovation 2012-13, Table 3).

Disaggregating these patterns further, Figure 18 reports the incidence and novelty of product innovation by industry sector and Figure 19 the incidence and novelty of process innovation by industry sector. Both figures emphasise the dominance of innovations that are 'new to the business only' over innovations that are new to the industry, Australia or the world.

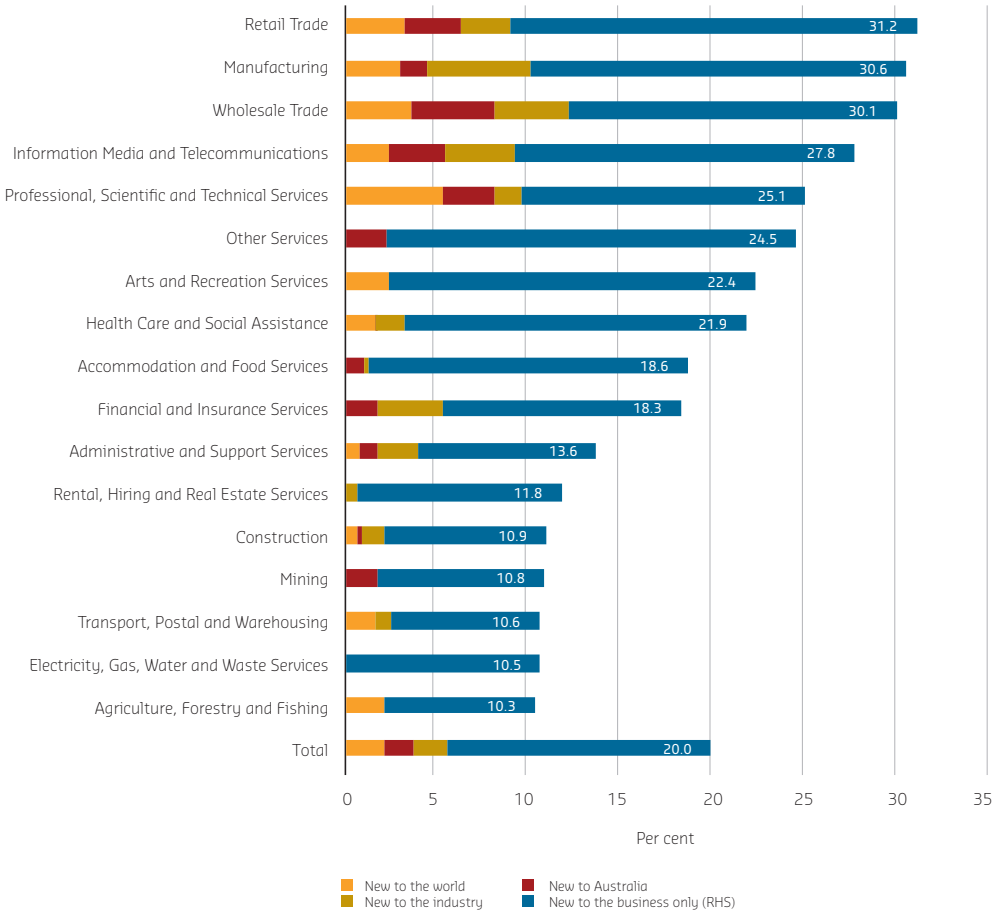
In the area of product innovation, Retail Trade, Manufacturing and Wholesale Trade rank most highly with over 30 per cent of businesses in these industries offering product innovation in 2012-13 (Figure 18). These three industries are also some of the most highly ranked in the area of process innovation. However, mining also features as one of the top performers in process innovation with one-quarter of mining businesses having offered process innovations in 2012-13 (Figure 19).

When looking at more disaggregated novelty categories, it is clear that the share of businesses offering 'new to the world' product and process innovations has been the highest in the Professional, Scientific and Technical Services industry. 5.2 per cent of businesses in the Professional, Scientific and Technical Services sector introduced product innovations in 2012-13 and 2.5 per cent introduced process innovations in the same year. With the added exception of Wholesale Trade and Retail Trade, no other Australian industries reported process innovation that was 'new to the world' in 2012-13.

Overall, this data suggests that, for the most part, innovation in Australia is based on adaptation of innovations that have been developed outside of Australia. In all industries, the innovations offered by businesses are dominated by innovations that are 'new to the business only', as represented by the blue bars in the two figures.

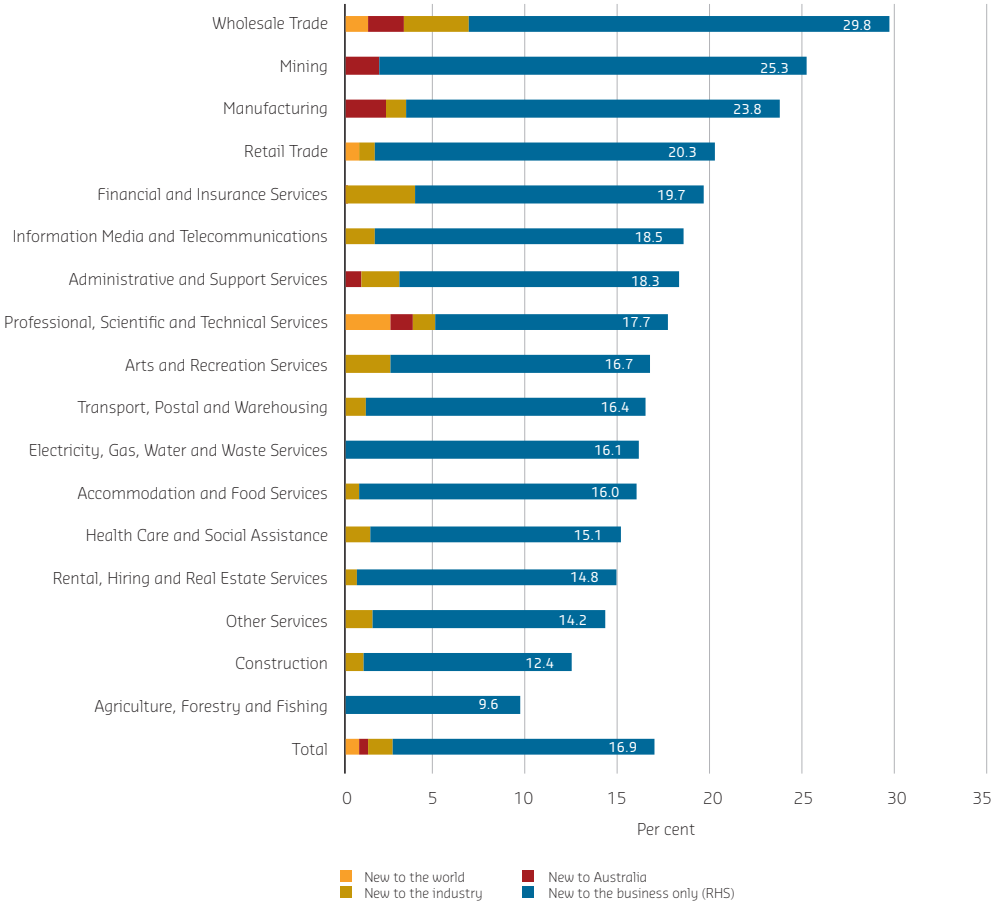
The share of businesses offering 'new to the world' innovations is highest in the Professional, Scientific and Technical Services industry.

Figure 18 Incidence and novelty of product innovation by industry sector: 2012-13



Notes: The overall length of each bar represent the shares of businesses in each industry sector that introduced a new or significant product innovation. Separate shades within each bar represent the degree of novelty of innovation.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from ABS Cat No 8158D002 (Goods and services innovation 2012-13, Table 3).

Figure 19 Incidence and novelty of operational process innovation by industry sector: 2012-13



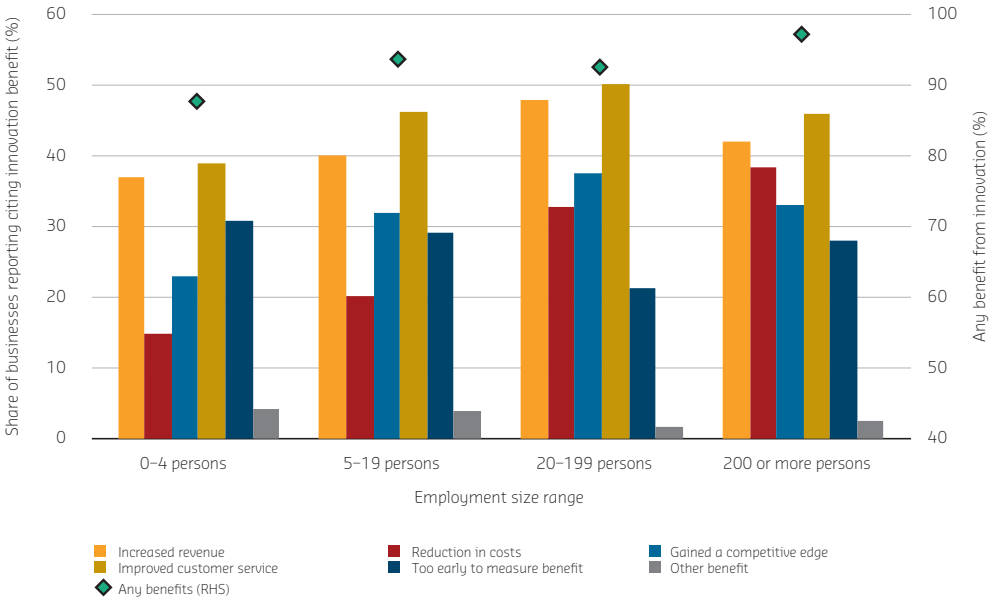
Notes: The overall width of each bar represent the shares of businesses in each industry sector that introduced a new or significant innovation in operational processes. Separate shades within each bar represent the degree of novelty of innovation.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from ABS Cat No 8158D003 (Operational process innovation 2012-13, Table 3).

Why do businesses innovate?

The self-reported benefits of innovation are plotted in Figure 20. As demonstrated by the diamond shape (percentages reported on the RHS), almost 100 percent of firms with 200 or more employees reported receiving a benefit from innovation. This is almost 10 percentage points higher than that reported by micro businesses (0-4 employees). This suggests that larger businesses are more successful at deriving benefits from innovation than micro-businesses.

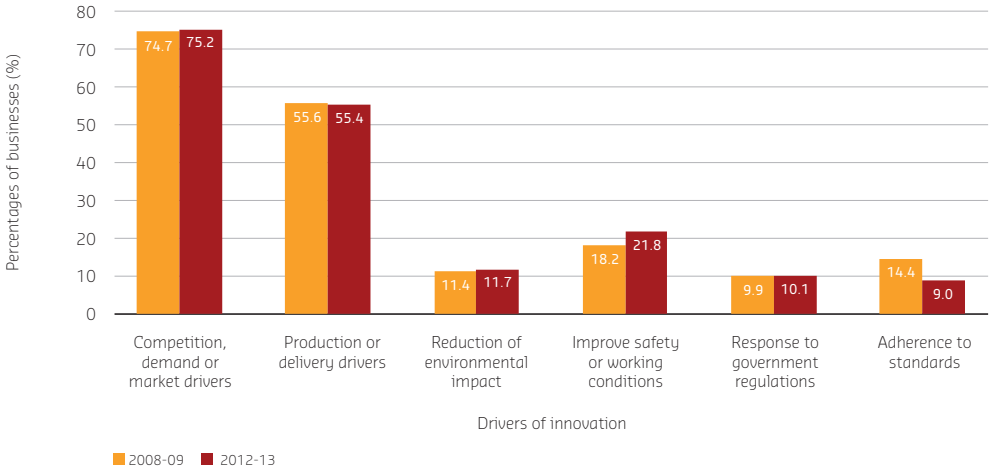
Key benefits received from innovation include an increase in revenue, improved customer service and gaining a competitive advantage. The most commonly reported benefit of innovation for micro-businesses is increased revenue, followed by improved customer service. Improved customer service is the most commonly reported benefit of innovation among other firm size groupings. Larger firms are most likely to report the benefit of a reduction in costs due to the introduction of an innovation.

Figure 20 Self-reported benefits from innovation, by firm size: 2012-13



Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 81580DO012 (Benefits of Introduced Innovation, 2012-13, Table 1).

Figure 21 Drivers of innovation, all industry sectors: 2008-09 and 2012-13



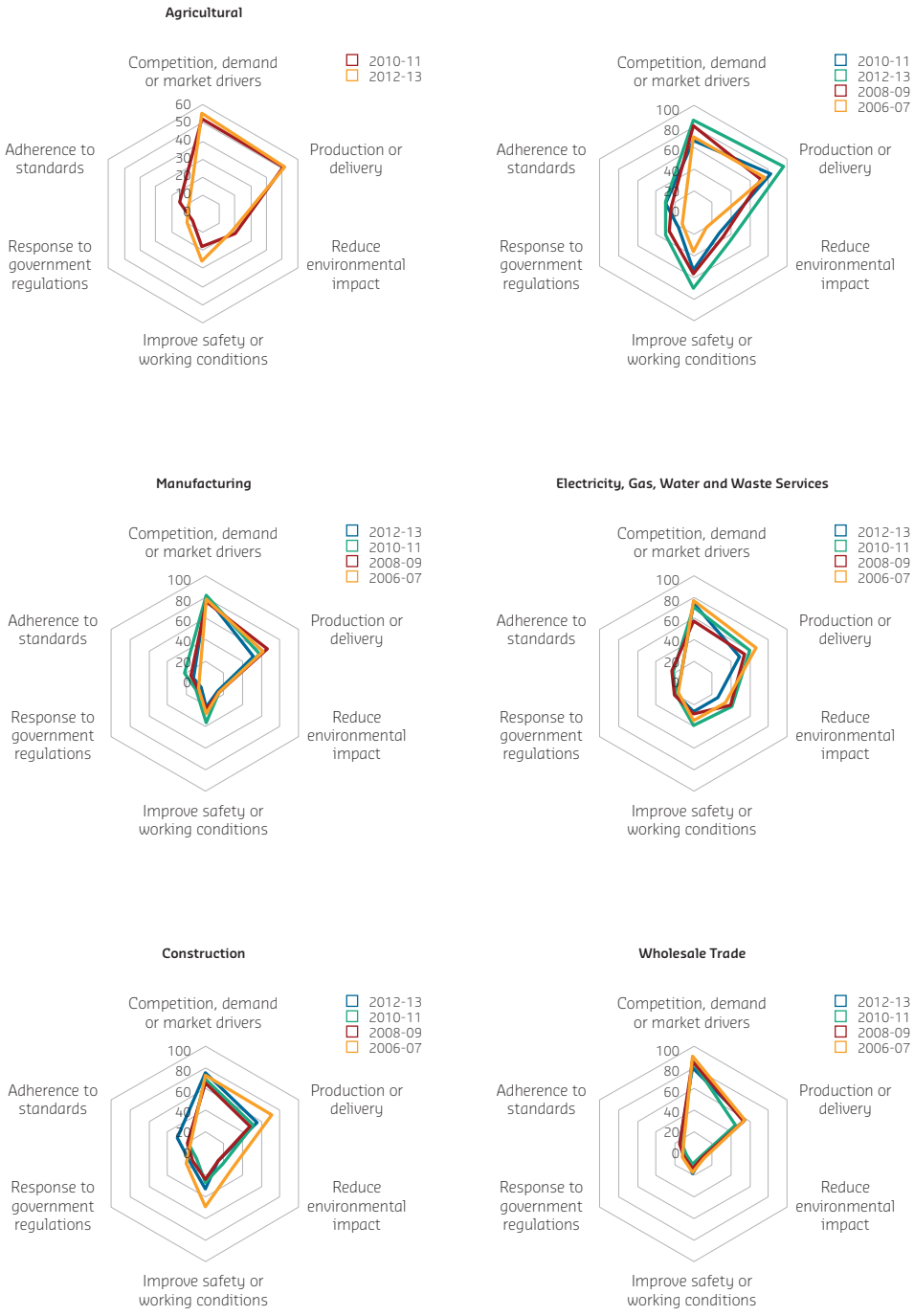
Notes: Estimates have relative standard errors of 10% to 25% and the upper and lower band were not shown to improve visibility. Bars in the figures show the average of percentages across the years.
Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 81580.

Figure 21 illustrates the factors driving innovation for Australian businesses. Competition, demand or market drivers are the most significant driver of innovation, with around three-quarters of all firms citing this as a key driver of innovation. This is followed by production or delivery drivers, with other innovation drivers ranking significantly lower in importance.

The picture is not that different across individual industries, as shown in Figure 22. In most of the industries competition and demand related motivations are the biggest drivers of innovation, followed by production and delivery related motivations.

