Australian Government
Department of Industry, Innovation and Science

ATSE
Australian Academy of Technology & Engineering

Improving Innovation Indicators

Better Data to Track Innovation in Australia

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Contents

Message from the Co-Chairs

Like most people in our respective fields, we'd always accepted that innovation was hard to define and even harder to measure, but the measures we had were the best we'd got.

Then a few years ago, an international comparison metric came out that showed Australia was dead-last in collaboration between universities and innovation-active small-medium enterprises, with large enterprises not faring much better. [1]

This finding led to a frenzy of negative commentary.

In discussions with Vice Chancellors and Deputy Vice Chancellors of Research around Australia, it was apparent that each university could present solid evidence of strong industry collaboration, and each thought that the cause of Australia's low collaboration ranking must lie with the other universities.

Upon further investigation, we found the ranking was misrepresentative, with our position influenced by Australia's use of different collection methodologies.

Other comparison metrics at that time looking at industry investment and patent investorship put Australia's collaboration between universities and innovation-active businesses in the middle of the pack.

Not nearly good enough, but far from dead-last.

We needed different policy responses than if Australia had been dead-last.

That is where our investigative journey into Australia's innovation metrics began.

The Review was commissioned by Government in response to a recommendation in the Innovation and Science Australia 2030 Plan that called for a review of existing innovation metrics for accuracy and adequacy.

We were appointed as Co-Chairs and asked ourselves 'where should we start?'.

We agreed that to start, we needed to focus on the outcome.

You all know the old joke about a police officer who sees a drunk searching for something under a streetlight and asks what the man has lost. He says he lost his keys and they both look under the streetlight together. After a few minutes the officer asks the drunk if he is sure he lost them here, and the man replies, no, he lost them in the park. The officer asks why he is searching here, and the man replies, 'the light is much better here'.

The moral: we look where it's easy, not necessarily where it's useful.

In our case, the outcome we all want is simple: increased productivity and higher living standards.

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[1] OECD 2017, OECD Science, Technology and Industry Scoreboard 2017: The digital transformation, OECD Publishing, Paris, viewed 11 November 2019

Innovation is the key that unlocks them, and metrics are the light with which we find the key.

There were several goals for this Review.

First, the Review sought to improve data sources and metrics that are not quite fit for purpose, are in some way inaccurate, or do not allow direct country comparisons.

Second, the Review sought to identify and fill measurement gaps, to capture hidden innovation.

Third, the Review sought to deliver a list of suitable metrics – what we call a scorecard – that would be of policy relevance to government and useful to guide evidence-based decision-making.

The Review found that:

- many innovation metrics have focussed primarily on measuring R&D activities, as this is where Government policy efforts have been concentrated. However, evidence shows that significant innovation activities are occurring that do not involve R&D, but not all these activities are being measured, and not all the policy levers potentially available to encourage them are being used
- intangible capital is now more important than tangible capital in several developed countries. Its importance is increasing in Australia and internationally, but there are significant gaps in the measurement of intangibles
- measuring digital activities in the economy is also of increasing importance, but where and how the economy has been most impacted by adoption of digital technologies is unknown.

Based on these findings, the Review proposes recommendations to:

- provide leadership of innovation measurement and reporting arrangements for the ongoing maintenance and reporting of innovation metrics including through the use of an innovation scorecard
- address data gaps to support the development and assessment of policy initiatives including where there are deficiencies in the frequency or availability of current data, or where conceptual or measurement challenges exist
- support the analysis of relevant new data, and data already available to the Australian Government that are not being fully utilised.

In adopting the recommendations of this Review, the Australian Government's ability to measure, report on, and compare the performance of the Australian innovation ecosystem with those of other countries will be greatly improved.

Why is it so important to take these steps now rather than later?

Former British Prime Minister Tony Blair was well known for his mantra 'education, education, education'.

Twenty years on, a more apposite trifecta would be 'innovation, innovation, innovation'.

We will in coming years begin to run into natural limits on raising education levels, but we will never run out of ideas about how to do things better. It is innovation that will continue to drive increases in longevity, rein in and reduce carbon emissions, and reverse flagging growth in productivity and living standards.

We can and must get better at innovation in Australia. A precondition for developing successful policy that supports innovation is that we measure innovation well and report on it regularly as part of an ongoing national conversation. What you measure, you optimise.

In setting out a roadmap for change, we aim to ensure the longevity of the changes to the data and measurement capability.

Producing this report required input from many people. We take this opportunity to thank Christine Williams, who led the Review's taskforce, the taskforce members, the Review's Steering Committee and Expert Reference Group, the panel of international experts who contributed their advice, the Scorecard Expert Working Group, the Intangibles Expert Working Group, ATSE's Expert Working Group and Broader Consultative Group, and the hundreds of stakeholders who took the time to consult with the taskforce, or present submissions for the Review.

To each person and organisation who shared their advice and time, we sincerely thank you for your contribution.

Alan Finkel

Australia's Chief Scientist

Mark Cully

Head of the Treasury's Regulatory Reform taskforce

Executive summary

Innovation is key to improving a country's long-term prosperity and well-being. However, innovation is a complex concept and is difficult to measure. Policymakers require an evidence base to understand how elements of the innovation system are performing and which areas need attention.

If the Australian Government does not focus on the right metrics for Australia, there is a significant risk that these metrics will inform policy settings, which will result in suboptimal outcomes.

The issue of metric reliability was highlighted in the report of Innovation and Science Australia (ISA) to the Australian Government, *Australia 2030: Prosperity through Innovation.* In response to the ISA report, the Innovation Metrics Review was commissioned by the Australian Government to deliver a series of recommendations regarding how Australia can improve its ability to measure key aspects of its innovation system.

The Review's aim is to develop a suite of metrics that more fully capture innovation and thereby improve government policy making, program design and evaluation, and overall decision-making.

The Review took a holistic approach to innovation measurement and investigated data sources, metrics, analysis and leadership.

The findings

Many existing innovation metrics focus on measuring R&D activities, as this is where a large portion of government innovation policy efforts have been concentrated both in Australia and internationally.

However large amounts of innovation activity and expenditure do not involve R&D.

Since these activities are not being adequately measured, the policy levers potentially available to encourage them are not being fully exploited.

Intangible assets are an increasingly important component of investment in developed countries, including Australia, but there are significant gaps in the measurement of intangibles.

Measuring digital activities in the economy is also of increasing importance, but where and how the economy has been most impacted by digitalisation is not well measured.

The Review identified major gaps in innovation data capture, metrics and analysis. These are discussed in this report. These information gaps and emerging data needs have been discussed under three themes:

- Areas of the innovation system where the concepts and measures in place are fit-for-purpose, but there are gaps related to the frequency and or granularity of current data
- Areas where there is a sound conceptual basis for measurement, but measurement challenges weaken data utility

- Areas where there are both conceptual and measurement challenges.

The recommendations

The Review made several recommendations that can be implemented to improve the current state of innovation measurement in Australia.

Regular measurement of the Australian innovation system with a scorecard.

National innovation systems are complex. Scorecards can cut through the complexity and quickly communicate the most important aspects of innovation.

Scorecards can underpin public discussion about where policymakers might usefully intervene.

Research by the Productivity Commission shows that productivity growth is a key factor in determining a country's standard of living. The Review has developed its Scorecard based upon the Productivity Growth Framework developed by the Productivity Commission. There is already a strong relationship between innovation, productivity growth and improved living standards. In developing its Scorecard, the Review therefore sought to align the measurement of innovation performance to where innovation policy can have the greatest impact on living standards.

The resulting Scorecard contains a handful of the most important indicators for monitoring innovation-driven productivity gains in the economy. The indicators are mapped against the drivers of productivity growth, given limitations on the data available to underpin them.

The Review recommends that an Innovation Metrics Scorecard should be reported annually to Government and regularly reviewed.

Better data and metrics for measuring innovation

Addressing information gaps and emerging data needs will require statistical, analytical and research solutions to be investigated and developed.

Many of the information gaps and emerging data needs highlighted by the Review are not unique to Australia. In many respects Australia is comparable to other countries in regard to data gaps. Since many National Statistical Offices (NSOs) are experiencing the same innovation measurement challenges, there is an opportunity to coordinate efforts to develop solutions.

Ongoing analysis of the innovation system

Due to the complex and dynamic nature of innovation systems, data and metrics alone are not enough to capture relevant innovation activities with enough clarity to provide insights for policymakers.

Analysis of data is important to identify the linkages through various innovation activities. There are several reasons why analysis of data is important; it can provide deeper insights on innovation system performance and impacts; it can assess existing information measures and identify new and emerging needs and information gaps; and it can maximise the value of the large amounts of data being generated.

Data analysis provides insights into the enablers of innovation activities of critical importance to jobs, productivity growth, and social and environmental impacts. There are some important data already collected that are not being analysed that should be, due to visibility and access issues. The Department of Home Affairs' trade data, which flag new to world and new to business Australian exports, were amongst these until recently. They were made accessible to analysts outside that Department through the Business Longitudinal Analysis Data Environment (BLADE) in October 2019.

Leadership in innovation measurement

Responsibility for Australia's innovation ecosystem, and for measuring its progress, is currently split across Australian, state and territory agencies. This makes the development of a national strategic approach for measuring innovation difficult and time consuming.

There should be an appointment of a single entity with a whole-of-government remit to provide national leadership of innovation measurement and reporting.

What's next

The Review has set out a roadmap to implement the recommendations of the Review.

These recommendations target strategic priorities and take a common sense approach to implementation to improve the measurement of innovation in Australia. Implementing the recommendations will require long-term support.

Two of the high priority recommendations are time sensitive as they relate to ongoing ABS survey work. These two recommendations should be implemented quickly to align with the timeframes of existing activities that they are leveraging.

Other recommendations are not as time-critical, however, the net benefits expected cannot be realised unless they are implemented.

Some of the Review's recommendations also provide direction on next steps, rather than presenting final solutions.