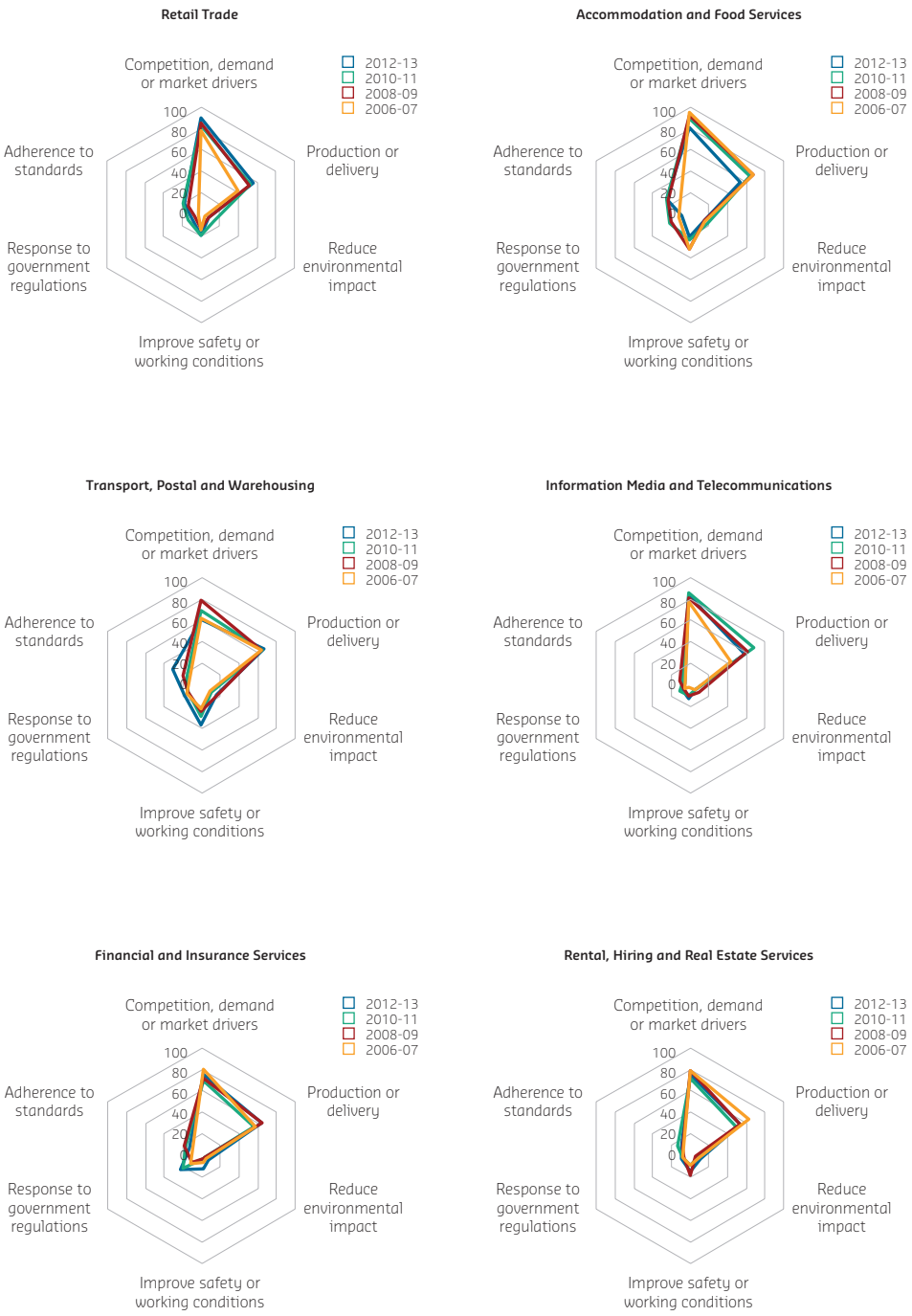
Relative to other industries, Mining, Construction, and Manufacturing, together with Agriculture, Forestry and Fishing and Transport, Postal and Warehousing, also report the importance of improvements to safety or working conditions as additional drivers to innovation. This is to be expected, given the nature of their business and production processes.

Figure 22 Drivers of innovation by industry sector: 2006-07 to 2012-13



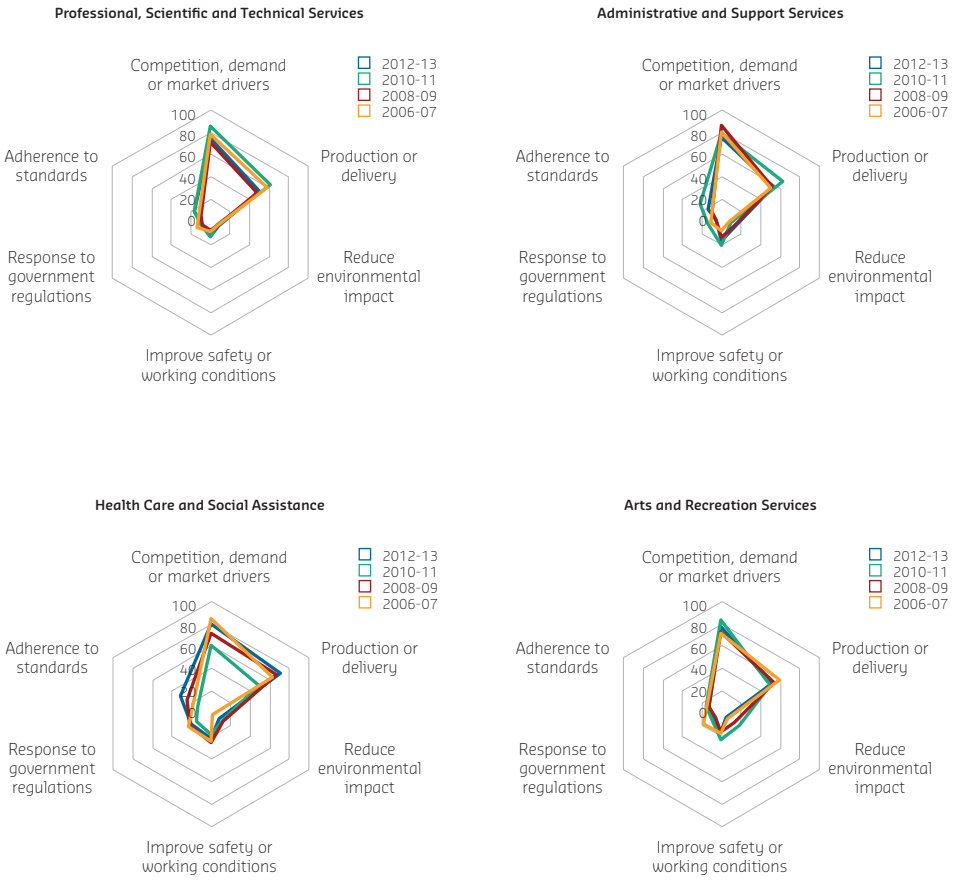
Notes: Estimates have relative standard errors of 10% to 25% and the upper and lower band were not shown to improve visibility. Values for "Adherence to Standard" are missing for 2006-07.
Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 81580.

Figure 22 continued



Notes: Estimates have relative standard errors of 10% to 25% and the upper and lower band were not shown to improve visibility. Values for "Adherence to Standard" are missing for 2006-07.
Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 81580.

Figure 22 continued



Notes: Estimates have relative standard errors of 10% to 25% and the upper and lower band were not shown to improve visibility. Values for "Adherence to Standard" are missing for 2006-07.
Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 81580.

Better together: collaboration and innovation

Collaboration is an essential mechanism to support the generation of ideas, and flow of new and existing knowledge. This section looks at some key indicators relating to the collaboration and openness of Australian businesses.

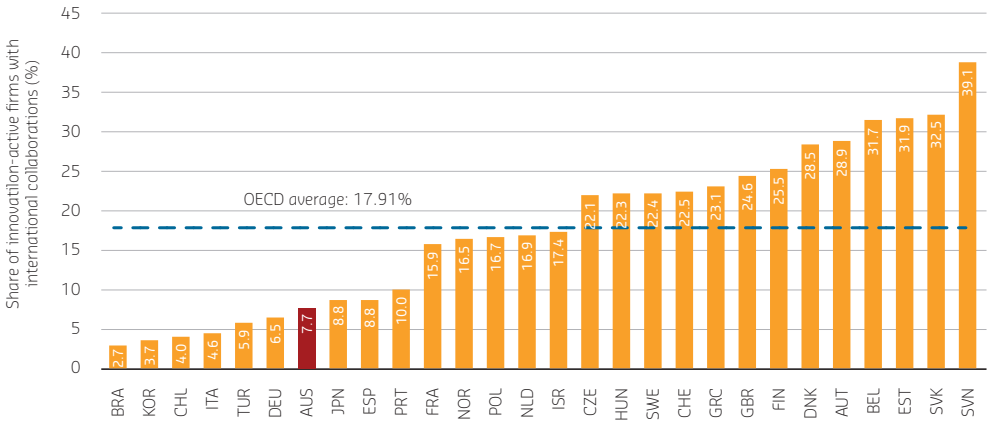
In Figure 14, we reported that around 60% of Australian firms are innovative. Figure 23 displays the share of innovation-active firms engaged in international collaborations for a selection of OECD economies in 2012-13, and shows that only 7.7 per cent of Australian's innovation active firms are collaborating internationally. This is well below the OECD average of 17.9 per cent. Interestingly, Germany also reports well below the OECD average for innovation-active firms engaged in international collaboration, despite the fact that they too reported an above average share of innovation-active firms.

Only 7.7 per cent of Australian's innovation active firms are collaborating internationally.

Barriers to international collaboration include geographic proximity, language, and culture as well as political and historical factors, amongst others. For Australia, geographic proximity (an issue discussed in further detail later in this report), is likely to be the key determinant of our low levels of international collaboration.

Given Australia's geographic proximity and the isolation of Australian cities, access to international collaboration networks and knowledge is more crucial for innovation than it is in Europe or America, since collaborations will be more difficult to access locally in Australia. Therefore, it is important that any constraints to accessing knowledge and in developing international collaborations are addressed to support Australian innovation. Factors could include faster broadband, international connectivity (for example airports and related infrastructure), integration with global markets (through for example free trade agreements), and a flexible migration system.

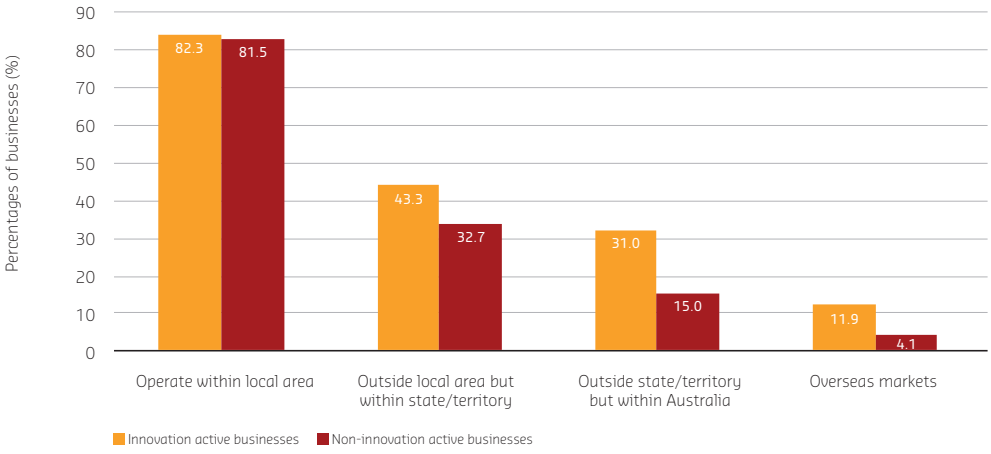
Figure 23 Share of innovation-active firms engaged in international collaborations: OECD, 2012-13



Notes: Figures report the share of innovation-active firms who are engaged in some form of international collaborative activity. Innovation activity can relate either to process or product innovation. OECD comparison data are compiled from country-specific national innovation surveys. For Australia, data come from the Business Characteristics Survey (BCS) and refer to financial year 2012/13.
Source: BANKWEST CURTIN ECONOMICS CENTRE | OECD Innovation Indicators, June 2015.

Innovation active businesses are almost three times as likely to operate in overseas markets.

Figure 24 Geographical markets of operation, by innovation status of businesses: 2013-14



Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 8167.

Figure 24 reports the global nature of Australian businesses in 2013-14. There is a minimal difference in the proportion of innovation-active and non innovation-active businesses operating within the 'local area'. However, for those businesses that expand beyond their local area, differences become more apparent and increasing in nature. That is, innovation-active businesses are almost 33% more likely to operate 'outside their local area, but within their state/territory', twice as likely to operate 'outside their state/territory, but within Australia' and almost three times as likely to operate in overseas markets.

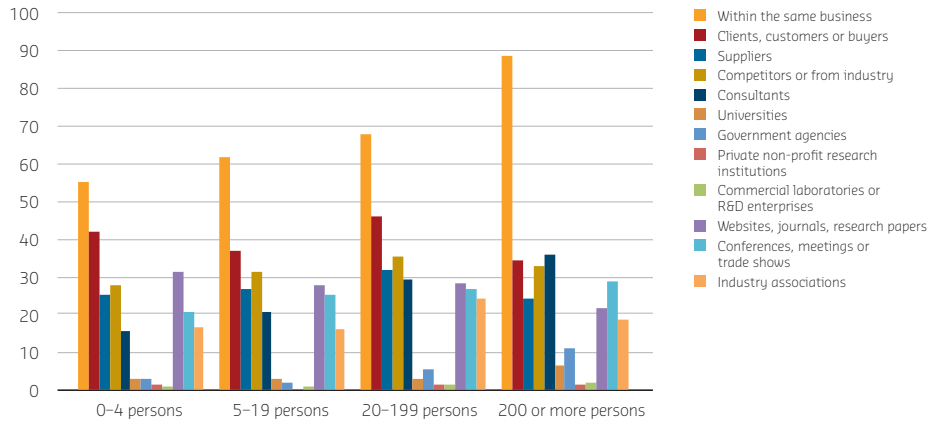
Therefore, the view that innovative firms are much more likely to participate in international markets is supported by these findings. With less than one in five Australian firms operating in global markets, Australian companies are not global in nature. Distance to markets may be a contributing factor to the inward facing nature of many Australian companies.

As a regional economy, it is imperative that Australian cities have a 'local buzz' – attracting the best people, and ensuring we have a creative environment. The 'buzz' is the learning processes taking place among innovation actors in a community. It is equally important that we have the 'global pipelines' (infrastructure) to get our products, processes and ideas out to market.[7]

7 Bathelt, H., Malmberg A., and Maskell, P. (2004), Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. Progress in Human Geography 28,1 (2004) pp. 31-56.

Figure 25 presents the sources of innovation idea by business size in 2012-13. All business sizes report 'within the business' as the primary source of their innovative idea. This increases with business size, as one would expect – larger businesses have more internal knowledge and skills from which to draw and create new ideas. With many Australian businesses being SMEs, it is important that they have access to additional networks and channels for sourcing new ideas for innovative business activity. While SMEs report similar levels of idea sourcing from clients, suppliers and competitors as larger businesses, they are less likely to source ideas from conferences, government agencies, universities and consultants. Time and resources are likely barriers preventing micro-business and SMEs from engaging further in these activities.

Figure 25 Sources of innovative idea across different business size, 2012-13



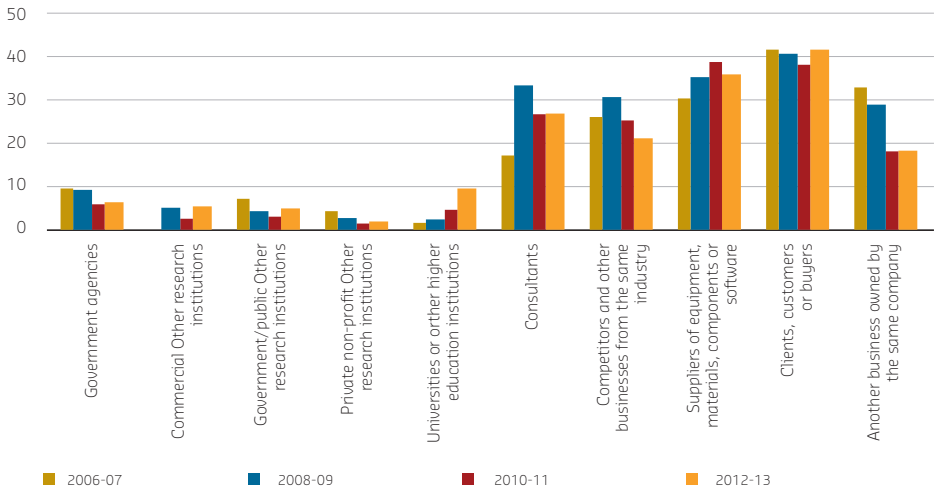
Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 81580.

Increased collaboration with universities suggests that Australian businesses are increasingly seeking new sources of knowledge.

Figure 26 shows the organisations Australian businesses collaborate with, and how this has changed between 2006 and 2013. For 2012-13, customers are the most likely source of co-collaboration, followed by collaboration with suppliers, consultants, competitors and another business owned by the same firm.

Collaboration with Universities has seen a marked and consistent increase over the time period, which suggests that Australian businesses are increasingly seeking existing and new (research) sources of knowledge.