Findings

Evidence gathered by the Review shows that there is a substantial amount of innovation activity and expenditure occurring in the economy that does not involve R&D.

The Review also uncovered that significant amounts of non-R&D innovation activities and expenditures are not being captured in current measures. The Review found evidence of widespread under-reporting of continuous incremental improvement in business processes across all four sectors examined. It also found some sector-specific under-reporting (such as de-risking in mining and extension in agriculture).

- Internationally, government innovation policies have a focus on promoting R&D based activities, and as a result tend to focus on sectors of the economy that invest more heavily in R&D, such as advanced manufacturing and medical research
- Australia's areas of comparative advantage – including resources, education, tourism, and agriculture – are different from those of Europe. The resources, tourism and agriculture industries around the world have relatively low R&D expenditure as a percentage of revenue
- Measures of expenditure on R&D are important, but on their own are insufficient to provide a complete picture of the breadth of innovation activities occurring in the Australian economy. In Australia, non-R&D innovation expenditure is of a similar order of magnitude to R&D expenditure, and is more common (in that more businesses engage in it).

Intangible assets are an increasingly important component of investment in developed countries, including Australia, but there are large gaps in the measurement of intangibles.

- Intangible capital consists of assets that lack physical substance; in contrast to physical assets (such as machinery, land and buildings), and financial assets (such as government securities). Intellectual property (IP), goodwill and brand recognition are all examples of intangible assets
- There are significant gaps in the measurement of intangibles. These gaps are due to their exclusion from international standards such as the System of National Accounts (SNA), to which Australia adheres. For example, we do not directly capture the value of data created (just the cost of collecting it), although this value is indirectly captured in GDP
- Other gaps include design and other product development, training, market research and branding, business process re-engineering, and networks.

Measuring digital activities in the economy is also of increasing importance, but where and how the economy has been most affected by digitalisation is unknown.

- The sectoral studies provided qualitative evidence that Australian businesses are investing heavily in digitalisation

- However, there is little quantitative evidence available regarding investment in and take-up of digital technologies and the impact of these technologies on the Australian economy

The Review identified gaps in innovation data, metrics and analysis, which are discussed in this report. These information gaps and emerging data needs have been captured under three themes:

- Areas of the innovation system where the concepts and measures currently in place are fit-for-purpose, but where there are gaps related to the frequency or availability of current data
- Areas where there are sound conceptual grounds for measurement, but where measurement challenges reduce data utility
- Areas where there are conceptual and measurement challenges.

There are also areas where data are available and fit-for-purpose but have not yet been analysed.

The Review developed the Scorecard to track Australia's current innovation performance.

- The Review mapped innovation metrics to the drivers of productivity growth identified in the Australian Productivity Commission's analysis of innovation
- The Scorecard contains a handful of the most important indicators for Australia, based on currently available data, for monitoring innovation-driven productivity gains in the economy (see the attached Scorecard)
- The Review visually represented the drivers of productivity growth to show how innovation feeds into productivity improvements
- The Review also highlighted the policy levers that can foster improvements in economic prosperity via the innovation system in Australia.

Recommendations at a glance

Measuring the performance of the Australian innovation system

RECOMMENDATION 1.1: INTRODUCE ANNUAL INNOVATION SYSTEM REPORTING

The Review recommends that an appropriate entity responsible for innovation measurement in Australia should produce an innovation metrics scorecard and provide a report to the Australian Government annually.

Every year the responsible entity should provide:

- a publicly available report on the performance of the innovation ecosystem in Australia
- an innovation metrics scorecard that measures progress domestically and benchmarks Australia's performance internationally.

The Scorecard developed by the Review should be adopted until improved innovation data becomes available (a minor update for some of the metrics will be needed in the second half of 2021).

Future periodic reviews should be undertaken from the second half of 2022 to inform the approach for developing an updated scorecard.

Data and metrics for measuring innovation

RECOMMENDATION 2.1: IMPROVE MEASURES OF EXPENDITURE ON R&D

The ABS should produce annual indicators of Gross Expenditure on Research and Development (GERD) and Businesses Expenditure on Research and Development (BERD), including estimates of R&D expenditure at a more granular level than is currently available.

RECOMMENDATION 2.2: IMPROVE MEASURES OF BUSINESS USE OF DIGITAL TECHNOLOGIES

The ABS should update current survey content related to business use of digital technologies to reflect new technological advances and measure the extent of technology diffusion and its impact on business performance.

The ABS should also leverage work being done internationally that measures the link between the diffusion of these new technologies and their impact on innovation.

The responsible entity should investigate the feasibility of accessing and using alternative sources of data (e.g. Big Data analytics, administrative and transactional data) to provide new and complementary indicators of the extent of business adoption and use of digital technologies.

RECOMMENDATION 2.3: IMPROVE MEASURES OF BUSINESS INNOVATION ACTIVITIES

The ABS should review the collection of business innovation data and make sure it aligns better with that of other countries so that direct comparisons can be made.

The ABS should ensure any changes made continue to meet the needs of other users of the data and are useful in the context of the Australian economy. In particular the ABS should:

- introduce a standalone Australian business innovation survey, administered every two years using a two-year reference period, to enable more meaningful international comparisons to be made. This survey would be mandatory, as is the practice with other ABS business surveys
- investigate ways to increase the utility and meaningful measurement and analysis of total business innovation expenditure
- investigate the feasibility of developing broader measures of how businesses work together for the purpose of innovation, including fee-for-service arrangements
- provide a more complete picture of the impacts of innovation activities occurring in Australian businesses.

RECOMMENDATION 2.4: CONDUCT AN ANNUAL SECTORAL ANALYSIS

The responsible entity should commission an annual large-scale sectoral study to develop a better understanding of the nature of innovation in those sectors that are important to the Australian economy. This study should:

- draw comparisons with a selection of countries that are relevant to the sector being analysed (e.g. for the mining sector, comparison countries should include those with major mining activity)
- start with a sector that is important to the Australian economy and rotate annually to a different sector.

RECOMMENDATION 2.5: UPDATE OCCUPATION CLASSIFICATION SYSTEM

The ABS should review and update the Australian and New Zealand Standard Classification of Occupations (ANZSCO) for new and emerging occupations that are expected to have increasing importance.

RECOMMENDATION 2.6: UPDATE INDUSTRY CLASSIFICATION SYSTEM

The ABS should continue to engage with the United Nations Statistical Commission regarding the International Standard Industrial Classification (ISIC), with a view to influence any update to:

- better reflect the Australian economic structure
- facilitate meaningful sector analysis
- aid evidence-based decision-making.

The ABS should continue to engage with the United Nations Statistical Commission and the Organisation for Economic Cooperation and Development to influence the development of a more streamlined and flexible way of conducting updates of industry classifications

The ABS should review and update the Australian and New Zealand Standard Industrial Classification (ANZSIC) after the 2021 Census.

RECOMMENDATION 2.7: INTRODUCE AND IMPROVE MEASURES OF INTANGIBLE CAPITAL

The ABS should develop experimental estimates of intangible capital items not covered within the System of National Accounts (SNA).

The ABS should review and update the data sources and assumptions underlying intangible capital measurement within the SNA.

RECOMMENDATION 2.8: INTRODUCE AND IMPROVE MEASURES OF DIGITAL ACTIVITIES IN THE ECONOMY

The ABS should leverage work undertaken internationally and assess how digital activity measures can be developed, prioritising the following information needs:

- The total value of e-commerce (digitally ordered goods and services)
- The level of investment in digital technologies (such as cloud computing) occurring in the economy
- The total value of services provided by intermediary platforms as a separate proportion of the overall value of goods and services being provided by the producer
- The imputed value of free services (including data) not currently captured within the SNA.

In the longer term these measures may contribute to a future digital satellite account.

RECOMMENDATION 2.9: MEASURE GOVERNMENT INNOVATION ACQUISITION

The Australian Government regularly enters into arrangements to acquire new or significantly improved products (goods and services) and processes. At present it does not differentiate arrangements for acquisition of these innovative products and processes from other products.

Investigation, organised by the responsible entity, is needed to determine how data on government acquisition of innovative products and processes could be collected, in order to measure their worth and effect on encouraging innovation. Ideally, an approach that enables international comparison of performance should be adopted.

RECOMMENDATION 2.10: INTRODUCE AND IMPROVE MEASURES OF ENTREPRENEURSHIP; START-UPS AND SPIN OUTS

Work is needed to define the conceptual basis for measurement and develop measurement systems that enable conclusions to be drawn about the level, performance and drivers of entrepreneurial activity in Australia and other countries.

The responsible entity should coordinate this work drawing on expertise from the international and domestic research community, relevant policy areas and other stakeholders.

RECOMMENDATION 2.11: IMPROVE MEASURES OF ACCESS TO FINANCE FOR START-UPS

The responsible entity should investigate the compilation and connection of alternative public and private data sources for the measurement of access to finance; including use of angel investment, crowd-sourcing and accelerators. The investigation should assess whether there is an alternative to the Venture Capital and Later Stage Private Equity (VC&LSPE) Survey to meet the need for data on access to finance over the longer term.

In the interim the ABS should continue to undertake the VC&LSPE Survey.

RECOMMENDATION 2.12: MEASURE LOCATION-BASED INNOVATION

The responsible entity to investigate options, by working with the ABS and other relevant parties, to build location-based capability into Australian innovation data. Data custodians should be encouraged to collect location data that supports analysis of location-based innovative activity.

RECOMMENDATION 2.13: IMPROVE MEASURES OF RESEARCH COMMERCIALISATION

The collection of data through the National Survey of Research Commercialisation by the Department of Industry, Innovation and Science should be discontinued.

The responsible entity should coordinate the development of a conceptual framework for the measurement of research commercialisation activities. This should focus on measuring the success of publicly funded research organisations, in commercialising their ideas in conjunction with the business community.

The responsible entity should commence the collection of hitherto unavailable research commercialisation data. The entity will ensure this data can be properly measured and is important to stakeholders.

Analysis

RECOMMENDATION 3.1: TAKE A WHOLE-OF-GOVERNMENT APPROACH TO INNOVATION RESEARCH

The responsible entity should take a whole-of-government approach to innovation research, drawing on capabilities across Australian, state and territory government agencies, academia and the private sector.

The aim would be to build strong analytical capability regarding Australia's innovation ecosystem.

Leadership on innovation measurement

RECOMMENDATION 4.1: ASSIGN RESPONSIBILITY FOR LEADERSHIP OF INNOVATION MEASUREMENT

Appoint a single entity with a whole-of-government remit, to provide national leadership for innovation measurement and reporting.

This leadership role will entail:

- collaborating with stakeholders to identify and address data and metrics gaps and ensure the continued relevance of innovation data and metrics while considering Australia's changing economy, society and environment
- reporting to the Australian Government on the progress of the implementation of recommendations proposed in this Review
- ensuring Australia is represented in international efforts to improve innovation, science and technology measurement
- being a single point of contact to facilitate international engagement on innovation measurement issues
- allocating work through contract management to enable it to perform these functions.

This leadership role will not entail:

- collecting data directly
- conducting research directly.

The entity would collaborate with the ABS to ensure new data and metrics were consistent with international work where appropriate.

Introduction

KEY POINTS

- **The Australian Government commissioned the Innovation Metrics Review (the Review) to improve innovation measurement to support better decision-making**
- **The Review aims to take a holistic approach to innovation measurement and covers issues including metrics, data sources, analysis and leadership**
- **Innovation is a complex concept and is difficult to measure.**

There is no community consensus on the scope and definition of innovation

Innovation is a critical element of our modern society and we feel its influence everywhere.

Technology that was in its infancy 10 years ago, such as smartphones and electric cars, is far more advanced today.

Innovation is happening all the time, however innovation is a complex concept and there are many different definitions and interpretations of what innovation means.

The OECD's Oslo Manual, first issued in 1992 and updated at intervals since then, provides guidelines for collecting, reporting and using innovation data.

The 2018 Oslo Manual defines innovation as:

> "A new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)"[2]

However, even with this definition there are problems.

Innovation activities by their nature are novel and varied. For instance, innovation is undertaken in diverse ways across different sectors of the economy. This has led to actors in the innovation system having their own definitions of what constitutes innovation.

[2] OECD/Eurostat, Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation 4th Edition, OECD Publishing, Paris/Eurostat, Luxembourg, 2018.

Innovation is important for improving a country's long-term prosperity and well-being

Innovation is a key source of long-term prosperity and well-being. Analysis by the OECD found that innovation often contributes over half of GDP growth in member countries.[3] In addition to economic benefits, innovation propels substantial improvements in living standards through advances in areas such as healthcare, education and infrastructure.

Measuring the benefits from investment in innovation is a priority for governments around the world.

As growth has slowed in many developed economies, governments are now turning to innovation as a key source of future growth.

Policymakers require an evidence base to understand how elements of the innovation system are performing and which areas need attention.

If the Australian Government does not focus on the right metrics for Australia, there is a significant risk that these metrics will inform policy settings, which will result in suboptimal outcomes.

As Joseph Stiglitz observed,

> 'If we measure the wrong thing, we will do the wrong thing. If we don't measure something, it becomes neglected, as if the problem didn't exist'[4]

It is vital that the most relevant metrics are used to focus innovation policy on areas that maximise positive economic, social and environmental outcomes for Australia.

Concerns with current international innovation measures have led to a review of metrics in the Australian context

There are many indicators used to benchmark innovation, however concerns have been raised about the reliability of some of these measures to compare Australia's performance internationally.

There is a perception that Australia performs poorly regarding business collaboration with the research sector and with business expenditure on research and development (BERD).

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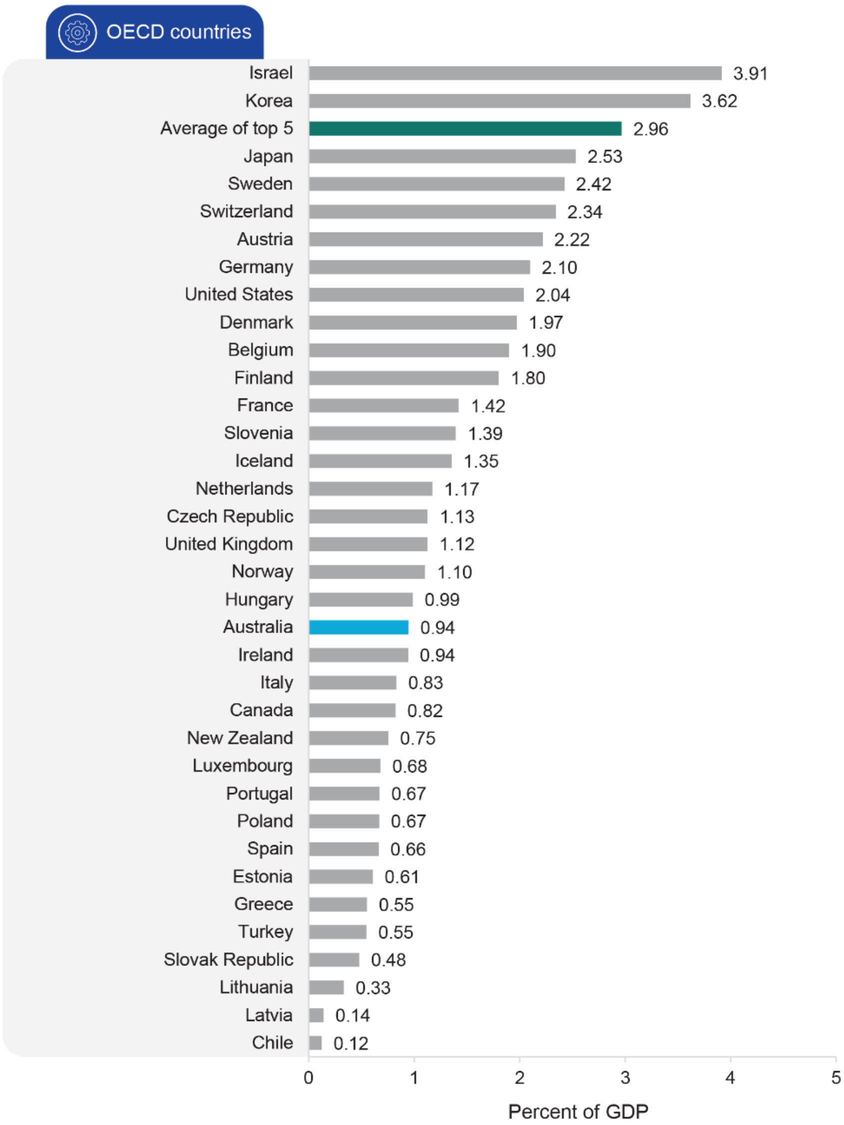
[3] Department of Industry, Innovation and Science 2017, Australian Innovation System Report 2017, Department of Industry, Innovation and Science, Canberra.

[4] J Stigltz, 2018, 'If we measure the wrong thing, we will do the wrong thing', The OECD Statistics Newsletter, Issue no. 69 pp. 3–4.

Figure i.1: Business expenditure on research and development (BERD) of OECD countries in 2017, percent of GDP



Source: OECD Main Science and Technology Indicators; Accessed 20 September 2019

Although this may be the case, it is unclear if these are useful assessments of Australia's innovation performance on their own, given that Australia remains an extremely competitive exporter in key sectors, such as mining, agriculture and education.

In isolation, giving too much weight to indicators like BERD as percentage of GDP to compare innovation performance across countries may be misleading because of differences in the structure of national economies. The level of investment in BERD varies by industry and hence the BERD of a country is affected by the composition of its economy. For example, at a global level, advanced manufacturing is a sector characterised by high BERD, and mining and agriculture are sectors characterised by low BERD (even though mining is a relatively high BERD sector by Australian standards).

Countries such as Germany with a comparative advantage in advanced manufacturing, will naturally tend to have a higher BERD than countries such as Australia with comparative advantages in agriculture and mining, which are characterised by low BERD.

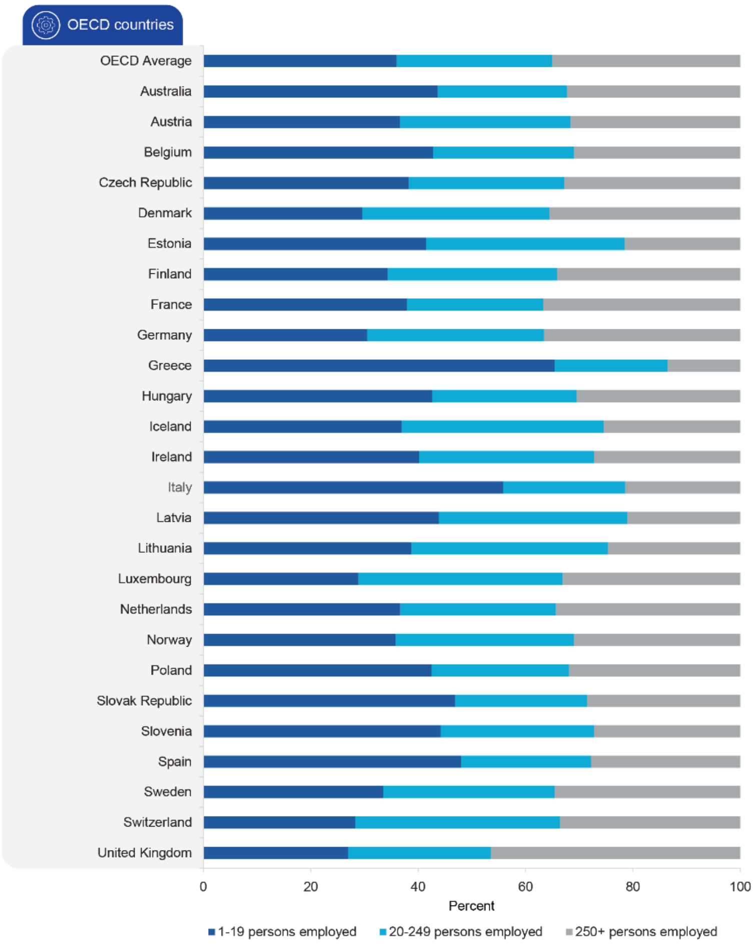
Previously, The Treasury report into Australia's international R&D efforts explained that Australia's low BERD has a significant relationship to Australia's industry structure.[5] This deduction is supported by the forthcoming report by AlphaBeta that notes that over 90 percent of the decline in BERD as a share of GDP since its peak in 2008–09 was the result of Australia's changing industry mix and a decline in mining exploration and development after the mining boom of the early 2000s.[6]

It has been anecdotally argued that the level of investment in BERD is affected by the size of businesses in the Australian economy. As shown in Figure i.2, Australia also has a slightly higher proportion of persons employed by small and medium enterprises (SMEs, 1–249 employees) than other nations, and a higher than average proportion of persons employed by smaller businesses (1–19 employees).