Figure 26 Australian businesses co-collaborators, 2006-2013



Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 81580.

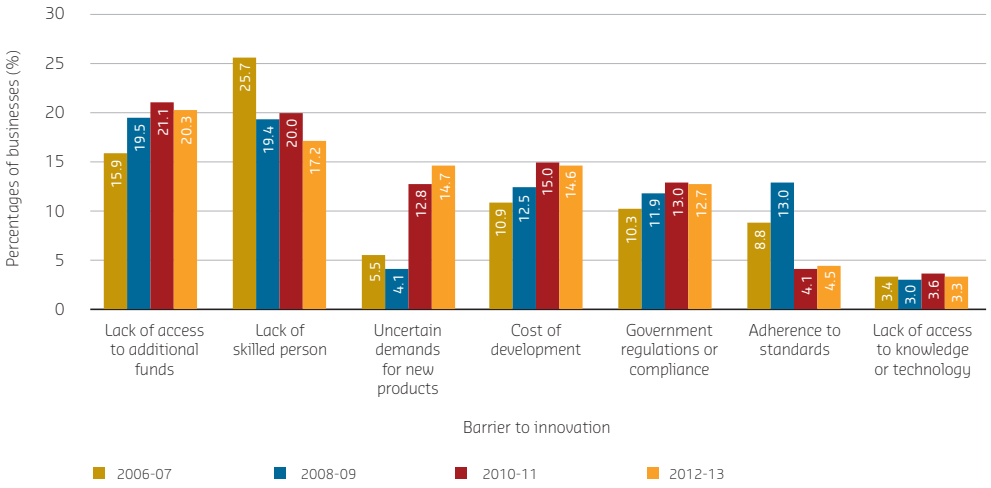
Getting in the way? Barriers to innovation

Barriers to innovation, as cited by Australian businesses, are reported in Figure 27. In 2006-07, the most significant barrier to innovation reported was the lack of availability of skilled workers. This occurred during a period of high economic growth, with unemployment levels at or below the natural rate of unemployment. However, the lack of skilled persons as barrier to innovation decreased from 25.7% in 2006-7 to 20% in 2010-11 and then to 17.2% in 2012-13.

In all reported periods after 2006-07, a lack of access to additional funds was the most common barrier affecting Australian businesses' ability to innovate. In 2008-09, 2010-11 and 2012-13, around one-fifth of Australian businesses report lack of access to additional funds as a barrier to innovation. The post-boom years have also seen a notable increase in 'uncertain demands for new products' as a barrier to innovation. In 2008-09, 4.1 per cent in 2008-09 cited this factor as a barrier to innovation and by 2012-13, this proportion had more than tripled to 14.7 per cent. Over the same period, the share of businesses reporting the 'cost of development' and 'government regulations or compliance' as a barrier to innovation also rose slightly.

Around one-fifth of Australian businesses report lack of access to additional funds as a barrier to innovation.

Figure 27 Self-reported barriers to innovation: all industries, 2006-07 to 2012-13



Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 81580.

The lack of access to additional funds and government regulations or compliance are increasingly viewed as a significant barrier to innovation in a range of industries.

Figure 28 reports the barriers to innovation by industry, and illustrates how these barriers have changed between 2006-07 and 2012-13.

In most industries, the 'lack of skilled persons' was the most commonly cited barrier to innovation back in 2006-07. In a range of industries – including Mining, Manufacturing, Electricity, Gas, Water and Waste Services, and Professional, Scientific and Technical Services – the proportion citing this as a barrier was even higher at around 25 per cent in 2006-07. This barrier appeared to be greatest in the Construction industry during the housing market boom of the mid-2000s, with almost one-third of construction businesses reporting a 'lack of skilled persons' as an obstacle to innovation in 2006-07. However, in most industries, there has been a notable decline in the share of businesses reporting the 'lack of skilled persons' as a barrier post-GFC, which coincides with a softening labour market.

Other common barriers to innovation that grew in importance between 2006-07 and 2012-13 include 'lack of access to additional funds' and 'government regulations or compliance'.

In many industry sectors, 'lack of access to additional funds' has grown in importance. For instance, in the Mining sector, the share of businesses citing 'lack of access to additional funds' as a barrier to innovation doubled from 10 to 20 per cent over the period of analysis. In the Accommodation and Food Services sector, the share also rose significant from 15 to 25 per cent. The share of businesses reporting 'lack of access to additional funds' as a barrier also increased in the Construction, Professional, Scientific and Technical Services, Health Care and Social Assistance, Wholesale Trade and Retail Trade. In other industries such as Financial and Insurance Services and Rental, Hiring and Real Estate Services, the share of businesses reporting this as a barrier peaked at during the GFC years before receding to lower levels after 2008-09 though these still exceeded the levels reported back in 2006-07.

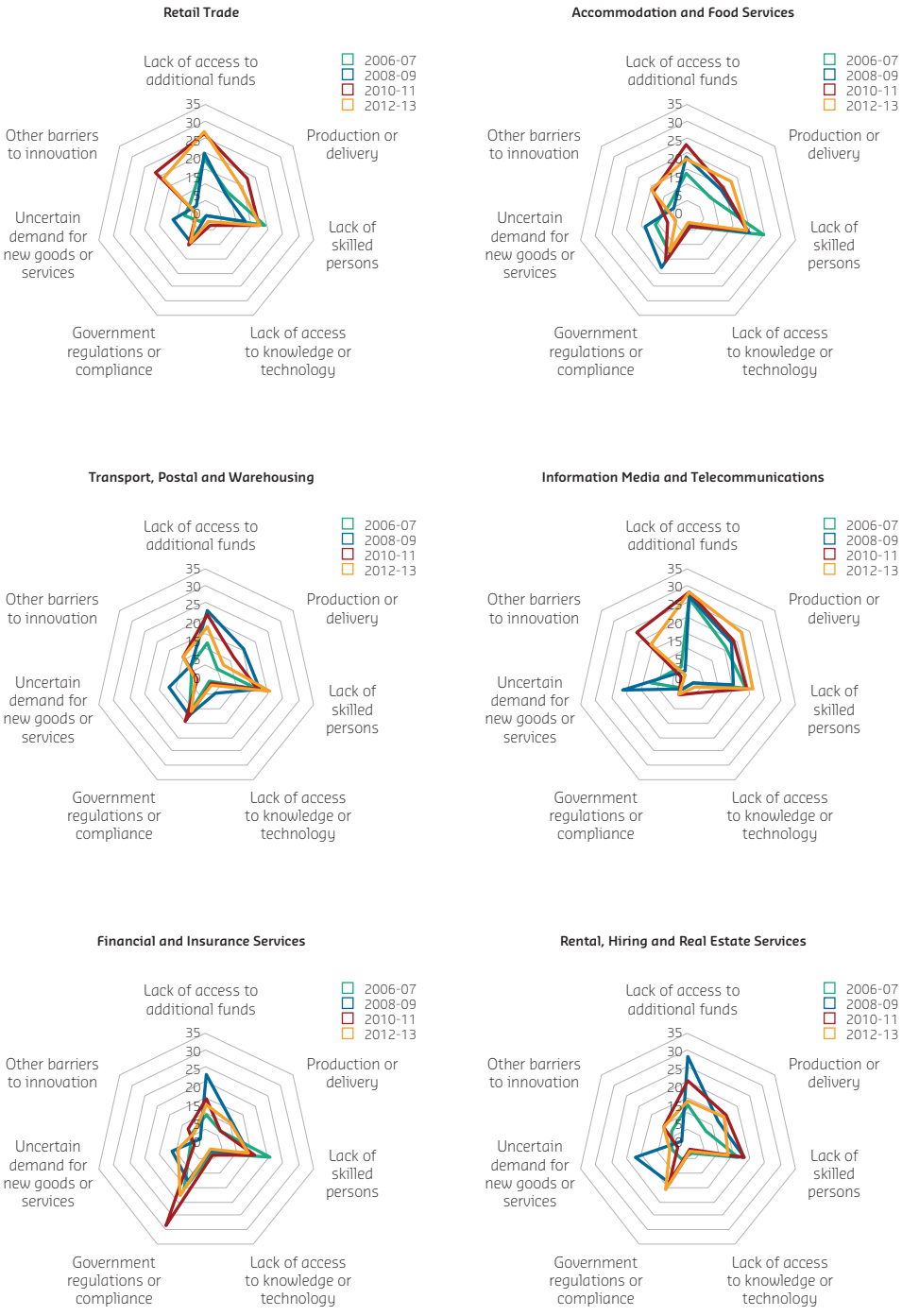
Another key barrier to innovation is 'government regulations or compliance'. The percentage of businesses reporting this as a barrier to innovation rose in industries such as Mining, Rental, Hiring and Real Estate Services, Professional, Scientific and Technical Services and Electricity, Gas, Water and Waste Services. In the Financial Services sector, there is once again a clear correlation between the importance of 'government regulations or compliance' as a barrier to innovation and economic conditions. The share of businesses in Financial Services that reported 'government regulations or compliance' as a barrier peaked at 30 per cent, before dropping again to 20 per cent in 2012-13 though once again this remained greater than pre-GFC levels.

It is also notable that the Wholesale Trade, Retail Trade and Accommodation and Food Services industries have increasingly cited the 'cost of development' as a barrier to innovation between 2006-07 and 2012-13.

Figure 28 Self-reported barriers to innovation by industry sector: 2006-07 to 2012-13

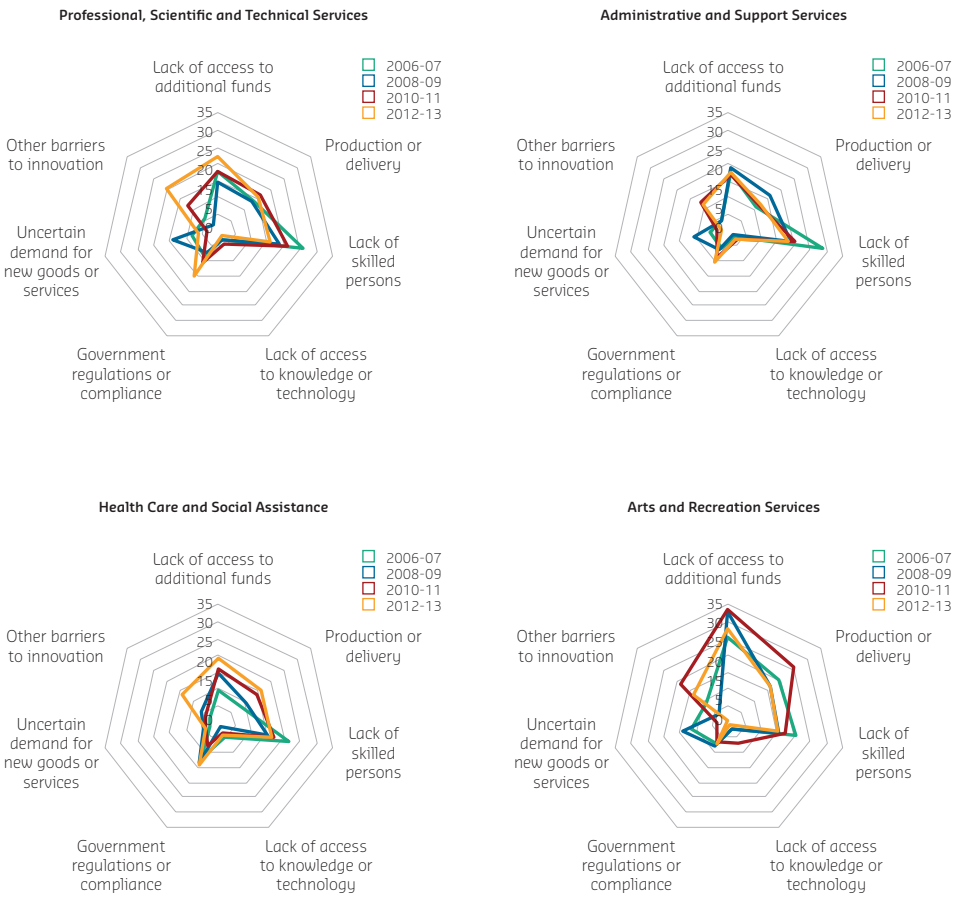
Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 81580.

Figure 28 continued



Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 81580.

Figure 28 continued



Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 81580.

Investing in the ideas boom

Real business R&D expenditure increased from $6.2 billion in 1999-00 to $19.4 billion in 2008-09.

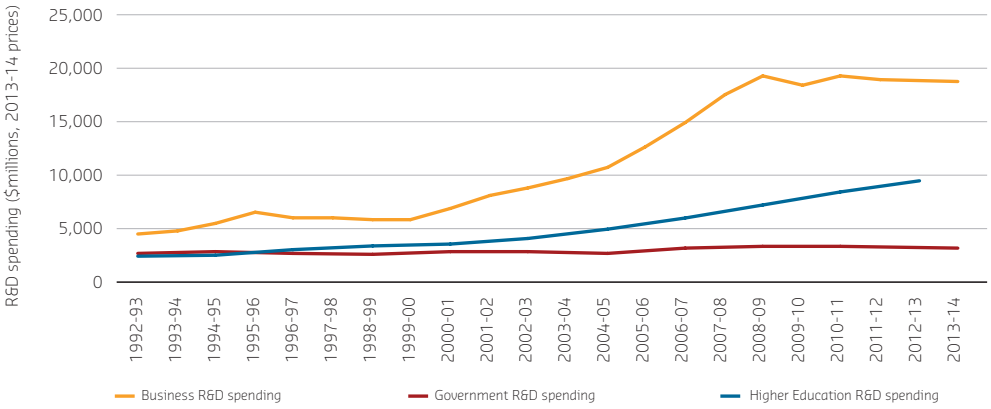
The Turnbull government has recently announced a $1.1 billion investment in an 'Ideas Boom' that is set to deliver for Australia the next age of economic prosperity. Underneath the umbrella of the National Innovation and Science Agenda, the investment strategy consists of four pillars – culture and capital, collaboration, talent and skills and government as an exemplar.

Specific funding has been directed towards a number of big ticket items, with one-third of all funding ($459m) committed to what the government deems as "critical research infrastructure", which includes the Australian Synchrotron and Square Kilometre Array. A further $250 million has been set aside for biomedical translation fund, which is set to facilitate the commercialisation of medical research. Other initiatives include tax breaks to encourage early stage investors in start-ups, funding to promote university-industry links and programs that will seek to boost digital literacy and the digital marketplace.

Over the past two decades, government spending on research and development (R&D) has remained relatively flat at around three to $3.5 billion from 1992-93 to 2013-14 (Figure 29). Higher education R&D expenditure has had a steady growth trajectory over the last two decades and currently stands at around $10bn. During this period, applied research has taken over from pure basic research as the research activity that attracts the most funding, and now constitutes around 45% of all higher education R&D expenditure.

Contributions by the business sector to research and development have increased significantly over the period, especially during the boom, which saw real business R&D expenditure increase from $6.2 billion in 1999-00 to $19.4 billion in 2008-09. However, since the GFC, business R&D spend has come off slightly and in 2013-14 stood at $18.8 bn.

Figure 29 R&D spending by category: 1992-93 to 2013-14 ($million, 2014 prices)



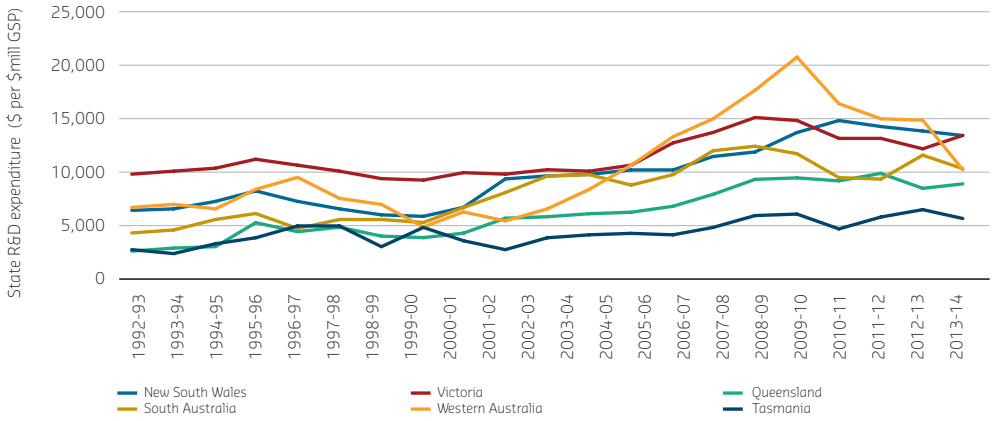
Notes: Government R&D expenditure includes both Commonwealth and State/territory General Government.
Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 8109.0, 8104.0.

Considerable variation exists in business R&D expenditure across Australia's states (Figure 30). It's no surprise that Western Australia's business R&D expenditure, relative to Gross State Product rose sharply over the course of the boom, peaking in 2008-09 to $20,000 for every $1m of Gross State Product. It was inevitable that this high water mark would recede and has since come off considerably, with business R&D expenditure now at around $10,000 for every $1m of GSP in WA.