[5] G Davis & G Tunny 2005, International comparisons of research and development, The Treasury, Canberra, viewed 16 December 2019.

[6] Innovation and Science Australia 2019, Australian Business Investment in Innovation: levels, trends and drivers, a report prepared by AlphaBeta, Sydney. (forthcoming)

Figure i.2: Proportion of persons employed in companies of OECD countries according to the size of the company in 2016

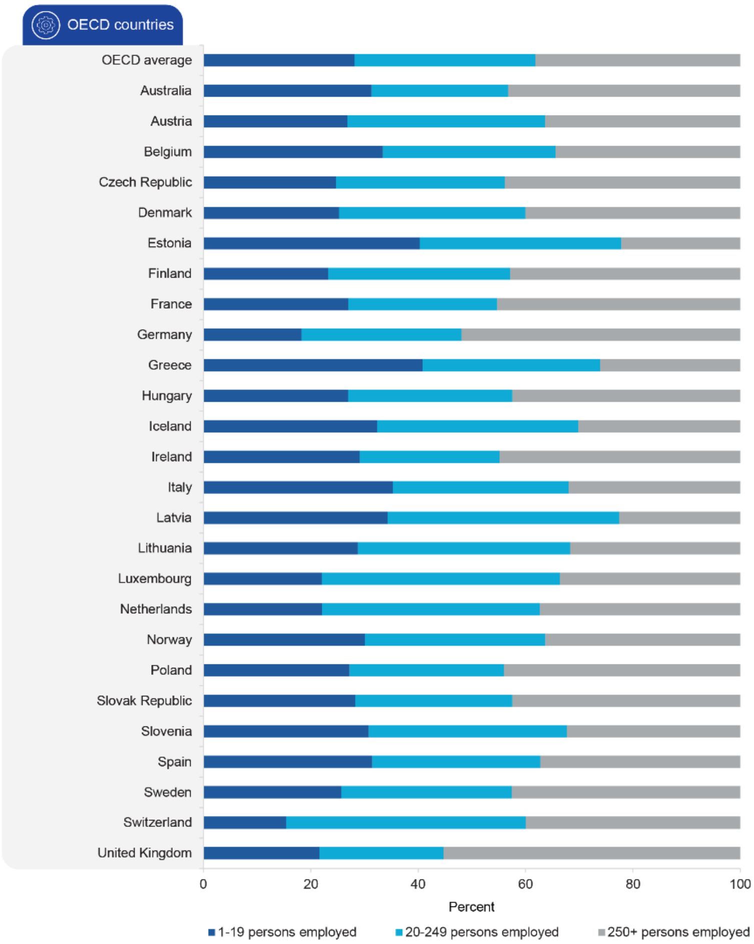


Notes: Sector coverage includes the business economy, except financial and insurance activities. Australian size class 20–249 employees refers to businesses with 20–199 employees.

Source: OECD Structural Business Statistics (ISIC Rev. 4)

This effect can also be seen in measures of revenue (see Figure i.3). Australian smaller businesses (those with 1–19 employees) have a higher revenue compared to the OECD average.

Figure i.3: Proportion of revenue in companies of OECD countries according to the size of the company in 2016



Notes: Sector coverage includes the business economy, except financial and insurance activities. Australian size class 20–249 employees refers to businesses with 20–199 employees.

Source: OECD Structural Business Statistics (ISIC Rev. 4)

SMEs tend to have proportionally lower BERD than larger enterprises. Australia also has fewer multinational research headquarters relative to other developed countries (noting it has some, including CSL, Resmed, and Cochlear, for example), which could also be expected to result in a lower BERD. However, the net effect from this is minor. Australia is not an outlier with regard to small business employment, as Greece is, and its lower BERD has more to do with the structure of the Australian economy.

OECD measures tend to focus on activities and sectors that are not major drivers of the Australian economy, such as advanced manufacturing, and not those, like agriculture and mining, that make a big contribution in Australia.

As in other industrialised economies, services now make up a large part of the Australian economy, representing over 80 per cent of Australia's GDP.[7]

[7] OECD, Australian Services Trade in the Global Economy, OECD Publishing, Paris, 2018.

Anecdotal evidence from the sectoral studies suggests that knowledge-intensive and human capital-related investments are more important to innovation in the services sector than physical capital intensive investments and R&D.

The under reporting of the level of innovation in these Australian sectors found by the Review in its sectoral studies discussed in Appendix B, points to further challenges around the international measurement of innovation.

Many innovation indicators focus on the use of established metrics, such as patents and R&D expenditure. However, this provides an incomplete picture of Australia's innovation performance and there are many other areas considered just as critical for success.

These include but are not limited to:

- the contribution of human capital, management practices and business organisation such as entrepreneurship, intrapreneurship and improvements to workplace culture
- the value of intangible investment such as design, market research, branding and digital platforms
- the influence of hidden innovation such as improvements to processes which are not properly captured and just considered to be business as usual.

These issues are not unique to Australia.

In addition, concerns have been raised about inconsistencies in reference periods and time lags before data are published. Many innovation indicators are lagged indicators – they capture historical data on activities that have already happened, rather than measuring current performance or predicting future performance.

These lags mean policymakers are making decisions based on old information.

The result can be a lack of clear direction for innovation policy interventions, with policies either overcompensating or failing to correct for poor innovation performance.

This could impede the effectiveness of government policy that was supposed to lift Australia's economic performance and standard of living.

There are also concerns about the definition of collaboration used by the OECD in the Oslo Manual in the Australian context.

Fee for service arrangements are not captured by current international collaboration indicators, but were very common in the sample of Australian businesses that participated in the Review's sectoral studies, discussed in Appendix B. Fee for service arrangements were routinely used even when risks and IP are being shared.

It is not known whether this is a significant issue, but the sectoral study results indicate it should be investigated.

The issue of metric reliability was highlighted in the report of Innovation and Science Australia (ISA) to the Australian Government, *Australia 2030: Prosperity through Innovation* that recommended a Review be undertaken of the metrics currently being used to assess innovation performance.[8]

The Review aims to improve innovation metrics and the evidence base for effective policy

In response to the ISA report, the Review was commissioned by the Australian Government to deliver a series of recommendations regarding how Australia can improve its ability to measure key aspects of its innovation system.

The Review's aim is to develop a suite of metrics that more fully capture innovation and thereby improve government policy making, program design and evaluation, and overall decision-making.

Goals and principles of the Review

The Review's co-Chairs established a set of goals and principles to provide the context for considering innovation and to help direct the approach taken during the Review.

The goals and principles were refined and agreed with the international Steering Committee. The key deliverables and scope of the Review are given in Appendix A.

Goals

The Review set out to deliver a report to the Australian Government recommending:

- An appropriate data and measurement infrastructure for capturing innovation metrics that:
    - is underpinned by a sound conceptual framework
    - captures data at the most efficient cost
    - sets out a roadmap for change.
- A suite of robust innovation metrics that:
    - accurately measure and communicate innovation performance and its effects across all sectors of the Australian economy
    - are presented in a way that is useful for government policy and program development
    - can measure the impact of government policy initiatives on innovation

[8] Innovation and Science Australia 2017, Australia 2030: Prosperity through Innovation, Innovation and Science Australia, Canberra, viewed 29 October 2019.

- may be useful for international adoption and comparisons.

Principles

The Review recognised the breadth of benefits that innovation delivers to society, but focused on the economic influences of innovation.

The task of innovation in this review is to drive growth in jobs, productivity, investment and exports.

The Review saw innovation in the context of a modern economy characterised by an increasing dominance of service industries, high levels of investment in intangible capital and deployment of digital technologies.

A key assumption was that Australians want the benefits of innovation from wherever it is sourced – for example, in sectors such as mining and agriculture – which means the Review was open to all sources of innovation including hidden innovation.

A mapping exercise would demonstrate which of the existing metrics in use are of sufficient quality and where new metrics need to be developed to fill gaps.

The starting position for the framework is in the *Australia 2030: Prosperity through Innovation* report.

Metrics must be directly relevant to government policy development and program performance.

Ultimately high-level metrics would be presented in a scorecard with around 15 useful indicators.

The full suite of metrics would serve broader purposes in monitoring, evaluation and research on the innovation system and the impact of government policy.

Where metrics are also collected and published internationally for advanced economies, these would be favourably considered. The recommended metrics should aspire to be internationally comparable with minimal correction required.

It was anticipated that the Review would recommend significant changes to the capture of innovation metrics. Where appropriate to do so, these would leverage off existing statistical collections and administrative data sources, but not shy away from using novel sources.

In setting out a roadmap for change, the Review would aim to ensure the longevity of the changes to the data and measurement infrastructure remain in place to 2030 and beyond.

Underpinning all of the above was the principle of pragmatism.

The Review's recommendations would be practical, achievable, have due regard for the burden imposed on data providers, and would focus on the most important improvements that could be made.