Throughout the 1990s and early 2000s, Victoria remained the front runner in terms of business R&D spend relative to GSP. While climbing at the same time as WA and other states business R&D spend grew, Victoria never reached the same peak that WA experienced. Victoria and NSW are currently equal first in terms of business R&D spend relative to GSP. Queensland has consistently recorded the second lowest business R&D spend over the two decades, when compared to the other states, despite being the third most populous. Like most other states, considerable growth in business R&D spend was noticeable for the sunshine state as the Australian economy expanded during the 2000s. Since the GFC, expenditure has reduced slightly from its peak of $10,000, to around $9,000 for every $1m of GSP in 2013-14.

Business R&D expenditure for WA relative to gross state product, has halved since peaking at $20K for every $1m in GSP in 2008-09.

Figure 30 Business R&D spending by state: 1992-93 to 2013-14 ($ per $million GSP)



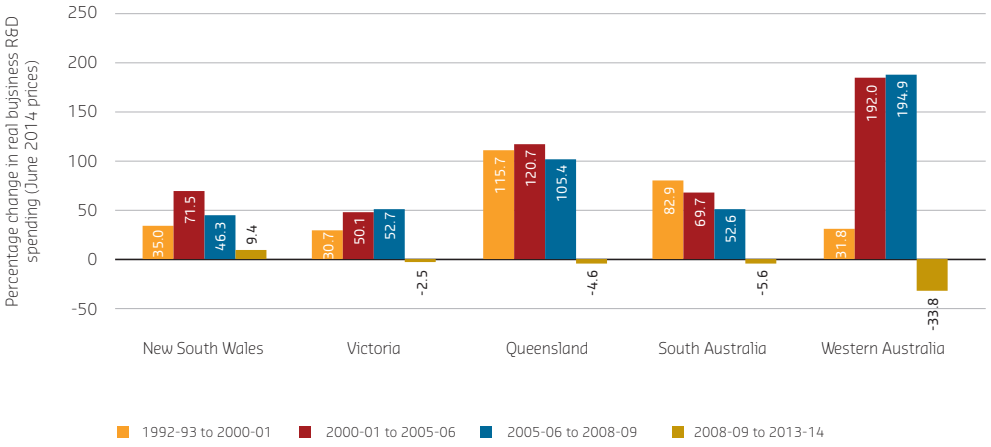
Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 81580, 5678.

Changes over time in real business R&D spend across states are shown in Figure 31. The large increases in business R&D expenditure for Western Australia stand out, with increases of close to 200% in the two boom periods (2000-01 to 2005-06 and 2005-06 to 2008-09). From 2008-09 to 2013-14, business R&D spend fell by 34% in real terms, however, this was from an already considerably high and untenable position.

All states have seen a decrease in business R&D expenditure since the GFC. However, NSW still remains on a positive trajectory – but only slightly, with R&D expenditure increasing by 9 per cent between 2008-09 and 2013-14.

All states bar NSW have seen a decrease in real business R&D expenditure since the GFC.

Figure 31 Percentage change in real business R&D spending: by state (2014 prices)



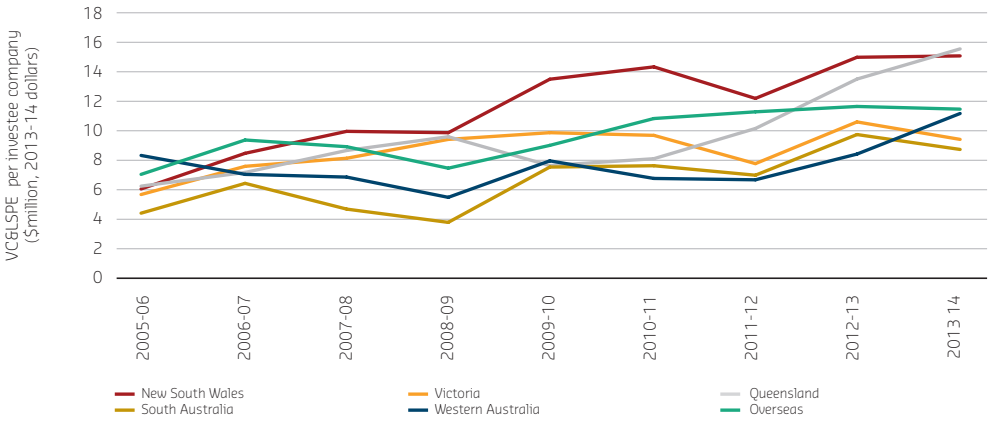
Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 81580, 5678.

The ability to access and raise capital is a key element of business operations and successes, allowing a business to build, grow and innovate. Access to high-risk capital can be particularly important for businesses at the pre-seed and seed stage, facilitating the commercialisation of new ideas and market access. Venture capital and Later Stage Private Equity (LSPE) can provide an indicator of the pool of potentially high-risk capital available to businesses. Venture capital in particular can provide a proxy for innovation as it refers to pre-seed, seed, start-up and early expansion stage of investment. While LSPE refers to late expansion, turnaround and buy-out or sale stage investment, these stages can still reflect innovative activity.

Venture capital and LSPE per investee company is shown over time for Australian states and overseas investment in Figure 32. Queensland demonstrates the strongest trajectory, with VC & LSPE funding increasing sharply since 2009-10, from $9.6m to $15.6m per investee company in 2013-14. NSW has had the highest VC and LSPE investment, falling between 2010-11 and 2011-12. The state is currently ranked second behind Queensland, at $15.2m per investee company.

Western Australia has also seen a recent increase in VC and LSPE investment per company, increasing from $6.8m per investee in 2010-11, to $11.3m in 2013-14.

Figure 32 Venture capital and late stage private equity (LSPE) investment per investee company ($million, 2013-14 dollars)



Notes: Stage of investee – Venture Capital (VC) refers to the pre-seed, seed, start-up and early expansion stage of investment. Later Stage Private Equity (LSPE) refers to the late expansion, turnaround and buy-out or sale stage of investment.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from ABS Cat No. 8158.0 and ABS Cat No. 5678.0.

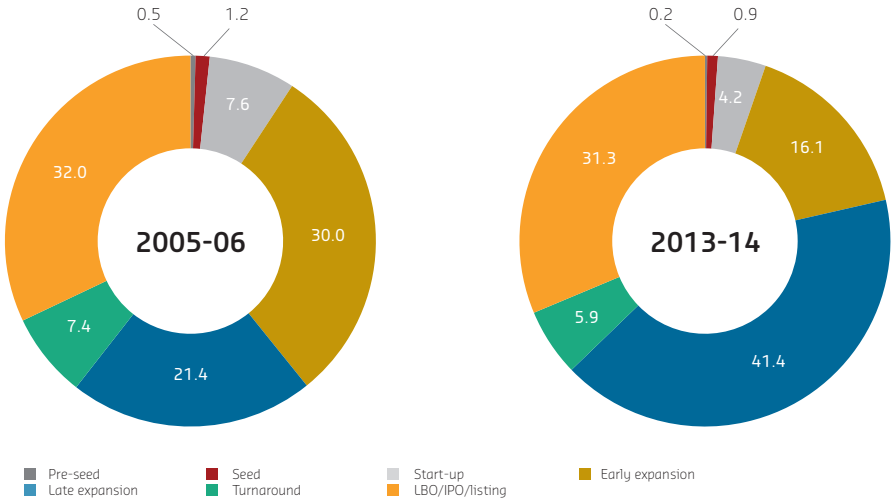
Venture capital and later stage private equity per investee company is the highest in Queensland at $15.6m.

Figure 33 shows the composition of venture capital and Later Stage Private Equity (LSPE) funding by stage of the investee for 2005-06 and 2013-14. A clear retreat from riskier investments across the period is observed. In 2005-06 a greater proportion of funding was directed towards investing in early expansion (30%). However this has almost halved over the last decade, with early expansion investment constituting 16% of all VC&LSPE. A similar decrease is also observed for investment in start-ups, decreasing from 7.6% to 4.2% across the same period.

A subsequent increase in late expansion investment is seen over the period, with funding allocated to investees at this stage in their business development doubling their total share from 21.4% to 41.4%. These changes are likely to be linked with both the GFC and the economy transitioning to a production phase as the mining boom tapers off. The diminishing share of funding dedicated to activities that are likely to suggest innovation and potentially productivity growth goes against the central ambitions of the ideas boom. However, given this new investment and policy direction, we can expect that this trend will revert if initiatives are proven successful.

The proportion of capital devoted to early expansion has almost halved over the last decade, from 30% to 16.1%.

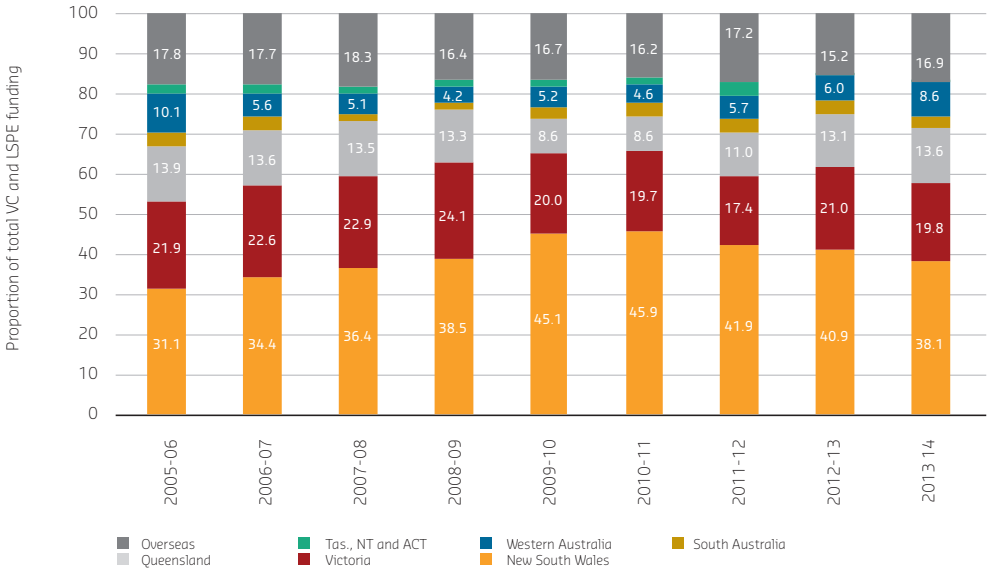
Figure 33 Share of investment by stage: 2005-06 and 2013-14



Notes Stage of investee - Venture Capital (VC) refers to the pre-seed, seed, start-up and early expansion stage of investment. Later Stage Private Equity (LSPE) refers to the late expansion, turnaround and buy-out or sale stage of investment.
Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 5678.

The share of venture capital and LSPE across states and territories largely reflects their relative populations (Figure 34). New South Wales currently attracts the largest share at 38.1%, however, this has decreased since 2010-11 from 45.9% of all VC & LSPE investment. Western Australia has increased the share of VC and LSPE investment that the state attracts, from a low of 4.2% in 2008-09, to 8.6% in 2013-14. Queensland has also seen an increase in the share of VC and LSPE investment the state attracts, returning to earlier trends in 2005-06, where the state had around a 13.9% share.

Figure 34 Share of venture capital and LSPE investment by state/territory: 2005-06 to 2013-14



Source: BANKWEST CURTIN ECONOMICS CENTRE | ABS Cat No. 5678.

Innovation

and australia's geography:
the importance of proximity

Introduction

The innovation systems approach emphasises the importance of knowledge flows between people, institutions and businesses as an integral part of the innovation process (OECD, 1997). An eventual innovation is the result of many complex interactions between members of the system including businesses, universities, research institutes and government agencies. Interactions facilitate the transfer and flow of knowledge. Understanding how these interactions occur in Australia and how they affect innovation outcomes can help to understand and improve the innovation performance of Australia.

One key input into innovation that cannot be measured directly is all of the existing knowledge that an innovation builds upon. Instead, researchers capture knowledge through composite indicators of innovation investment and innovation performance. In an innovation system, the environment in which researchers and workers live and the ways in which businesses, workers, universities, research institutes, entrepreneurs and financiers interact all governs how knowledge flows and contributes to the innovation performance of businesses, institutions and organisations.

There is no single accepted definition of a system of innovation, but the important component is the emphasis on knowledge flows and how this is driven by interaction (OECD, 1997). The relationship between knowledge flows and innovation is examined in a number of ways in this section. "Better" innovation systems are more effective at creating interactions to transfer knowledge and technology. More effective flows of knowledge are likely to lead to improved innovation performance and increased productivity. This section explores how our cities and universities have a role in facilitating successful innovation outcomes as key components of Australia's national system of innovation.

Innovation as defined in the OECD Oslo Manual deals with the implementation of a new idea. Innovation is broader than invention and involves many stages where innovators figure out more about the viability and potential for success from their ideas. While it is natural to think only about the inputs and outputs of the innovation process such as investment in research and development, "the interactions among the actors involved in technology development are as important as investments in research and development." (OECD, 1997)

In this section, we explore the importance of location in facilitating knowledge flows and innovation.

Why proximity matters for innovation

Agglomeration is an important concept in the innovation systems approach. Agglomeration refers to continuous urban areas. Agglomeration economies refers to the benefits from people and firms being located near each other in cities. These benefits come in many forms but are most closely related to savings in transport, communication and transaction costs: It is easier to connect to a neighbour than a person that is far away (Glaeser, 2010). When interactions occur more often, knowledge is transferred easily and innovations and ideas are generated more frequently.

From an innovation systems perspective, larger agglomerations are more likely to facilitate additional and more intense interactions between participants in the system and enable a greater and faster flow of technology and knowledge, provided congestion can be managed and the infrastructure to facilitate interaction is adequate. A better flow of knowledge leads to increased innovation performance because knowledge is a key component for innovations to build upon. It is in this perspective that we analyse where innovations occur because it demonstrates the importance of location in facilitating interaction.

While it is intuitive to expect that location would become less important as transport and communication costs decline, agglomeration economies are strengthened by reductions in the costs of transporting goods and transferring knowledge (Krugman, 1991; Baldwin, et. al., 2005). This is because as transport and communication costs decline, the ability to reach the largest market, including outside the agglomeration, or access the most knowledge increases by more for businesses choosing to locate in the agglomeration compared to businesses choosing to locate regionally.

The benefits of agglomeration appear even greater when we think about the flow of knowledge. It has often been argued that the internet, globalisation and technology have made location unimportant and that the world is now flat' (Friedman, 2005). However, others argue that 'the world is spiky' because location appears to be increasingly important as economic activity is increasingly concentrated in larger and larger cities (Florida, 2005). In Australia and around the world we have seen a decline in traditional manufacturing and a rise in services as a proportion of the economy. The economy has changed from one which rewards brawn to one which rewards brains.[8] In a modern economy with high knowledge-intensive production, the importance of interactions that require face-to-face contact has increased (McCann, 2007; 2008). In this world, interconnected cities have become a vital asset to facilitate the transfer of knowledge between people, universities, research institutes and businesses.

8 For more commentary on the increasing rewards for skilled labour see The Economist (2000) A survey of the new economy: Labour pains, Special report, 23 Sep. 2010. http://www.economist.com/node/375579.

Larger cities tend to produce more innovations per person than smaller cities.

Here we test the relationship between innovation and agglomerations, using patents as a proxy for innovation. While patents are always part of an innovation, leading to an improved product or process, not all innovations involve a patent. Innovations may also be recorded as trademarks or new businesses or they may not be recorded at all as 'trade secrets.' Nonetheless, because patents are recorded consistently and accurately around the world, they are an effective measure to make comparisons between countries about the location of innovation.

Patents also play a vital role in an innovation system for two reasons. Firstly they provide an incentive for the innovating firm by protecting their design from imitation but it requires significant documentation and publication of the knowledge underlying a new innovation. Secondly, while competitors are prevented from copying a patented idea, the publication of this knowledge in a patent becomes a key input to future research that could lead to new ideas and innovations, provided the improvement is substantial enough.

Patents also enable small businesses and start-ups to demonstrate their innovative capability and facilitate access to capital for expansion (Farre-Mensa et al., 2016). Even so, not all knowledge can be written down in a patent. Most knowledge is at least partially tacit such that it can only be transferred through face-to-face contact, interaction and practice. As a result the importance of being located in cities has increased for innovation as the importance of knowledge in the modern economy has increased (McCann, 2007, 2008).

Figure 35 charts the relationship between population and average annual patents from 2008 to 2012 for cities and regions in Australia, New Zealand, the United Kingdom and the United States. Each dot represents the number of patent applications in a city between 2008 and 2012 in comparison to the city's population in 2012. The dotted lines describe the average annual number of patents a city would produce if its patent count per capita were at the national average for the country of that city. It is noticeable that larger cities are typically above their country's national average while smaller cities are below. This is the benefit of agglomeration: larger cities are better than average at producing patents and smaller cities are relatively worse.[9]

Sydney produces more patents than Melbourne, Brisbane slightly more than Perth, but these larger cities also typically produce more patents than average while smaller cities typically produce fewer patents than average. Notably, Australian cities produce a similar number of patents to most comparably sized cities in the US, UK or New Zealand. This means that when a country or state has a higher or lower number of patents, it appears to be related to the size of its cities rather than its total population.

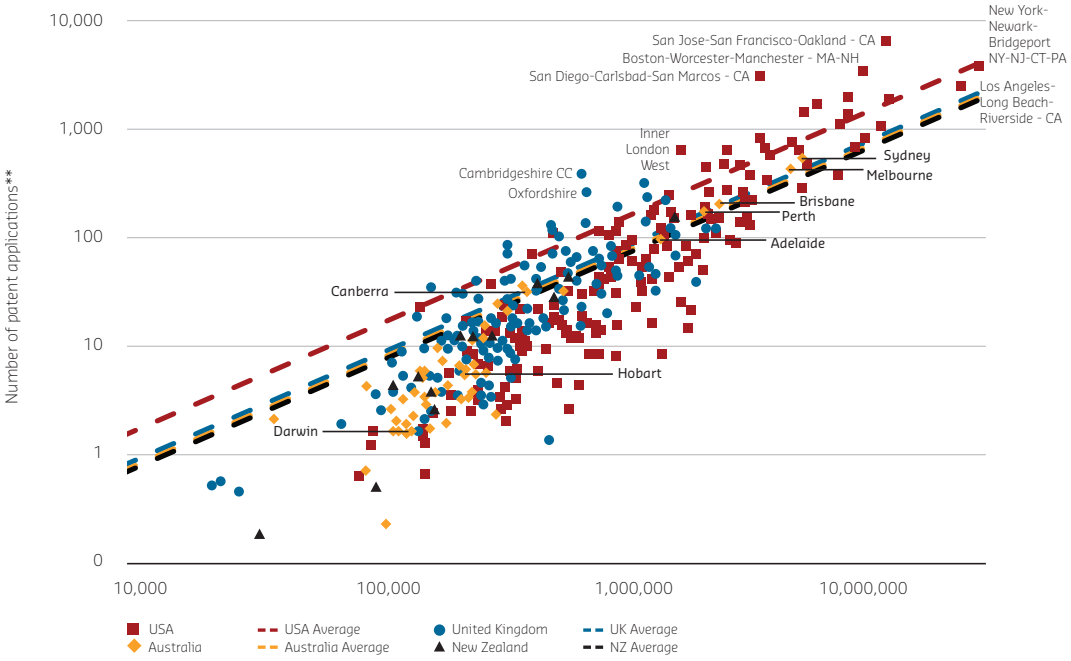
The patent count average lines for the United Kingdom and the United States are noticeably above the patent count average line for Australia, possibly because these countries have larger cities enabling people in those cities to produce relatively more patents just as Sydney produces relatively more patents than Perth or Brisbane. Similarly, the United States appears more innovative than the UK perhaps because it has many more very large cities. Australia has a higher patent count per capita than

[9] This analysis is an extension of a comparison between patent count and city population in Australia and New Zealand made in Hendy, S. and Sissons, C. (2011) Re-setting science and innovation for the next 20 years, New Zealand Science Review, Vol. 68 (1), p. 28-32.

New Zealand, also possibly related to the larger size of Australian cities than New Zealand's major cities. The cities that produce the most patents such as New York or Los Angeles also tend to be the largest. London is a little more difficult to compare in the graph because it is split into four (Inner London West, Inner London East, Outer London West and Outer London East) and several surrounding areas of London are considered separately (e.g. Surrey). Nonetheless, it is clear in the graph that Inner London West performs considerably better than the UK average or typical centres that size and we note that the other London centres are also mostly above average.

Overall it would appear that Australian cities produce patents in much the way you would expect based on city size. Despite our high rate of urbanisation, Australia's relatively lower population size and relatively smaller cities, may lead to production of relatively fewer patents than the US or UK which have much larger and denser cities and cities that are relatively close to each other. Australian cities are less densely populated and further apart from one another. This may hinder knowledge flows between people and between businesses resulting in relatively lower innovation performance than some of our international comparators.

Figure 35 Average annual patent applications by city size, 2008-2012*



Notes: *Regions and city sizes based on OECD TL3 statistical areas. In Australia these are equivalent to ABS SA4 regions in regional areas and the sum of SA4 regions in contiguous urban areas. TL3 regions correspond to the new Australian Statistical Geography Standard. The patent count average line is not shown for ACT because there is only one statistical region. ** Patent count data is recorded under the patent cooperation treaty (PCT). The number of patents is the annual average across a five year period – 2008 to 2012.

Source: BANKWEST CURTIN ECONOMICS CENTRE | Data sourced from OECD, REGPAT database, February 2016 available at https://stats.oecd.org/Index.aspx?DataSetCode=PATS_REGION;

Specialised clusters, strong universities and university-business relationships are likely to be an important factor for innovation performance.

However, it is also clear in Figure 4 that population is not the only driver of innovation performance. Several cities and regions appear as outliers. Noted in the chart are the outliers of San Jose-San Francisco-Oakland, Boston-Worcester-Manchester, San Diego-Carlsbad-San Marcos, Cambridgeshire and Oxfordshire. All of these cities and regions produce substantially more patents than the national average for their countries and more patents than many other cities that are even considerably larger. While we don't analyse the causes of this further, it is likely that a key contributor to the higher innovation performance of these cities and regions is the presence of specialised clusters as well as the strength of their universities and the relationships between these universities and innovative businesses. These cities may have better 'innovation systems' to support the flows of knowledge leading to better innovation performance.

San Jose-San Francisco-Oakland is the most obvious of the outliers. It is the location of Silicon Valley: a large industrial cluster of information technology and other high-tech businesses. The emergence of the cluster is largely borne out of Stanford University encouraging faculty and graduates to start businesses locally, the first major success story being Hewlett-Packard.[10] While economic "clusters" might be less known in the other highlighted regions, each of these has a highly ranked university (or universities) and may have effective measures in place to facilitate the transfer of knowledge from universities to businesses.

Boston-Worcester-Manchester is home to several universities, most notably, two of the world's best universities in Harvard University and Massachusetts Institute of Technology. Boston maintains an innovative cluster in life-sciences that is stronger than life-sciences in Silicon Valley (MIT Industrial Performance Center, 2015) which can be traced to the late 1970s when two biotech drugmakers Biogen and Genzyme, were founded by academics from the nearby universities.[11]

Similarly Cambridgeshire and Oxfordshire are home to the UK's two best universities, Cambridge University and Oxford University respectively. Cambridge has a large technology cluster that has grown out of the establishment of Cambridge Consultants in 1960 to enable university faculty to be used by industry and later the establishment of Cambridge Science Park by Trinity College in 1970.[12] Cambridge also benefits from its close proximity to London. Oxford is also home to a number of technology start-ups – many of them university spin-offs. "The contribution of [Oxford] University to innovation through the spin-off process is remarkable. In the period 2005–2009, Oxford University produced the most university spin-offs in the sector of all UK universities."[13] The success is largely attributed to the university, research institutes and Oxford's highly educated population.[14]

San Diego-Carlsbad-San Marcos has clusters in biotech driven by the University of California San Diego, high-tech manufacturing related to Qualcomm and a ship-building and defence cluster built on activities by the US Navy.[15]

10 Stanford University, The Rise of Silicon Valley, https://www.stanford.edu/about/history/history_ch3.html
11 The Economist (2016) Clusterluck. Jan 16 2016, http://www.economist.com/news/business/21688385-bostons-biotech-hub-surviving-challenge-silicon-valley-clusterluck.
12 University of Cambridge, The Cambridge cluster, https://www.cam.ac.uk/research/innovation-at-cambridge/the-cambridge-cluster
13 Smith, Helen Lawton., Innovation in Oxfordshire's Biosciences Cluster, Institute for small business and entrepreneurship., http://www.isbe.org.uk/Innovation-in-Oxfordshires-Biosciences-Cluster
14 SQW (2013) The Oxford Innovation Engine: Realising the Growth Potential, http://www.sqw.co.uk/files/2613/8690/7243/Oxford_engine.pdf
15 Fulton, W. (2013) San Diego: Linking Up Innovation and Local Manufacturing, Brookings Institute, Metropolitan Infrastructure Initiative Number 70 of 176, http://www.brookings.edu/blogs/the-avenue/posts/2013/12/09-san-diego-innovation-manufacturing-fulton

How innovative are Australia's regions?

Regions with dispersed populations tend to be less innovative.

Australia has a unique economic geography with a large share of its population concentrated in its capital cities. While the above analysis showed how large agglomerated cities are typically more innovative than smaller cities, differences also exist within these larger cities and regions. Local and regional innovation systems also affect innovation performance. This section compares the innovation performance within Australian cities and regions and considers some of the factors that may influence their performance.

Figure 36 uses the same counts of patent applications as above, but focuses on Australian cities only and compares states. Notably the same trend appears: Larger cities typically produce more patents than average for their state and smaller cities typically produce fewer patents than average for their state. As a result, states with larger cities or a greater share of their population living in their largest city tend to produce more patents per person than states with smaller cities. NSW produces the most patents per capita, indicated by the dotted line, perhaps in part because it is the location of Australia's biggest city. NSW is closely followed by Victoria and Western Australia. The territories or states with the lowest innovation rates are also the states with the smallest cities: Northern Territory and Tasmania respectively.

A higher patent count per capita in Western Australia compared to Queensland may be driven by the location of the population in each state's cities. While Brisbane is larger than Perth, and Brisbane itself produces more patents than Perth as would be expected, the concentration of Western Australia's population in Perth may drive the slightly higher state-wide patent applications per capita rate compared to the more distributed population in Queensland with its other relatively large cities in the Gold Coast, Sunshine Coast, and Townsville. A similar population distribution could be driving the slightly higher state-wide patent count per capita rate in South Australia compared to Queensland. South Australia also has a concentration of its population in Adelaide and relatively fewer large cities in other parts of the state.

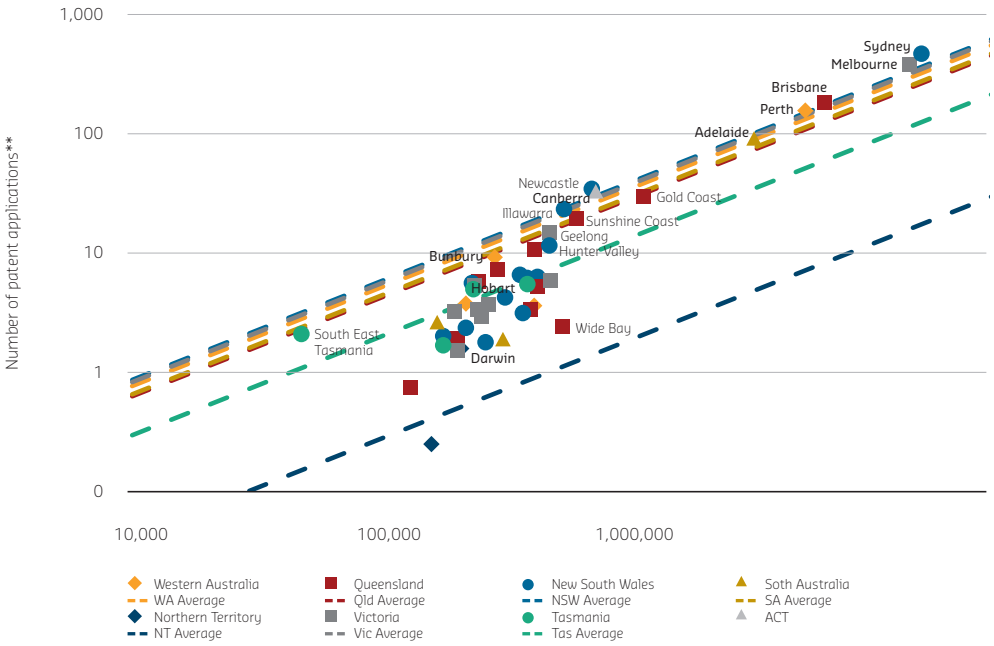
Figure 38 compares patents per 1,000 inhabitants rate for each city, state and all of Australia. Cities and regions are ordered from the most patents per 1,000 inhabitants to the fewest. Again it would appear that Australian cities generally perform where it would be expected based on city size. Larger cities appear near the top of the list while smaller and less dense regions appear further down. Two outliers are particularly interesting. The SA3 region of 'Wide Bay' in Queensland is relatively sparsely populated, so while it has over 280,000 inhabitants overall, each of its towns are relatively small and this is reflected in the relatively low patent count for its population. Conversely Tasmania's South East produces patents at approximately the national average rate despite its small population. But its proximity to a much larger agglomeration (it surrounds Hobart) suggests that its innovation performance may be driven by the broader agglomerated region. This 'noise' in the patent application statistics occurs because it can be difficult to compare regions with many small towns to a single city with a similar population size or to compare an isolated city to a region that is in close proximity to a major city.

These observations also suggest that not only is city size important, but so is location. Relatively small cities that are close to much larger agglomerations might be expected to be more innovative than relatively small cities that are far away. This

Newcastle produces more patents per person than all other non-capital cities in Australia.

also emerges in the data: Newcastle, Illawarra, Geelong, the Sunshine Coast, the Gold Coast and Bunbury may all benefit from their close proximity to major capital cities. Fitzroy (encompassing Gladstone, Rockhampton and others) and Mackay on the other hand underperform relative to cities of a similar size, perhaps due to their relative isolation. One exception to the rule is Townsville which produces almost as many patents as Geelong, despite its isolation. This could be for two possible reasons that we cannot investigate further here but may be worth considering. Townsville may have a better innovation system than other cities of a similar size and the characteristics of its innovation system could be worth examining. But Townsville may also be performing a role similar to a capital city in that it serves the regions of North and Far North Queensland. The role of a city serving a broader region can also facilitate additional interactions resulting in a greater flow of knowledge and improved innovation performance.

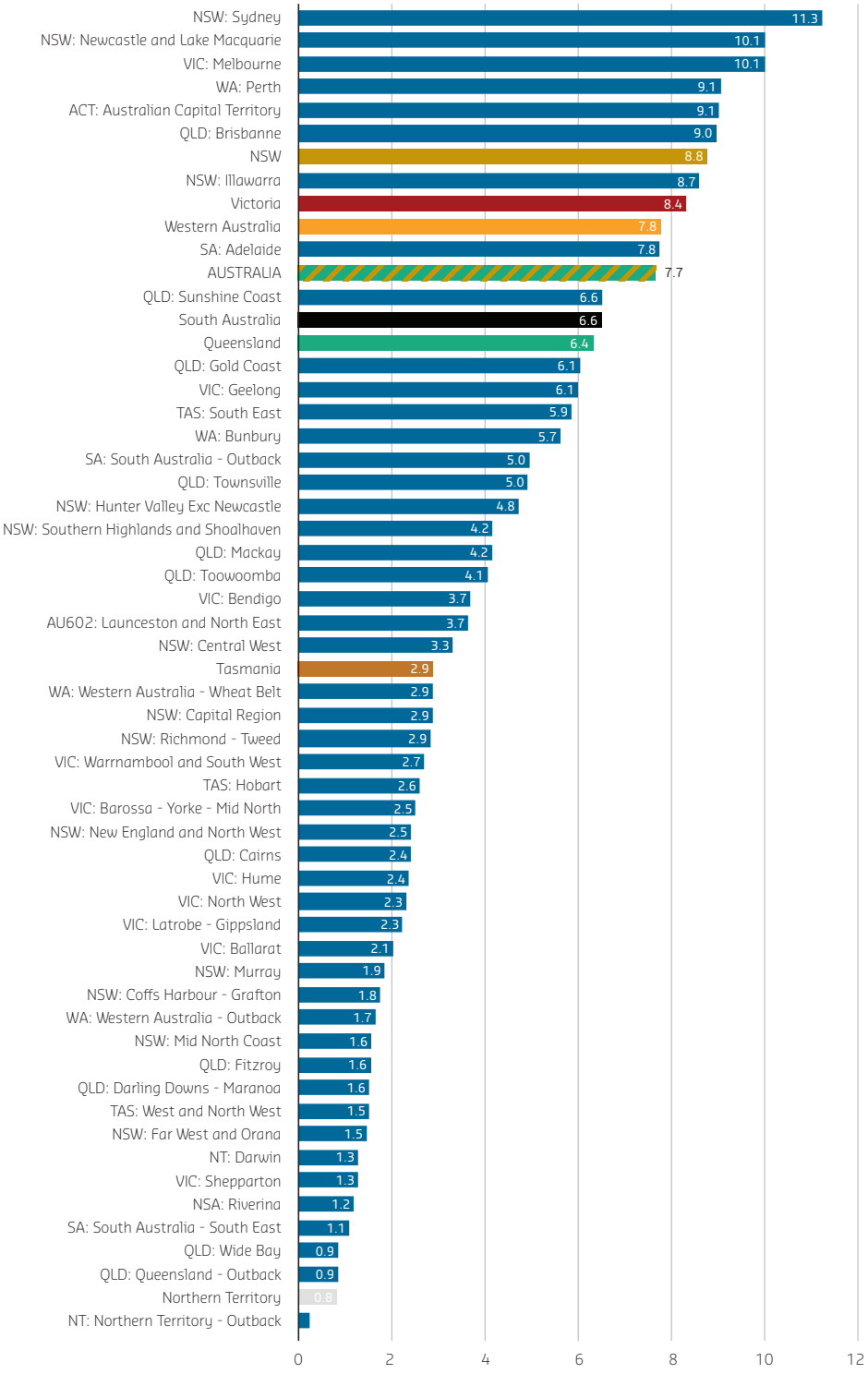
Figure 36 Average annual patent applications in Australia by city size*, 2008-2012



Notes: *Regions and city sizes based on OECD TL3 statistical areas. In Australia these are equivalent to ABS SA4 regions in regional areas and the sum of SA4 regions in contiguous urban areas. TL3 regions correspond to the new Australian Statistical Geography Standard. The patent count per capita line is not shown for ACT because there is only one statistical region. ** Patent count data is recorded under the patent cooperation treaty (PCT). The number of patents is the annual average across a five year period – 2008 to 2012.