Structure of the report

The report takes a holistic approach to innovation measurement and covers data sources, metrics, analysis, and leadership issues.

The Review process and methodology sets the scene for innovation measurement and outlines the methodology used to guide the Review.

Chapter 1 explores the importance of measuring Australia's innovation system performance including benchmarking internationally.

It notes the key issue of communicating the performance of the Australian innovation ecosystem to a broad audience. It provides a scorecard with a small number of high-level indicators that have been developed in close consultation with key stakeholders and experts in the field.

The Review's scorecard (the Scorecard) reflects the close relationship between innovation and productivity growth in driving improvements to living standards and long-term prosperity.

Chapter 2 explores the importance of data. It is critical to ensure that data are meaningfully used, and that collection is coordinated. Vast amounts of data are already being collected.

However, there are data gaps and problems associated with collection and measurement. Gaps have been identified in several areas:

- Where there are no conceptual or measurement challenges, but existing data are low quality. For example, the coverage of data on the diffusion of digital technology is too narrow
- Where there is a sound conceptual basis for measurement, but measurement challenges exists. For example, genuine collaborations may be excluded from measurement because fee for service arrangements are excluded
- Where there are conceptual and measurement challenges. For example, some components of intangible capital are not measured, and it is not clear how best to do so.

Opportunities exist to fill gaps in data collection using both quantitative and qualitative approaches. The report explores substantial changes in data collection that ensure all innovation activity is properly captured, particularly in new and emerging fields.

Chapter 3 highlights the importance of analysis that builds on data to inform policy making.

The improved collection of data and reporting of metrics alone is not enough to facilitate policy and business decisions to improve innovation performance.

Meaningful analysis is required to identify trends and other key issues that can inform the development of effective policies. There can be considerable time lags and difficulties in directly attributing a specific activity as a driver of innovation, which could be the result of a combination of factors.

The Review shows how increased analysis of data will improve Australia's ability to identify relationships that deliver outcomes in key areas, such as jobs, productivity growth, health, education and broader social and environmental benefits.

The Review also explores how to improve policy making through evidence-based analyses by making existing Australian, state and territory government innovation-related datasets available for analysis.

Chapter 4 highlights the importance of leadership on innovation metrics. Collection and publication of innovation metrics is currently very fragmented with many competing stakeholders and priorities.

The Review suggests a model of a national, coordinated, non-partisan and non-competitive entity to align and link innovation measurement efforts.

The Review shows the benefits of annual public reporting on innovation performance as well as progress in the implementation of the recommendations in the report.

The Review explores the provision of a central point of contact to participate in international discussions on innovation measurement issues.

Chapter 5 sets out the steps required to build on the momentum of the Review, including a roadmap for change that identifies priorities for the improvement of measurement of innovation in Australia.

The Review prioritises activities that should be supported over the immediate, medium and long-term.

The Review introduces a timeline for the implementation of recommendations in the report, as well as guidance on when the Scorecard should be reviewed to ensure it continues to capture the most important aspects of innovation for Australia.

There are areas recommended for further work beyond the Review.

As the economy continues to evolve, it is essential that innovation measures continue to remain relevant and guide improvements in the right direction. This will ensure that Australia's ability to harness both existing and emerging opportunities is maximised.

Finally, the following documents on the key activities that served to provide information underpinning the findings and recommendations of the Review, can be found in the appendices.

These are:

- Appendix A: Scope of the Review
- Appendix B: Sectoral studies
- Appendix C: Updated improving innovation indicators consultation paper, following the public submission process
- Appendix D: Innovation Metrics Review Workshop Proceedings 13–14 March 2019

- Appendix E: The Australian Academy of Technology and Engineering's (ATSE)'s Innovation Metrics Review literature review
- Appendix F: Compendium of metrics
- Appendix G: Governance of the Review
- Appendix H: Scorecard metrics descriptions and data coverage
- Appendix I: Sources of data and metrics currently available
- Appendix J: Priority ordering of the recommendations

The Review process and methodology

KEY POINTS

- The Review has focused on innovation measurement areas that are required to support government decision-making
- A Steering Committee and Expert Reference Group, along with selected international innovation measurement advisers, guided the work of the Review. The Review was also guided by separate Expert Working Groups with regard to the Scorecard and Intangibles. The ATSE was guided by an Expert Group of ATSE Fellows
- The Review undertook the following activities:
  - Consultation with stakeholders
  - Sectoral studies
  - International workshop
  - Literature review, prepared by ATSE
  - Assessment of innovation metrics
  - Gap assessment
  - An assessment of how to fill the gaps identified.
- The Review adopted an innovation metrics framework to identify the full range of activities and complexities that make up the innovation ecosystem
- The innovation metrics framework is central to the Review's assessment of innovation metrics which informed the findings and recommendations of the Review.

Review of Australia's measurement of innovation

The ISA report to government, *Australia 2030: Prosperity through Innovation,* raised questions about how measurement of the performance of the innovation system can be improved.[9] ISA called for a Review of the existing innovation metrics for accuracy and adequacy.

In response to this recommendation, the Australian Government commissioned the Review to deliver a series of recommendations on how Australia can improve its ability to measure key aspects of its innovation system.

This chapter outlines the process and methodology used to inform the findings and recommendations of the Review.

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[9] Innovation and Science Australia 2017, Australia 2030: Prosperity through Innovation.

Governance of the Review

The Review was funded by the Department of Industry, Innovation and Science (the Department), and undertaken by a taskforce consisting of officers from the Department, the Office of Innovation and Science Australia (OISA), Office of the Chief Scientist, the ABS, IP Australia, and ATSE.

ATSE's role was to provide an independent viewpoint, whilst working in close collaboration with the taskforce, to ensure the Review was robust and considered a broad range of viewpoints. ATSE was commissioned to undertake a literature review and advise on a framework to measure and track innovation; the data currently available, including gaps, and the metrics to be used or developed for future use.

The taskforce was directed by a Steering Committee, and received advice from an Expert Reference Group, international technical advisers, separate Expert Working Groups with regard to the Scorecard and Intangibles. ATSE was guided by its own Expert Working Group and feedback from its Broader Consultative Group. The members of those are listed in Appendix G.

The Review undertook the following activities to inform its findings and recommendations:

- Consultation with stakeholders
- Sectoral studies
- International workshop
- Literature review
- Assessment of the quality of innovation metrics
- Gap analysis of data and metrics
- An assessment of how to fill the gaps identified
- Development of a scorecard of the best metrics available.

Stakeholder and public consultations

The Review held meetings with key stakeholders to help identify gaps, issues and opportunities for innovation metrics.

Consultations were conducted with:

- international statistical and government agencies
- international innovation measurement experts
- academics and the higher education and research sectors
- Australian Government agencies, including agencies within the DIIS portfolio
- state and territory government officials
- private sector organisations
- the general public, via the public submission process.

The insights gained from those meetings were incorporated into the *Improving Innovation Indicators Consultation Paper,* which was provided to the public for feedback on 7 March, 2019.

The public submissions provided feedback concerning the key messages that emerged from the initial stakeholder consultations, as well as other themes or issues that had not yet been raised. The *Improving Innovation Indicators Consultation Paper* was updated in June 2019 to include feedback from written submissions to the Review (see Appendix C). The paper reflects the Review's consultation process and content at that point in time.

In total, meetings were conducted with 94 organisations. Submissions were received from 36 organisations and individuals, and over 200 people were consulted. The breakdown of interviews by organisation type and by individual is shown below. For example, suppose a private sector business was consulted in one interview involving three representatives of that business. The number of organisations consulted and the number of private sector organisations consulted would each increase by one, but the number of individuals consulted and the number of private sector individuals consulted would each increase by three.

A workshop was conducted to inform the Review about international developments

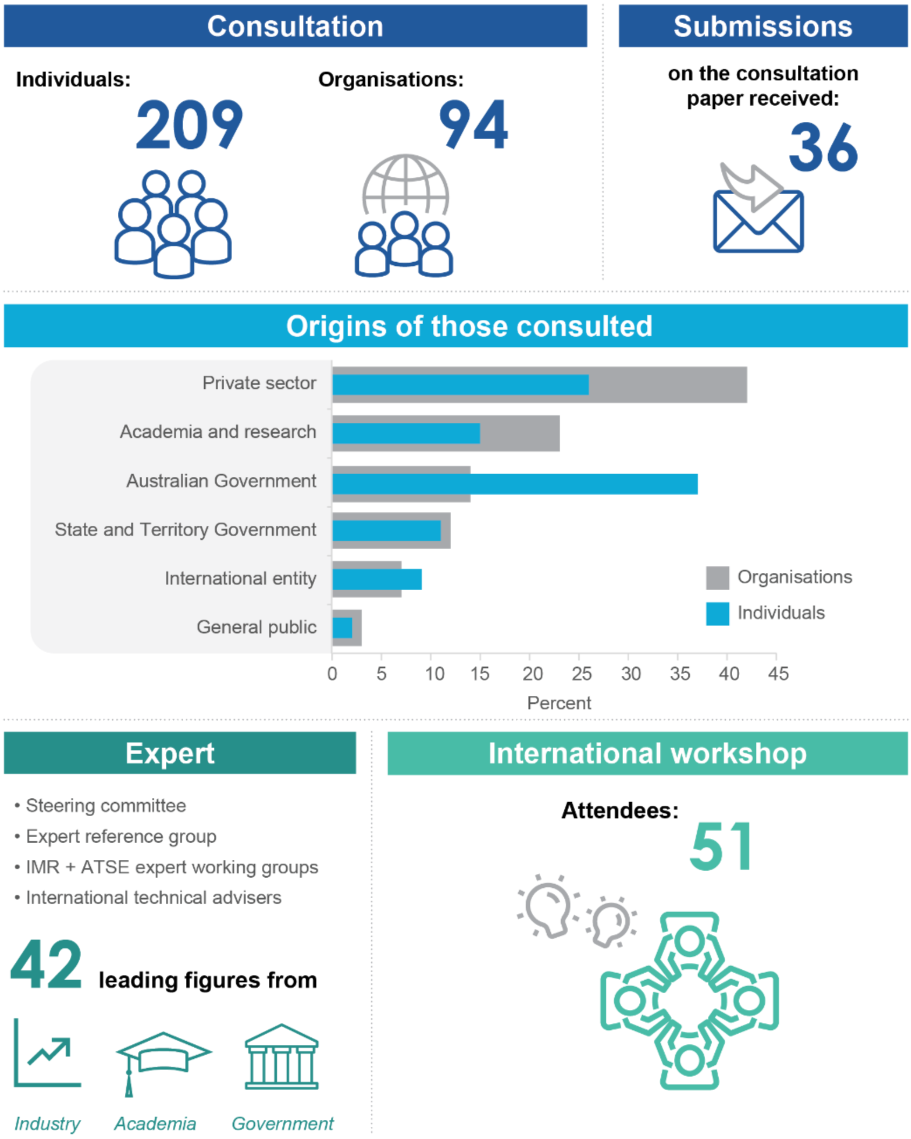
An International Innovation Metrics Workshop was held on 13–14 March, 2019 in Canberra. The 51 invited attendees included innovation metrics experts and innovation system stakeholders, and included most of the members of the Review's governance and advisory bodies.