Source: BANKWEST CURTIN ECONOMICS CENTRE | Data sourced from OECD, REGPAT database, February 2016 available at https://stats.oecd.org/Index.aspx?DataSetCode=PATS_REGION;

Figure 37 Patent applications per 1,000 inhabitants by cities*, states and nationally, 2008-2012



Sydney produces the most patents per person of all cities in Australia.

Notes: *Figure is local average annual patent count per 1,000 inhabitants. Regions and city sizes based on OECD TL3 statistical areas. In Australia these are equivalent to ABS SA4 regions in regional areas and the sum of SA4 regions in contiguous urban areas. TL3 regions correspond to the new Australian Statistical Geography Standard. ** Patent count data is recorded under the patent cooperation treaty (PCT). The number of patents is the annual average across a five year period – 2008 to 2012.

Source: BANKWEST CURTIN ECONOMICS CENTRE | Data sourced from OECD (2015) REGPAT database https://stats.oecd.org/Index.aspx?DataSetCode=PATS_REGION;

Suburbs close to the city centre produce more patents more effectively than surrounding suburbs.

A similar trend appears within cities. Figure 38 shows the geographic distribution of patent applications per capita between 2009 and 2014 using smaller SA3 regions and data from the Australian Bureau of Statistics. The ranking of the top 20 SA3 regions is shown in Table 3. It is very noticeable that suburbs surrounding central business district (CBD) suburbs typically have a much higher per capita production of patents than outer suburbs or the CBD itself. This is partly because CBD's provide professional services that support a wider area than just the CBD itself. Surrounding suburbs benefit from these services although the workers providing that support are recorded in the CBD suburb. Inner cities may also enable additional interactions that are possible in densely populated urban centres which may help to stimulate knowledge flows and improve innovation outcomes. Suburbs close to the city centre are also more densely populated and also benefit from close proximity to other densely populated suburbs.

Table 3 Ranking of SA3 regions based on patents 2009-2014 per 10,000 workers in 2011

Rank	Region	State	Patents per 10,000 workers
1	Kenmore – Brookfield - Moggill	Queensland	335
2	Sherwood – Indooroopilly	Queensland	315
3	Manningham – East	Victoria	238
4	Mudgeeraba – Tallebudgera	Queensland	222
5	Ryde – Hunters Hill	New South Wales	219
6	Central Highlands (Tas.)	Tasmania	171
7	Beenleigh	Queensland	159
8	Stonnington – West	Victoria	155
9	Centenary	Queensland	154
10	Chatswood – Lane Cove	New South Wales	144
11	Pennant Hills – Epping	New South Wales	140
12	Blacktown – North	New South Wales	137
13	Pittwater	New South Wales	136
14	Leichhardt	New South Wales	132
15	Ku-ring-gai	New South Wales	129
16	Manly	New South Wales	127
17	North Canberra	Australian Capital Territory	126
18	Dural – Wisemans Ferry	New South Wales	126
19	Cottesloe – Claremont	Western Australia	124
20	Warringah	New South Wales	121

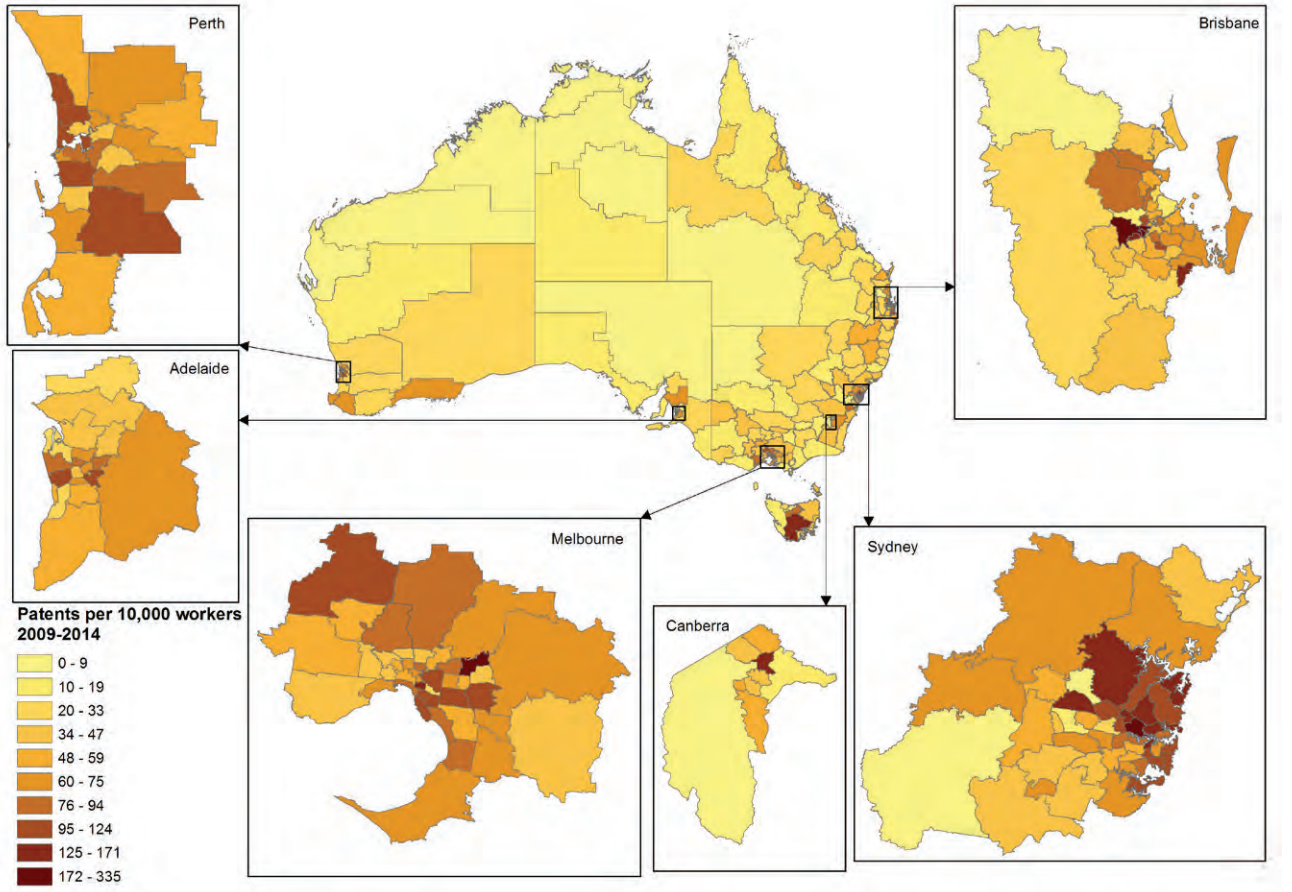
Notes: *Regions based on ABS SA3 statistical areas. The SA3 regions of Fyshwick-Pialligo-Hume, Illawarra Catchment Reserve, Lord Howe Island, Blue Mountains – South and Cotter-Namadgi were excluded due to small population size.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Data sourced from Department of Industry, Innovation and Science National Innovation map available for download here http://www.industry.gov.au/Office-of-the-Chief-Economist/Pages/National-Innovation-Map.html; Shape files from ABS.

Kenmore – Brookfield – Moggill in Queensland has produced the most patents per 10,000 workers closely followed by the inner city Brisbane suburb of Sherwood – Indooroopilly. While it is somewhat surprising that a number of outer residential suburbs are also particularly innovative, this may represent recent growth in these regions and a number of new innovative businesses. It also appears that suburbs with a main university campus also feature highly and innovation performance may benefit due to spillovers from universities. While city centres appear less innovative, the greater urban areas in the larger capital cities compensates for the relatively lower innovation rates in those city centres. This is seen by the relatively high rankings of inner city suburbs in Sydney, Melbourne and Brisbane.

University suburbs perform higher in producing patents than surrounding suburbs.

The three key factors that seem to increase a region's ranking in patent production are recent urban growth, universities and proximity to the city centre. Sherwood-Indooroopilly borders Brisbane Inner and contains the main campus of the University of Queensland. Ryde-Hunters Hill includes the suburb of Macquarie Park containing Macquarie University and a number of technology based businesses. Chatswood in Sydney may benefit from its proximity to the Macquarie Park cluster. The SA3 regions of Cotteslow-Claremont and Canning contain the University of Western Australia and Curtin University respectively and perform higher in patents per capita than surrounding regions in Perth.

Figure 38 Patents per 10,000 workers in 2011 by SA3 regions, 2009-2014



Source: BANKWEST CURTIN ECONOMICS CENTRE | Patent data sourced from Department of Industry, Innovation and Science National Innovation map available for download here http://www.industry.gov.au/Office-of-the-Chief-Economist/Pages/National-Innovation-Map.html; Shape files and place of work data sourced from ABS.
Notes: *Regions based on ABS SA3 statistical areas.

Patents are not the only way to record innovation. In the next two maps innovation is measured as a composite index of many innovation indicators that includes patents per 10,000 workers, trademarks per 10,000 workers, new business entry per 10,000 workers, business R&D investment per worker, proportion of inhabitants with a post graduate qualification and a ratio of research institutes to resident population.[16] A composite index approach may also smooth volatility in the data. In Figure 39 the innovation index is presented for 2014 and Figure 40 shows the change between 2009 and 2014. Table 4 shows the rankings for the top 20 SA3 regions in 2014.

Table 4 Ranking of SA3 regions 2014 Innovation index

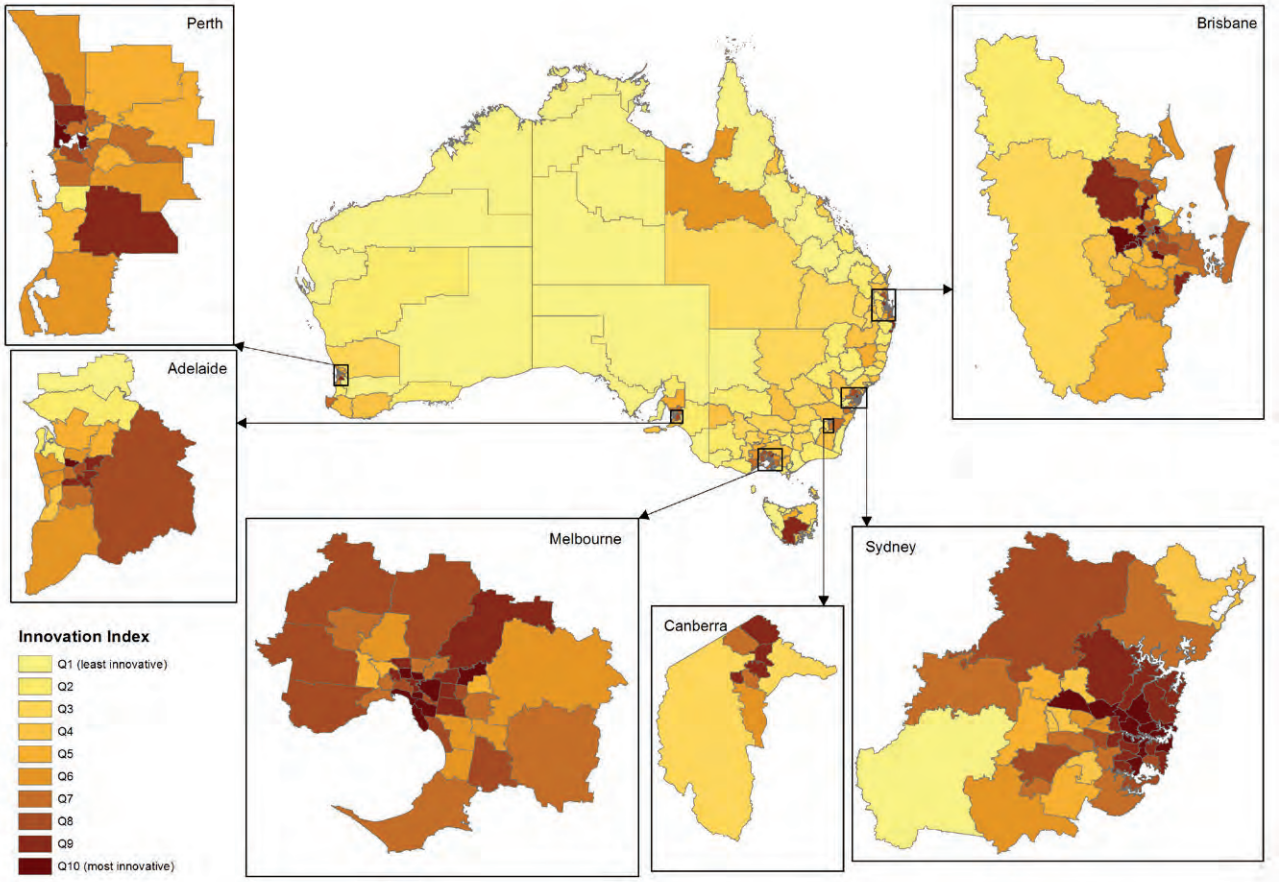
Rank	Region	State
1	Kenmore - Brookfield - Moggill	Queensland
2	Manningham - East	Victoria
3	Stonnington - West	Victoria
4	Eastern Suburbs - North	New South Wales
5	Sherwood - Indooroopilly	Queensland
6	Manly	New South Wales
7	Brisbane Inner - East	Queensland
8	Sunnybank	Queensland
9	Blacktown - North	New South Wales
10	Centenary	Queensland
11	Mudgeeraba - Tallebudgera	Queensland
12	Boroondara	Victoria
13	Port Phillip	Victoria
14	Marrickville - Sydenham – Petersham	New South Wales
15	Pennant Hills - Epping	New South Wales
16	Leichhardt	New South Wales
17	Bald Hills - Everton Park	Queensland
18	Baulkham Hills	New South Wales
19	Bayside	Victoria
20	Ku-ring-gai	New South Wales

Notes: Regions based on ABS SA3 statistical areas. The composite index is created using principle component analysis for the entire period of 2009 to 2014 and calculating an index for each region in each year.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from data sourced from the Department of Industry, Innovation and Science National Innovation Shape files and population data sourced from ABS.

On this measure the innovation performance of SA3 regions is relatively similar to the patent measure alone. Commercial centres feature slightly higher in the innovation index ranking compared to the ranking of regions by patents per 10,000 workers. This may be due to additional trademarks and new business entries in these areas compared to suburban regions with universities which feature highly in the patent rankings but may be less involved in the more commercial aspects of innovation. Some outer suburbs also feature highly in this ranking which may be due to recent urban growth. This would enable entry by a number of new businesses that may be more innovative than older or more established businesses.

[16] The composite index is created using principle component analysis for the entire period of 2009 to 2014 and subsequently calculating an index for each region in each year.

Figure 39 Innovation index in 2014 by SA3 regions



Notes: Regions based on ABS SA3 statistical areas. The composite index is created using principle component analysis for the entire period of 2009 to 2014 and calculating an index for each region in each year.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from data sourced from the Department of Industry, Innovation and Science National Innovation. Shape files and place of work data from ABS.

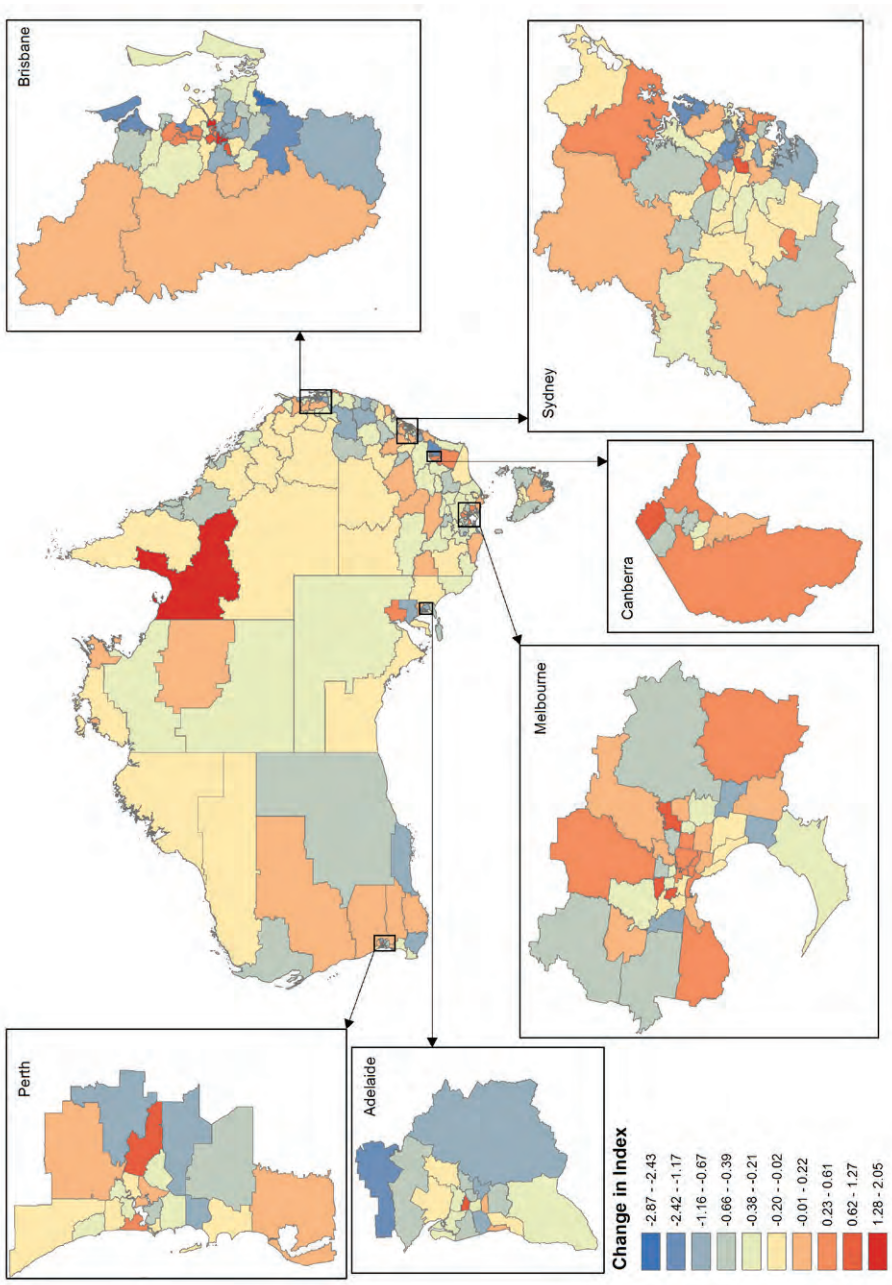


Figure 40 Change in the innovation index between 2009 and 2014 by SA3 regions

Notes: Regions based on ABS SA3 statistical areas. The composite index is created using principle component analysis for the entire period of 2009 to 2014 and calculating an index for each region in each year.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from data sourced from the Department of Industry, Innovation and Science National Innovation. Shape files and place of work data from ABS.

Brisbane suburbs improved their innovation performance between 2009 and 2014 while other cities had mixed results.

Notably there are some regions that increase their innovation performance over the period. Brisbane suburbs feature highly in Figure 40 and Table 5. Queensland appears to be the most improved with the top three SA3 regions and six SA3 regions in the top 20, and Victoria has seven in the top 20. The inset maps also show suburbs in central Brisbane with large increases in innovation performance over the period yet a number of other Brisbane suburbs have reduced their innovation output. Most of the capital cities show big gains in some suburbs and big losses in others. Conclusions should be treated with caution however as much of the change in these regions between 2009 and 2014 could simply be volatility. A longer term analysis would be required to understand if these are lasting trends.

Table 5 Ranking of SA3 regions by biggest net gain in the Innovation index between 2009 and 2014

Rank	Region	State
1	Brisbane Inner – East	Queensland
2	Outback – North	Queensland
3	Sherwood – Indooroopilly	Queensland
4	Brighton	Tasmania
5	Prospect – Walkerville	South Australia
6	Gungahlin	Australian Capital Territory
7	Manningham – East	Victoria
8	Centenary	Queensland
9	Auburn	New South Wales
10	Essendon	Victoria
11	Kalamunda	Western Australia
12	Moreland – North	Victoria
13	Brisbane Inner – West	Queensland
14	Cotter – Namadgi	Australian Capital Territory
15	Bald Hills – Everton Park	Queensland
16	Whitehorse – West	Victoria
17	Port Phillip	Victoria
18	Cardinia	Victoria
19	Fyshwick – Pialligo – Hume	Australian Capital Territory
20	Boroondara	Victoria

Notes: Regions based on ABS SA3 statistical areas. The composite index is created using principle component analysis for the entire period of 2009 to 2014 and calculating an index for each region in each year. The SA3 regions of Lord Howe Island and Cotter – Namadgi are not included in these rankings due to small worker population size causing large volatility in parameter values.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from data sourced from the Department of Industry, Innovation and Science National Innovation Shape files and population data sourced from ABS.

Interestingly remote and regional areas are not left out. Outback – North in Queensland improved its innovation output as did Brighton in Tasmania. However these two regional results should also be interpreted with caution given the relatively small count of workers in these regions. Their rankings may be emphasised due to greater volatility in small regions and due to their small worker population size.

Table 6 shows the regions with the greatest fall in the innovation index between 2009 and 2014. It is also noticeable that many of the top ranking regions were significantly less innovative in 2014 than in 2009. This may in part reflect the volatility of innovation statistics as well as the significant differences between regions. The difference between a highly innovative region and an average one is massive, such that even a substantial fall in innovation output does not have a significant effect on

overall rankings. Furthermore, it may be part of a broader medium-term downward trend in innovation performance across Australia between 2009 and 2014.

The innovation performance of Australia's regions and suburbs has generally declined between 2009 and 2014.

Table 6 Ranking of SA3 regions by biggest net loss in the Innovation index between 2009 and 2014

Rank	Region	State
1	Mudgeeraba – Tallebudgera	Queensland
2	Beenleigh	Queensland
3	Leichhardt	New South Wales
4	Sandgate	Queensland
5	Pittwater	New South Wales
6	Jimboomba	Queensland
7	Gawler – Two Wells	South Australia
8	Bribie – Beachmere	Queensland
9	Buderim	Queensland
10	Coolangatta	Queensland
11	Gold Coast – North	Queensland
12	Ryde – Hunters Hill	New South Wales
13	Queanbeyan	New South Wales
14	Armidale	New South Wales
15	Hobart – South and West	Tasmania
16	Burnside	South Australia
17	Chatswood – Lane Cove	New South Wales
18	Hervey Bay	Queensland
19	Pennant Hills – Epping	New South Wales
20	Kwinana	Western Australia

Notes: Regions based on ABS SA3 statistical areas. The composite index is created using principle component analysis with the three components, patents, new businesses and trademarks per 10,000 inhabitants for the entire period of 2009 to 2014 and calculating an index for each region in each year. The SA3 regions of Lord Howe Island and Cotter – Namadgi are not included in the index due to small worker population size causing large volatility in parameter values.

Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from data sourced from the Department of Industry, Innovation and Science National Innovation Shape files from ABS.

The role of universities: knowledge creation and knowledge flows

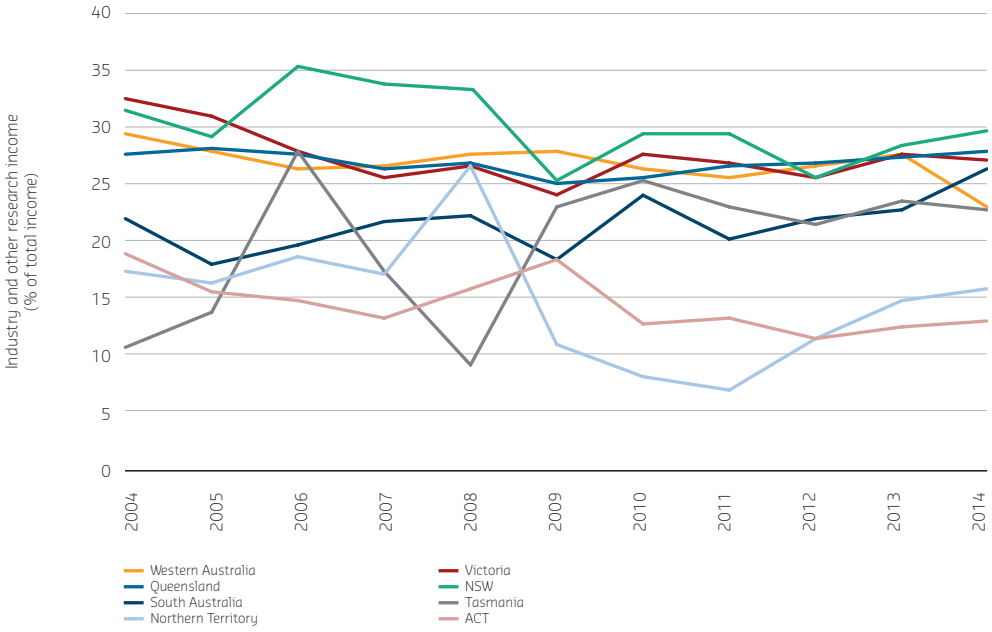
Universities in South Australia and Tasmania have increased their share of research income sourced from industry.

As the analysis above has shown, universities appear to play a key role in a region's innovation performance, particularly in producing patents. This is through a few key mechanisms. Universities conduct blue-sky and applied research, producing patents and innovations of their own as well as the knowledge that may be used in later innovations. Universities improve the human capital of graduates who continue to contribute to the local economy once they enter the workforce. Similarly city centres and surrounding suburbs may perform highly because the available jobs in CBDs attract highly-skilled graduates. But highlighted in the earlier discussion of technology clusters in Silicon Valley, Boston, Cambridge, Oxford and San Diego was the presence of high-tech businesses and start-ups that were founded locally by academics and graduates or were university spin-offs.

Industry collaboration and university spin-offs may be a key contributor to a region's innovation performance because it facilitates the transfer of knowledge from research and academia to industry and commerce. In particular the patent output of the SA3 regions of Ryde (Macquarie University); Monash (Monash University); Cottesloe-Claremont; (University of Western Australia; and Canning (Curtin University) is higher than surrounding suburbs. Other central city suburbs also have higher innovation performance due to their local universities. It is difficult to measure how universities influence innovation performance but income from industry sources may be a proxy for university engagement with commerce and industry.

The figures below analyse university research income from industry and other sources by state. Industry and other research income is an indicator for the ability for each state or territory's universities to collaborate and share knowledge with businesses in their region and beyond.

Figure 41 Industry and Other research income* as a percentage of all university research income by state 2004-2014



Notes: *Industry and other research income includes: Australian Funding-Contracts; Australian Funding-Grants; Australian Funding-Donations Bequests and Foundations; HDR Fees for Domestic Students; International A: Competitive, Peer-reviewed research income; International B: Other income; and International C: HDR fees for international students – The largest components are Australian funding-Contracts and Australian funding-Grants.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from the Department of Education and Training – Higher Education Research Data Collection

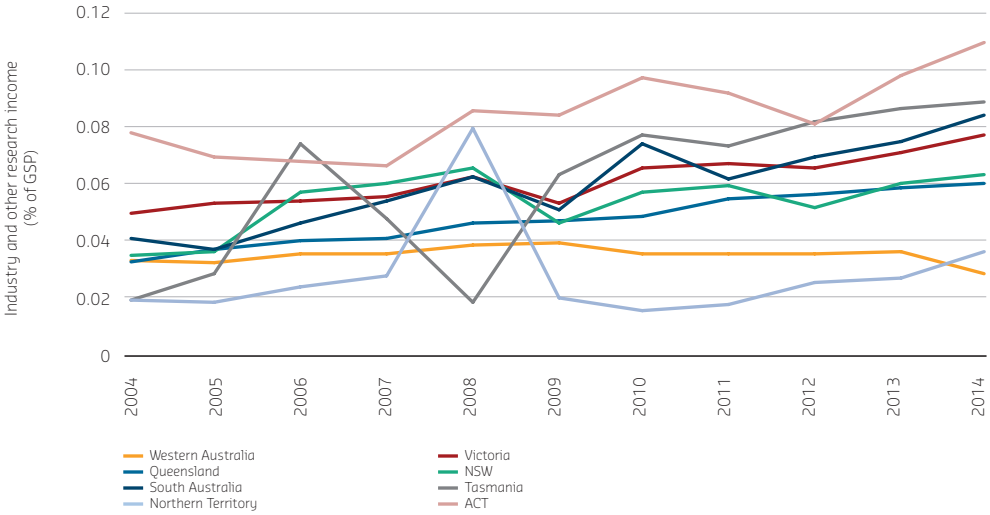
NSW universities have the highest proportion of research income sourced from industry.

Figure 41 describes industry and other research income as a percentage of all research income for all universities in each state or territory. It is expected that universities which earn a greater share of research income from industry are better able to collaborate, spin-off new businesses or otherwise engage with industry as a mechanism to transfer knowledge to industry and commerce. It appears in the graph that states and territories are split between two groups. NSW, Queensland, Victoria and Western Australia form the first group, with between one-quarter and 30 per cent of research income sourced from industry and other sources. Universities in the territories of the ACT, Northern Territory, South Australia and Tasmania have typically earnt a lower share of research revenue from industry than other states. However, since 2004, South Australia and Tasmania have moved from this lower group to the upper group.

Taking an industry perspective on university industry research income, consider industry spending on research at universities as a proportion of all economic activity, Figure 43 shows industry or other research income for universities relative to gross state product. In these charts the opposite trend emerges with the ACT recording the highest industry investment in research and Western Australia the lowest in 2014. This is likely to reflect the importance of the university sector for the ACT economy,

with four major universities located here – Australian National University, University of Canberra, ADFA and the Australian Catholic University[17]. In WA, the dominance of the mining industry in gross state product may have a watering down effect on the share of economic activity that is devoted to research in WA's universities.

Figure 42 **Industry and Other research income* as a proportion of Gross State Product by state 2004-2014**

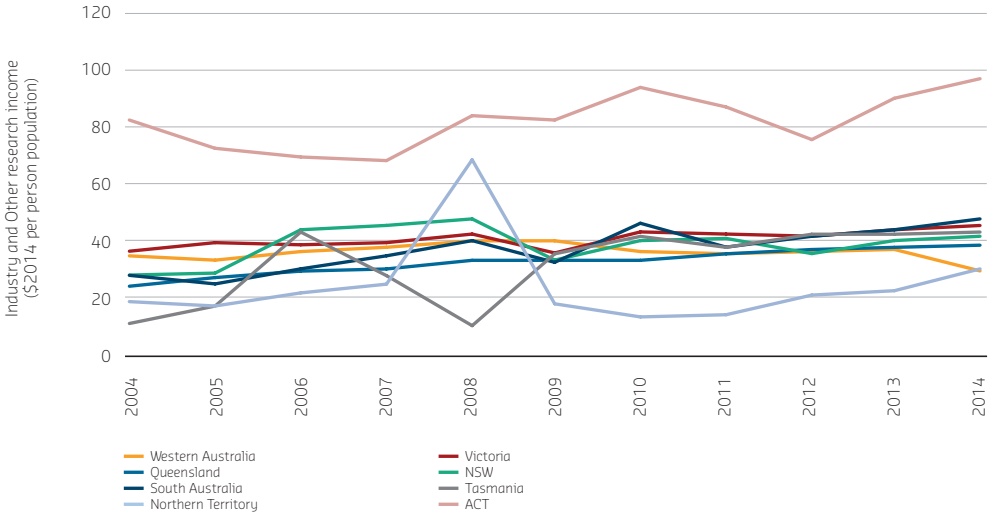


Notes: *Industry and other research income includes: Australian Funding-Contracts; Australian Funding-Grants; Australian Funding-Donations Bequests and Foundations; HDR Fees for Domestic Students; International A: Competitive, Peer-reviewed research income; International B: Other income; and International C: HDR fees for international students – The largest components are Australian funding-Contracts and Australian funding-Grants.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from the Department of Education and Training – Higher Education Research Data Collection

Lastly, we examine university research income on a per capita basis in each state and territory (Figure 44). Universities in the ACT receive considerably more industry research income relative to its population than all other states or territories. This may in part be due to a higher student population as a proportion of the territory's total population but it also indicates that universities in the ACT may be more engaged with industry leading to better innovation outcomes in the territory.

[17] Research income for the Australian Catholic University (ACU) has not been included in this analysis because the ACU operates across many states. The ADFA is not included in the Higher Education Research Data Collection database. Including ACU and ADFA would increase the value for ACT in Figure 42.