The purpose of the workshop was to inform the Review about international developments and share the thinking of international and domestic experts on how innovation measurement could be improved.

There were eight thematic sessions at the workshop, with each session introduced by a pair of speakers. These themes included:

- Entrepreneurship
- Innovation metrics – state of play: a World Intellectual Property Organisation's Global Innovation Index perspective
- Hidden innovation in mining
- Measurement of R&D and innovation policies
- Creative inputs into innovation
- Knowledge diffusion and research commercialisation
- Intangibles
- Capability and absorptive capacity.

Proceedings from the Innovation Metrics Review Workshop is at Appendix D.



Sectoral studies were conducted to provide insights that might not be captured by current metrics

The Review undertook four sectoral studies to provide insights to the Review on:

- how innovative activities occur across different sectors of the Australian economy
- how current innovation measures are capturing (or not capturing) those innovation activities
- what is possible and practical in the measurement of innovation activities
- how measures might be improved to provide a more comprehensive picture of the relative innovation performance in all sectors of the Australian economy and assist policymakers to make evidence-based decisions.

The four sectors selected for sectoral studies were:

- mining
- agriculture
- health services
- finance and insurance services.

To ensure coverage of each sector and consideration of a diverse range of perspectives, the Review identified and consulted with a range of potential stakeholders. These included: small, medium and large businesses; peak bodies and industry-owned companies; statutory bodies; and academic institutions. The consultation process involved interviews that were conducted with individuals or in groups. In addition to the interviews, a range of information sources was consulted to provide further context and supplement the evidence provided by interviewees.

The sectoral studies are in Appendix B.

ATSE conducted a literature review that provided context and learnings used by the Review

ATSE was commissioned to undertake a literature review as part of the Review. The literature review:

- provides context for the Review's activities
- helps to relate the Review to authoritative sources
- looks at the innovation measurement frameworks being used by others
- describes the evolution of innovation thinking, changes in the nature of innovation and its increasing diversity
- looks at innovation beyond the business
- examines entrepreneurship
- looks at opportunities to improve the measurement of innovation.

The literature review is given in Appendix E.

ATSE also provided input into the conceptual framework used by the Review. More detail on the framework is given below.

The Review adopted an Innovation Metrics Framework

The Review adopted an Innovation Metrics Framework (the Framework) that draws on key concepts and elements identified in the *ISA 2016 Performance Review*.[10] The Framework has been deliberately developed at a broad level (Figure i.4). This allows the Framework to encompass the full range of activities and complexities that make up the innovation system (Table i.1).

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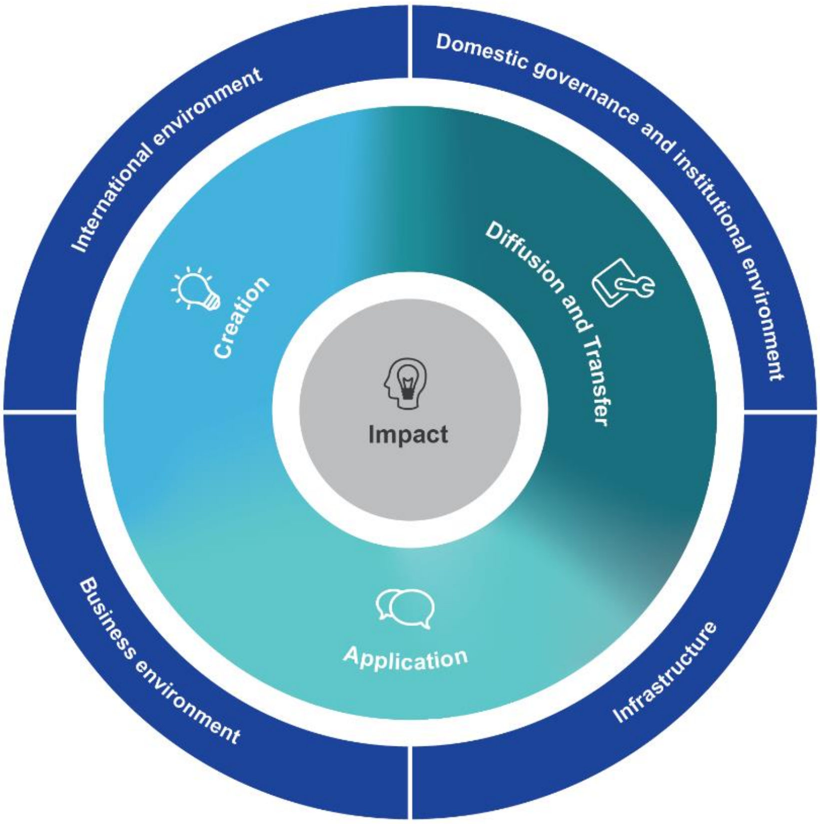
[10] Innovation and Science Australia 2017, Performance Review of the Australian Innovation, Science and Research System 2016, Innovation and Science Australia, Canberra, viewed 29 October, 2019.

Figure i.4: Innovation Metrics Framework



At its centre, the Framework focuses on the impact of innovation. The Review recognises the breadth of benefits that innovation delivers to society, but focused on the economic impacts of innovation (in particular productivity, investment, jobs and exports), as these are where innovation policy can have the greatest impact on living standards. Innovation has economic, environmental, social and governance-related impacts, but the Review has focused on the economic impacts.

At the middle, the Framework identifies the key components that form an innovation ecosystem. These have been categorised under three headings, ‘creation’, ‘diffusion and transfer’ and ‘application’.

The creation, diffusion and transfer, and application components behave in a non-linear fashion.

- Creation refers to the creation of new ideas and knowledge. It acknowledges that innovation creation occurs across various stages and with various actors. For instance, both R&D and non-R&D based knowledge and idea creation are performed by government, businesses, higher education institutions, and not-for-profit organisations
- Diffusion and transfer refers to the exchange, adaptation, diffusion and translation of ideas and distribution of knowledge. This can occur through human capital training and spillovers, as well as more formal collaborative and information sharing arrangements

- Application refers to the development, refinement and implementation of innovation. Application capabilities and application performance depend on capabilities and capacities in the innovation system, such as management capability and access to skills and finance.

For the components of the innovation ecosystem to operate effectively, a well-functioning overarching operating environment needs to be in place (outer circle of the Framework). The operating environment broadly covers key areas, such as domestic governance and institutional environment; infrastructure and business environment; and the international environment.

The Framework was used by the Review to assess the components of the innovation system, for which there are either few or no innovation metrics available and fit for use. This was done by mapping available metrics against the components of the Framework as outlined below.

Table i.1: Innovation Metrics Framework

1. OPERATING ENVIRONMENT

1.1. Domestic governance and institutional environment

- 1.1.1. Political environment
- 1.1.2. Legislative and regulatory environment
  - 1.1.2.1. Entry and exit barriers
- 1.1.3. Taxation environment
- 1.1.4. Financial environment
  - 1.1.4.1. Credit
  - 1.1.4.2. Equity
- 1.1.5. Policy and program environment
  - 1.1.5.1. Innovation procurement

1.2. Infrastructure

- 1.2.1. ICT and digital infrastructure
- 1.2.2. Research infrastructure
- 1.2.3. General infrastructure

1.3. Business environment

- 1.3.1. Business churn
- 1.3.2. Diversity
- 1.3.3. Entrepreneurship environment

1.4. International environment

- 1.4.1. Trade and competition
  - 1.4.1.1. Free trade agreements
  - 1.4.1.2. Tariff barriers
  - 1.4.1.3. Non-tariff barriers

KEY COMPONENTS OF AN INNOVATION ECOSYSTEM

CREATION – Creation of new ideas and knowledge

2. FROM THE RESEARCH SYSTEM

- 2.1. R&D Funders
  - 2.1.1. Government
  - 2.1.2. Business
  - 2.1.3. Higher Education
  - 2.1.4. Not-for-profit
  - 2.1.5. Overseas
- 2.2. R&D Performers
  - 2.2.1. Government
  - 2.2.2. Business
  - 2.2.3. Higher Education
  - 2.2.4. Not-for-profit
  - 2.2.5. Overseas

3. NON-R&D BASED KNOWLEDGE AND IDEA CREATION

- 3.1. Domestic
  - 3.1.1. Government
  - 3.1.2. Business
- 3.2. Overseas
  - 3.2.1. Government
  - 3.2.2. Business

DIFFUSION AND TRANSFER – Exchange, adaptation, diffusion and translation of ideas and knowledge