Figure 43 Industry and other research income* per person by state 2004-2014



The ACT has the highest industry research income per capita among all states and territories – $97 per person

Notes: *Industry and other research income includes: Australian Funding-Contracts; Australian Funding-Grants; Australian Funding-Donations Bequests and Foundations; HDR Fees for Domestic Students; International A: Competitive, Peer-reviewed research income; International B: Other income; and International C: HDR fees for international students – The largest components are Australian funding-Contracts and Australian funding-Grants.
Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from Department of Education and Training – Higher Education Research Data Collection

Summary

and discussion

Summary and discussion

The much anticipated National Innovation and Science Agenda launched by Prime Minister Malcolm Turnbull in December 2015 has committed funding of $1.1 billion over four years to twenty eight action areas, which include de-risking start-ups; investing in STEM; attracting and keeping overseas entrepreneurs; and improving university-industry connectedness, amongst others.

These measures are welcome not just because of the commitment of financial support to innovation programmes, but also because of the important signal that promoting a culture of innovation is essential to Australia's economic growth and future prosperity.

So is Australia positioned to capitalise on an ideas boom?

This Focus on the States report examines Australia's productivity, with a focus on the trajectory of standard measures of labour and multifactor (technical) productivity over time, across industry sectors, and how Australia compares internationally. The report also addresses the challenges of adequate measurement, highlighting some of the key limitations with traditional metrics by which productivity is assessed.

Labour productivity in Australia as measured by GDP per hour worked – sits just above the OECD average, matching that of the United Kingdom and a number of our main international comparators but behind France, Germany and the United States. Interestingly, more of the recent growth in labour productivity in Australia has occurred after the resources boom, which likely reflects the shift from the construction phase in the resources sector towards production.

Two observations are worthy of note in relation to the evolution of productivity in Australia. First, the contribution of capital technology in production has grown significantly in Australia, with much of the growth in labour productivity over the last two decades attributable to 'capital deepening' – a rise in the capital to labour ratio. Second, the changing composition of the labour force – and specifically the transition towards a more skilled workforce – has enhanced output growth at an increasing rate over recent growth cycles.

This report notes, however, that our capacity to measure productivity is contested, and complex. Traditional measures of labour productivity and technological advancement (multifactor productivity) are subject to external influences beyond the production process and efficient use of labour, capital and technology. Business cycle effects, the changing price of goods and services on international markets, and the changing composition of labour and capital inputs, all present challenges in the authentic measurement of productivity gains. There is a pressing need to review how best to monitor productivity outcomes in Australia, with consideration of complementary metrics against which to benchmark Australia's progress as the innovation strategy takes hold.

We also note that traditional productivity measures don't capture the value of non-market work, caring responsibilities or the contributions of the community and voluntary sectors to Australia's output and economic growth, nor do they capture the potential gains in productivity through a better use of our 'latent' talent pool of people not currently part of the employed workforce.

Our findings confirm that Australia is transitioning towards a more knowledge-intensive economy. Technology-intensive processes and services are playing a more significant role in Australia's growth narrative, in emerging industry sectors as well as those industries of traditional strength. Our findings also highlight the growing importance of skills 'knowledge workers' in Australian industry, and suggests that 'knowledge workers' will be a key driver of Australia's continued productivity growth.

Innovation-active businesses involved in global collaborations enjoy greater exposure to new ideas, world leading advances in technology, and commercialisation opportunities. Yet OECD comparisons show that innovation-active firms in Australia are far less likely to collaborate with international organisations compared with our principal country partners in Asia, Europe or the United States.

This Focus on the States report shows that very few Australian businesses cite a lack of access to knowledge as a barrier to innovation. This suggests – rightly or wrongly – that the majority of businesses rely on national 'knowledge partnerships' for research and development activities.

It is difficult to square this circle, other than to speculate that some businesses in Australia 'don't know what they don't know' – that is, they are not fully aware of the benefits to be gained from international collaboration, exposure to global industry innovations or the international 'state of the art' in new research developments. This suggests that one strategy to promote greater Australian innovation is to encourage a more open mindset and attitude towards global partnerships.

The benefits of a collaborative mindset also applies to partnerships between industry, universities and research organisations. Australia ranks 29th out of 30 in the OECD in terms of the proportion of businesses collaborating with universities and research institutions to pursue innovation. Strategies are required so that Australian businesses are aware of the potential benefits of engaging with universities and research organisations, and incentives that promote an increased industry focus for university research are a welcome development in the drive towards the commercialisation of new ideas.

The report presents findings from a new small area innovation index developed by Centre researchers for Australia, and reveals a number of hotspots of relatively high innovation in outer suburbs that are adjacent to city centres and co-located in proximity to universities and research institutions. Queensland's outer suburbs are highlighted in particular as showing the greatest increase in the rate of innovation between 2009 and 2014. These hotspots may arise from recent urban growth, but also show the benefits of support for new businesses – many of which are small to medium enterprises – that may be more innovative than older or more established firms.

What might get in the way of the ideas boom?

The first concern raised by a significant proportion of businesses in Australia as a barrier to innovation is the lack of access to funds. The report draws attention to the falling share of business R&D investment in the early stages of business development – with the share of pre-seed through to early expansion project funding falling by half (from 40% to 20%) since 2005-06 as a share of total investment.

We can speculate on the reason – for example, tighter economic times leading to more risk adverse behaviour. But whatever the explanation, it is critical that we foster an environment in which creative entrepreneurship and the pursuit of product and process innovation is encouraged, and where it is safe to fail in the pursuit of big ideas.

Consistent with the innovation statement is the recognition that failure is often an engine of future success. As Malcolm Turnbull said at the launch of the National Innovation and Science Agenda, "you may have lost some money, your investors may have lost some money, but the overall economy massively benefits because you are wiser, your employees are wiser, your investors are wiser, everyone's learnt something and the ecosystem benefits".

The importance of incentivising investment at an early stage is critical to the delivery of Australia's innovation strategy, and in this regard the tax incentives for early stage investment, support for small business innovators, and the reduced penalties for business failure are key to its success.

The second barrier to innovation highlighted by businesses is the lack of availability of skilled labour. Although this barrier has declined to a degree since the height of the resources boom, it is still reported an issue. This evidence provides support for the Federal Government's commitment to promote greater take-up of STEM subjects at schools and universities, as well as strategies – and targets – to encourage greater access to science and technology courses by women and minority groups.

Many businesses report the burden of government regulation and compliance as a third significant barrier to innovation. The regulation of research and development activities is necessary in providing adequate protections for stakeholders in the innovation process, of course, but it should be fit for purpose, efficient and not over-burdensome to an extent that hinders rather than supports entrepreneurism and creative endeavour.

We noted earlier that the production of goods and services in Australia has been characterised by a progressively more intense use of technology and capital across most market industry sectors – a process of 'capital deepening' – with capital to labour ratios having more than doubled in two decades. A successful 'ideas boom' will continue with this trajectory, and in many ways this presents us with an excellent opportunity to develop a 'smarter', more productive workforce.

However, we must ensure that the push towards enhanced innovation and technological advancement doesn't leave some people behind, or widen inequalities that exist in relation to labour market opportunities across the full skills base. Workforce participation is essential for economic security and social cohesion, which emphasises the need to create employment opportunities to sit alongside the new innovation agenda. Education and training programs should be configured to develop the country's future skills base, and enhance – or adapt – the skills of the current workforce to take advantage of the new possibilities afforded by innovation and technological advancement.

So is Australia positioned for an ideas boom?

It is more important now than ever for Australia to both learn from, and drive, prosperity through international collaborations. Australia has the people, the resources, the environment, the knowledge and the creativity to thrive into the future, and to contribute to national and global economic growth. But significant barriers remain, specifically in relation to access to research and development funding and venture capital investment, especially to smaller enterprises and at early stages of business expansion.

The National Innovation and Science Agenda provides a credible and coherent prospectus of policies, and significant government funding support, to drive productivity and innovation growth in Australia. The opportunity, and the responsibility, falls on us all – government, families, businesses, universities and research institutions – to bring the ideas boom to reality.

Glossary

and technical notes

Glossary and technical notes

Productivity Growth

As per the ABS definitions, productivity is broadly defined as the ratio of a volume measure of output to a volume measure of input; that is, output per unit of input. Productivity can be defined for an individual entity, for an industry or sector of the economy, or for the economy as a whole. Growth in productivity can occur from an increase in output, a decrease in inputs or a combination of both. Productivity growth is that part of output growth that is not accounted for by increases in the amount of inputs being measured (ABS, 2015b). Productivity (the ratio of output produced to inputs used) is sometimes referred to as productive efficiency.

The ABS produces annual estimates of three different measures of productivity – labour productivity (LP), capital productivity (KP) and multifactor productivity (MFP). The ABS definitions used for this report are outlined here, along with the concept of capital deepening.

Labour Productivity

Labour productivity is defined as a ratio of a measure of output to labour input; that is, output per unit of labour. Put more simply, labour productivity is the amount of output produced by an hour of paid work. An increase in labour productivity means that more output is being produced per hour of work (ABS, 2015b).

Growth of labour productivity is the growth of output over and above the growth of labour input – it captures the value added from growth in capital (including more advanced technologies intrinsic in the new investment) that supports increased output without the increased use of labour (referred to as capital deepening) and multifactor productivity.

Labour input is measured on an hours worked basis. It is important to note that labour productivity growth is achieved by working smarter, not by working longer or harder. Labour productivity is often regarded as an indicator of improvements in living standards as growth in labour productivity has a close long term relationship with growth in labour earnings (ABS, 2015b).

Capital Productivity

Capital productivity is defined as a ratio of a measure of output to capital input; that is, output per unit of capital. Changes in this ratio can also reflect technological changes and changes in other factor inputs (such as labour) (ABS, 2015b).

Capital input is measured based on ABS estimates of the 'productive value' of the capital stock (of plant and equipment, non-residential buildings, livestock, computer software, artistic originals and capitalised exploration expenditure). While labour input is an actual number of hours worked used, the measure of capital services used in calculated capital productivity reflects the capital stock that is actually available, whether it is used or not.

Capital Deepening

Capital deepening refers to changes in the capital to labour ratio. Increased capital deepening means that, on average, each unit of labour has more capital to work with to produce output, so is an indicator of ability to augment labour. Labour saving practices, such as automation of production, will result in increased capital deepening, which is often associated with a decline in capital productivity. Growth in capital deepening is an important driver (alongside MFP) of labour productivity growth. It may not be very useful to interpret declines in capital productivity in isolation since declines in capital productivity can be more than offset by gains in labour productivity (resulting in MFP growth) (ABS, 2015b).

Multifactor Productivity

The ABS aggregate multifactor productivity (value adding output produced per unit of combined inputs of labour and capital) is the measure that comes closest to the underlying concept of productivity – efficiency of producers in producing output using both labour and capital. Growth of multifactor productivity is the growth of output over and above the growth of labour and capital inputs (ABS, 2015).

In the long-term, MFP represents improvements in ways of doing things (technical progress), which is the primary source of real economic growth and higher living standards. In the short run however, MFP also reflects unexplained factors such as cyclical variations in labour and capital utilisation, economies of scale and measurement error (ABS, 2012b).

Growth Accounting

Growth accounting involves decomposing gross output growth into contributions from growth in labour, capital and intermediate inputs and MFP. This framework provides an analytical tool to identify the underlying drivers of growth. ABS MFP statistics are compiled on the basis of the standard growth accounting framework, which is widely adopted by leading statistical agencies and recommended by the OECD. Growth accounting allows us to better understand the contribution of productivity growth to output growth, as well as the other drivers of output growth. In the growth accounting framework, growth in labour productivity can be decomposed into growth in capital deepening (the ratio of capital to labour), growth in labour quality and growth in MFP (ABS, 2015b).

Growth Cycles

Productivity measures often show significant short term volatility. This can be due to economic shocks, or as a result of changes in employment to lag changes in output. Therefore, it is recommended to compare productivity growth over a number of years, rather than quarterly or yearly changes.

The ABS recommends that productivity trends be measured between 'productivity growth cycle peaks'. Productivity growth cycle peaks are determined by comparing the annual MFP estimates with their corresponding long-term trend estimates. The peak deviations between these two series are the primary indicators of a growth cycle peak, although general economic conditions at the time are also considered. The purpose is to minimise the effects of cyclical factors that may cause the year-to-year changes in MFP to deviate from its conceptual definition. In doing this, most of the effects of variations in capacity utilisation and much of the random error are removed. By averaging between peaks, it is assumed that these peaks represent similar levels of capacity utilisation, allowing more like-for-like comparisons of MFP between different growth cycles (ABS, 2015b)[18].

Venture Capital

Venture Capital (VC) is defined as high risk private equity capital for typically new, innovative or fast growing unlisted companies. A venture capital investment is usually a short to medium-term investment with a divestment strategy with the intended return on investment mainly in the form of capital gains (rather than long-term investment involving regular income streams).

Later Stage Private Equity

Later Stage Private Equity (LSPE) is defined as investment in companies in later stages of development, as well as investment in underperforming companies. These companies are still being established, the risks are high and investors have a divestment strategy with the intended return on investment mainly in the form of capital gains (rather than long-term investment involving regular income streams).

Investee Company Stage

Early expansion

An investee company which is operational and has product in the market place. The investee company will show significant revenue growth, and may or may not be profitable.

Late Expansion

Current product improvement or new product development. Continued revenue growth. Approaching, or at, profitable operating levels.

[18] For a more comprehensive discussion on productivity measurements, see for example, the Productivity Commission 2013 PC productivity update, May.

Pre-seed

An investee company in the process of setting up. Product is in research and development stage.

Seed

An investee company in the process of setting up. Product at testing or pilot production stage.

Start-up

The investee company is not yet fully operational. May or may not be generating revenue.

IPO

Initial Public Offering (IPO) is a type of public offering where shares of stock in a company are sold to the general public, on a securities exchange, for the first time.

LBO/LBI

Leveraged buy-out/in (LBO/LBI) involve the acquisition of a product or business from either a public or private company often utilising a significant amount of debt and little or no equity.

Turnaround

Financing provided to a company at a time of operational or financial difficulty with the intention of improving the company's performance. The company may not be profitable, its product turnover stagnant and/or with flat or declining revenue.

Appendix

Table 7 Productivity, labour and capital contributions to output growth: 1995-96 to 2014-15

	Year				
	1995-96	1996-97	1997-98	1998-99	1999-00
Output growth	4.54	4.04	4.79	5.39	4.15
Contributions to output growth (ppt)					
Capital services	1.71	1.80	2.06	1.87	1.92
Hours worked	0.71	0.38	0.78	0.41	2.60
Labour composition	0.31	0.30	0.32	0.31	0.31
Multifactor productivity	1.81	1.56	1.63	2.80	-0.68
Contributions to output growth (per cent)					
Capital services	37.67	39.65	45.37	41.19	42.29
Hours worked	15.64	8.37	17.18	9.03	57.27
Labour composition	6.83	6.61	7.05	6.83	6.83
Multifactor productivity	39.87	34.36	35.90	61.67	-14.98
	2000-01	2001-02	2002-03	2003-04	2004-05
Output growth	1.94	3.87	3.10	4.60	3.15
Contributions to output growth (ppt)					
Capital services	1.54	1.37	1.86	2.22	2.35
Hours worked	-0.40	-0.47	1.17	0.91	1.63
Labour composition	0.31	0.23	0.23	0.23	0.23
Multifactor productivity	0.49	2.74	-0.17	1.24	-1.06
Contributions to output growth (per cent)					
Capital services	33.92	30.18	40.97	48.90	51.76
Hours worked	-8.81	-10.35	25.77	20.04	35.90
Labour composition	6.83	5.07	5.07	5.07	5.07
Multifactor productivity	10.79	60.35	-3.74	27.31	-23.35
	2005-06	2006-07	2007-08	2008-09	2009-10
Output growth	3.11	3.98	4.23	1.28	2.16
Contributions to output growth (ppt)					
Capital services	2.60	2.60	2.97	2.45	1.93
Hours worked	0.85	1.59	1.72	0.29	-0.44
Labour composition	0.22	0.30	0.30	0.30	0.29
Multifactor productivity	-0.55	-0.52	-0.77	-1.75	0.38
Contributions to output growth (per cent)					
Capital services	57.27	57.27	65.42	53.96	42.51
Hours worked	18.72	35.02	37.89	6.39	-9.69
Labour composition	4.85	6.61	6.61	6.61	6.39
Multifactor productivity	-12.11	-11.45	-16.96	-38.55	8.37
	2010-11	2011-12	2012-13	2013-14	2014-15
Output growth	2.41	4.20	2.58	2.41	2.13
Contributions to output growth (ppt)					
Capital services	1.97	2.88	2.42	1.75	1.39
Hours worked	1.27	0.40	-0.57	0.20	0.47
Labour composition	0.28	0.30	0.31	0.34	0.35
Multifactor productivity	-1.11	0.62	0.41	0.12	-0.07
Contributions to output growth (per cent)					
Capital services	43.39	63.44	53.30	38.55	30.62
Hours worked	27.97	8.81	-12.56	4.41	10.35
Labour composition	6.17	6.61	6.83	7.49	7.71
Multifactor productivity	-24.45	13.66	9.03	2.64	-1.54

Source: BANKWEST CURTIN ECONOMICS CENTRE | Authors' calculations from ABS Cat. 5260.0.55.002 (Industry Multifactor Productivity, Australia)

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