4. **HUMAN CAPITAL**
    - 4.1. Education and training
        - 4.1.1. Early childhood development
        - 4.1.2. Schools
        - 4.1.3. VET
        - 4.1.4. Higher Education
        - 4.1.5. Non-accredited education and training
        - 4.1.6. On the job training and professional development
    - 4.2. Labour and skills mobility
        - 4.2.1. Internships
        - 4.2.2. Cross-sectoral staff placements and exchanges
        - 4.2.3. Skilled migration
    - 4.3. Entrepreneurship skills

5. **DISTRIBUTION OF KNOWLEDGE**
    - 5.1. Publications
    - 5.2. Intellectual Property, licensing (out and in) and trade secrets
    - 5.3. Collaborations, contracts and consultancies, between businesses and research institutions
    - 5.4. Publicly-funded research organisations facilities, technology, materials, processes
    - 5.5. Networks

APPLICATION – Development, refinement and implementation

6. **APPLICATION CAPABILITIES**
    - 6.1. Absorptive capacity
    - 6.2. Management capability
    - 6.3. Innovation capability
        - 6.3.1. R&D capacity
        - 6.3.2. Design capability
        - 6.3.3. Workforce skills and HR
        - 6.3.4. Digital capability
        - 6.3.5. Intellectual Property management and appropriation
        - 6.3.6. Supply chain integration
    - 6.4. Financial capability
        - 6.4.1. Investment (debt or equity)

7. **APPLICATION PERFORMANCE**
    - 7.1. New products and processes
    - 7.2. Start-ups and spinouts

8. IMPACTS

8.1. ECONOMIC[1]
- 8.1.1. National economic performance
    - 8.1.1.1. Employment
    - 8.1.1.2. Workforce composition
    - 8.1.1.3. Productivity & efficiency
- 8.1.2. International performance
    - 8.1.2.1. Exports
    - 8.1.2.2. Competitiveness
- 8.1.3. Economic diversity
- 8.1.4. Economic complexity
- 8.1.5. Investment
    - 8.1.5.1. Foreign investment

8.2. ENVIRONMENTAL

8.3. SOCIAL

8.4. GOVERNANCE RELATED

[1] The Innovation Metrics Review focusses on the economic impacts

The effectiveness of innovation metrics was determined using seven key principles and assessment criteria

The Innovation Metrics Framework is central to the identification of the full range of activities and complexities that make up the innovation ecosystem.

The Review obtained metrics from a wide range of sources – including the OECD, Eurostat, the Global Innovation Index (GII), the Global Competitiveness Report (GCR), the ISA scorecards, Australian Innovation System Report, and the ABS – and mapped the available metrics against the components of the Innovation Metrics Framework.

An innovation metrics assessment matrix was developed (see Table i.2) based on principles drawn from the *Oslo Manual 2018*.[11] These included how fit for purpose the selected metrics are using the principles of relevance, accuracy and validity, reliability and precision, timeliness, coherence, comparability, accessibility, and clarity.

The assessment matrix allowed the Review to make a preliminary assessment of whether metrics were relevant to the Framework and fit for purpose. Metrics that had no issues identified with them that would affect their use were assessed as 'green'. Those of limited use in relation to the Framework were assessed as 'orange'. Those with significant limitations were assessed as 'red'. Where metrics had issues based on some of the principles but not others, the worst colour code applicable to that metric was used.

This does not mean that all metrics assessed as 'orange' or 'red' are useless to policymakers. For example, metrics generated using data produced by the Programme for the International Assessment of Adult Competencies (PIAAC) were assessed as 'red' because PIAAC is administered every 10 years. Yet PIAAC data and metrics are regarded as very important for policy purposes. The long interval between PIAAC cycles does, however, mean that other metrics are required to supplement PIAAC metrics. Education accounts for a high proportion of Australian, state and territory expenditure and it would not be reasonable to evaluate performance in this area only every 10 years. Thus metrics generated by the Programme of International Student Assessment (PISA) are recommended for use when only old PIAAC data is available, as PISA data, while far more limited, is produced every three years and is therefore more useful for program evaluation.

Appendix F, 'the Innovation Metrics Compendium', has been provided to show where existing metrics map to components of the innovation ecosystem, including an assessment to identify the gaps in coverage in terms of either the number or the quality of metrics. The numbering system shown on Table i.1 corresponds with the structure of the Compendium.

Figure i.5 provides an indication of the Review's assessment of innovation metrics against the Framework components. Of the 597 metrics collected, 186 (31 percent) were rated as green, 302 (51 percent) were rated as orange, and 109 (18 percent) were rated as red. In the metrics assessed by the Review, gaps in innovation data exist in the non-R&D based knowledge and idea creation category, as well as in the application performance category. While

[11] OECD/Eurostat, Oslo Manual 2018.

the Review considered many metrics for the research system, most have been assessed as having issues associated with their use (orange or red), with around 10 percent of metrics having a green quality assessment.

The assessment matrix also assisted the Review's selection of innovation metrics for the development of an innovation metrics scorecard. Further detail on the development of the Scorecard is provided in Chapter 1.

Figure i.5: Number of quality-assessed metrics within each Framework component

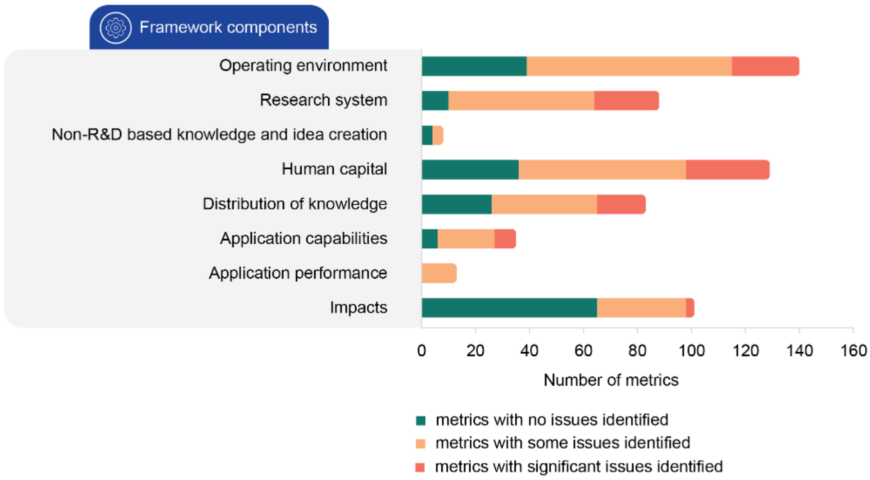


Table i.2: Metrics selection assessment matrix

This framework articulates the principles and assessment criteria used to guide the assessment of metrics for their quality and fitness for purpose for measuring the Australian innovation system. These principles have been drawn from the Oslo Manual 2018 (Table 11.1). In the comments column, the text in white refers to that drawn from the Oslo Manual 2018 and the text in the light blue box is specific guidance added by and for the Review.

Principles	Description	Comments	Assessment criteria			Questions to assist in assessment
			Green	Orange	Red	
Relevance	Serves the needs of actual and potential users	Innovation involves change, leading to changes in the needs of data users. Relevance can be reduced if potential users are unaware of available data or data producers are unaware of users' needs. In the context of the Review, a number of factors were considered when assessing the relevance of metrics. Data and metrics should have a demonstrable relationship with a concept described in the Innovation Metrics Review Framework (the Framework); The Framework was developed to capture and encompass innovation activities and concepts relevant to government policy and program development effectively. Whether or not a metric links to the Framework provides some indication of policy relevance. Data and metrics should provide meaningful information about the Framework concept to which it is linked; They should be presented in a way that is useful for government policy and program development. Data and metrics should be amenable or linked to policy action and (where relevant) addressable through government policy levers; They should materially respond to government policy initiatives.	The metric has a direct relationship to, and provides meaningful information about, a concept described in the Framework, and is amenable or linked to government policy action	The metric has an indirect relationship to a concept described in the Framework; or provides somewhat meaningful information about the concept; or is somewhat amenable or linked to government policy action	The metric has no relationship to any concepts described in the Framework; or does not provide meaningful information about these concepts; or is not amenable or linked to government policy action	• Which Framework concepts is the metric linked to? • Can the relationship between the metric and the Framework concept be easily described? • What does the metric inform about the Framework concept? • Is the metric amenable or linked to policy action? Are there any factors that may impact or limit policy action or utility?
Accuracy and validity	Provides an unbiased representation of innovation phenomena	There may be systematic differences in how respondents provide information depending on the collection method or respondent characteristics. Metrics can fail to capture all relevant phenomena of interest. Accuracy relates to the degree to which the metric correctly describes the phenomena it was designed to measure (how close it is to the 'true value'). It is usually characterized in terms of error in statistical estimates and is traditionally decomposed into bias (systematic error) and variance (random error) components. It may also be described in terms of the major sources of error that potentially cause inaccuracy. Validity is the extent to which a score represents the variable it is intended to measure. Validity may be affected by the collection method or respondent characteristics.	No known issues	Some minor issues identified	Major issues identified	• What are the data collection methods used? What is the metric designed to measure? How might this impact on the metric's utility in respect to understanding the Framework concept it is linked to? • Does the metric provide an unbiased representation of the Framework concept it is linked to across all relevant sectors or populations of the economy?

Principles	Description	Comments	Assessment criteria			Questions to assist in assessment
			Green	Orange	Red	
Reliability and precision	Results of measurement should be identical when repeated and have a high signal to noise ratio	Results can differ by the choice of respondent within a firm. Reliability can decline if respondents guess the answer to a question or if sample sizes are too small. A metric is reliable if it is based upon stable and consistent data collection processes across collection points and over time. Progress toward performance targets should reflect real changes rather than variations in data collection approaches or methods. Precision is how repeatable a measurement is.	No known issues	Some minor issues identified	Major issues identified	• Is the metric based upon stable and consistent data collection processes across collection points and over time? • Would results of measurement be identical if the collection process was repeated (i.e. was the size of sample large enough)? • Was there a high signal to noise ratio?
Timeliness	Available on a sufficiently timely basis to be useful for decision making	Lack of timeliness reduces the value of metrics during periods of fast economic change. Timeliness can be improved through now-casting or collecting data on intentions. However, some aspects of innovation are structural and change slowly. For these, timeliness is less of a concern. The measure of timeliness is the delay between the end of the reference period to which the information pertains, and the date on which the information becomes available. Timeliness is typically involved in a trade-off against accuracy. The timeliness of information will influence its relevance.	Metric is updated every year or more frequent	Metric is updated every two years or, if annual, is available with a time lag of three years or more	Metric is updated less frequently than every two years	• How frequently is the metric updated? • Is there a significant time lag between the reference period and the date on which the information becomes available?
Coherence	Logically connected and mutually consistent	Additive or decomposable at different aggregation levels; High levels of aggregation can improve reliability/precision, but reduce usefulness for policy analysis. Low levels of aggregation can influence strategic behaviour and distort measurement. Decomposable by characteristics; Metrics can be constructed for different types of firms according to innovations or innovation activities. Coherence over time; Use of time series data should be promoted. Breaks in series can sometimes be addressed through backward revisions if robustly justified and explained. Coherence relates to the degree to which a metrics and data can be successfully integrated with other statistical information within a broad analytic framework and over time. The use of standard concepts, classifications and target populations promotes coherence, as does the use of common methodology across surveys.	No known issues	Some minor issues identified	Major issues identified	• Does the metric use standard methods, classifications and populations? • Are the methods used coherent over time?

Principles	Description	Comments	Assessment criteria			Questions to assist in assessment
			Green	Orange	Red	
Comparability	International comparability	Coherence across sectors, regions or countries, including international comparability; Comparability across regions or countries requires standardisation to account for differences in size or industrial structure of economies. The comparability of a metric will be determined by the extent to which it can be compared across time and between sectors and countries against one or more international benchmarks. Metrics calculated for Australia only are less useful than those measured by a significant number of other countries. Six factors determine the international comparability of Australian metrics obtained from innovation surveys including: • the reference period • differences in the distribution of firms by size • differences in industry structure • differences in the extent of industry coverage (such as the services sector) • the design of response categories • the wording of questions.	No known issues	Some minor issues identified	Major issues identified	• Are there any factors that impact on the comparability of Australian data internationally? (e.g. methodological differences, lack of availability of international data, metric is not standardised to account for country differences such as size of economy)
Accessibility and clarity	Widely available and easy to understand, with supporting metadata and guidance for interpretation	Challenges to ensure that the intended audience understands the metrics and that they "stir the imagination of the public". • Accessibility may be understood as the ease with which the metric (or its underlying components) can be obtained from its underlying data source. This includes the ease with which the existence of information can be ascertained, any preconditions that have to be met to obtain access, the suitability of the form or medium through which the information can be accessed, the cost of the information, if any, and the cost of obtaining it and putting it in a usable form. • Clarity is affected by how easy data and metrics are to understand. This is also impacted by the availability of supporting metadata and guidance for interpretation.	Information is publicly available online	Information is available on request or for payment	Information is not currently accessible	• Is the information publicly available free of charge? • Is the information easy to understand? • Is supporting metadata and guidance for interpretation provided?

1. Measuring the performance of the Australian innovation system

Key points

- **National innovation systems are complex and scorecards can provide an effective mechanism for quickly communicating the most significant aspects of innovation**
- **Scorecards can underpin public discussion about where policymakers might usefully intervene**
- **Research by the Productivity Commission shows that productivity growth is a key factor in determining a country's standard of living. The Review has developed a Scorecard based upon the Productivity Growth Framework developed by the Productivity Commission**
- **There is already a strong relationship between innovation, productivity growth and improved living standards. In developing the Scorecard, the Review therefore sought to align the measurement of innovation performance to where innovation policy can have the greatest impact on living standards**
- **The Scorecard contains a handful of the most important indicators for monitoring innovation-driven productivity gains in the economy. The indicators are mapped against the drivers of productivity growth, given limitations on the data available to underpin them**
- **The Review recommends that an Innovation Metrics Scorecard should be reported annually to Government and regularly reviewed.**

Why is measuring the performance of the innovation system important?

Innovation systems are complex and difficult to measure

National innovation systems are very large and complex entities, and are constantly changing. The innovation metrics framework discussed in the Review Process and Methodology section is central to the Review's assessment of innovation metrics and their selection to measure the performance of an innovation system. The framework encompasses the full range of activities, actors and complexities that make up the innovation system.

Innovation is more than just the conception of a new idea, it requires implementation to realise its potential.[12] Innovation systems are the network of actors that are collectively responsible for the creation, diffusion and implementation of these new ideas.[13] The system is dynamic and actors come from diverse sectors and levels of the economy.

There are two main challenges in the study of innovation and innovation policy:

1. It must try to 'measure how things that are themselves difficult to measure affect other things that are also difficult to measure'.[14]
2. Innovation systems are dynamic and interconnected and 'understanding the process, products and eventual impact of science and innovation activities requires the ability to observe and understand action at multiple levels of analysis'.[15]

The measurement of the performance of innovation systems, and the selection of metrics to guide innovation policy, are therefore matters that require expert understanding and ongoing attention.

What is the current status of Australia's innovation performance measurement?

Due to the complexity of innovation systems, measuring innovation performance is often linked to models or organising frameworks. The selection of an appropriate organising framework is independently taken by authors based on various factors, including fitness for purpose. A subset of suitable metrics is then selected and grafted onto the organising framework.

There have been numerous previous analytical approaches taken to measure the performance of innovation systems in an economy. These innovation performance measures can be generally categorised in three areas:

- On one end are composite indices that combine multiple indicators to produce an overall ranking of a country's innovation performance. Composite indices often include a call to action but provide no policy clarity, given the focus on an overall single score
- On the other end are dashboard monitors that provide comprehensive data about many aspects of an innovation system but are too detailed to provide simple insights to policymakers or other decision makers
- Somewhere between composite indices and dashboard monitors are scorecards, which provide a high-level brief overview of a country's innovation performance, focusing on a limited number of indicators where policy action can improve performance in a key area of national priority.

Prominent examples of these analytical approaches include the European Innovation Scoreboard (EIS), the GII, the OECD Science, Technology and

[12] OECD/Eurostat, Oslo Manual 2018.

[13] JS Katz, 'What is a complex innovation system?' PLoS One vol. 11 (6), 2016.

[14] A Gonzalez-Cabral, F Galindo-Rueda, & S Appelt, 2018, 'Indicators of R&D Tax Support', Issues in Science and Technology, vol. 34, no. 4, (Summer 2018).

[15] Ibid.

Industry (STI) Scoreboard, the Australian Innovation System Monitor (AIS Monitor), and the ISA scorecards. These are outlined in more detail below.

Australian Innovation System Report and Monitor

The Australian Innovation Systems Report (AISR) annual series (2010–2017) identifies three components: innovation activities, networks and framework conditions that collectively work as a system to generate and diffuse innovations that have economic, social or environmental value. The AIS assessed the performance of Australia's innovation system by comparing identified indicators against other countries.

The AIS Monitor[16] is a new flagship digital dashboard for tracking Australia's innovation system performance, superceding the highly regarded AISR. The new mobile-ready web platform gives readers up-to-date information on business innovation, entrepreneurship, science and research, network and collaboration, and skills and capability. It maps the Australian innovation system through interactive charts, downloadable data and regular content updates. The AIS Monitor provides a comprehensive set of innovation indicators to inform the performance of an innovation system.

Innovation and Science Australia Scorecards

The *Performance Review of the Australian innovation, science and research system 2016* (the 2016 ISA Review)[17] assessed the performance of the innovation, science and research system using a simple framework to identify three innovation activities: knowledge creation, knowledge transfer, and knowledge application. The 2016 ISA Review included a scorecard that mapped a limited number of indicators against the performance framework of outcomes, outputs, and the innovation activities.

In 2017, ISA published the *Australia 2030 Prosperity through Innovation* plan (the ISA 2030 Plan),[18] introducing a new scorecard that developed a common set of metrics to underpin performance reviews in the future to inform decisions about the most effective way to invest in Australia's innovation, science and research system.

The European Innovation Scoreboard

The EIS[19] provides a comparative analysis of innovation performance in European countries and other countries, including Australia. It assesses relative strengths and weaknesses of national innovation systems and helps countries identify areas they need to address. These are discussed in the main report and summarised in an interactive tool, akin to a dashboard.

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[16] Department of Industry, Innovation and Science 2019, Australian Innovation System Monitor, Department of Industry, Innovation and Science, Canberra, viewed 11 November, 2019.

[17] Innovation and Science Australia 2017, Performance Review of the Australian innovation, science and research system 2016.

[18] Innovation and Science Australia 2017, Australia 2030: Prosperity through Innovation.

[19] European Commission 2019, European Innovation Scoreboard, European Commission, European Union, viewed 11 November, 2019.

The scoreboard distinguishes between a summary indicator and four main indicator groups to provide a comparative assessment of innovation performance for its member states. These indicator groups include: framework conditions, investments, innovation activities, and impacts.

The Global Innovation Index

The GII[20] is a high profile international index that compares the performance of national innovation systems across economies.

The GII measures innovation based on a summary index score, supported by separate innovation input and output sub-indices including: institutions; human capital and research; infrastructure; market sophistication; business sophistication; knowledge & technology outputs; and creative outputs. These dimensions of innovation are then combined into a single score or composite indicator.

OECD Science, Technology and Industry Scoreboard

The OECD STI Scoreboard[21] draws on the latest comparable data, primarily from its Main Science and Technology Indicators (MSTI) as well as other innovation survey data. It provides insights that can help governments design more effective science, innovation and industry policies.

The OECD STI Scoreboard uses minimal composite indicators. Instead, it provides harmonised data for the purpose of international comparison and benchmarking against OECD averages to help users develop analysis based on their own interests.

An Innovation Metrics Scorecard for Australia

Purpose of a scorecard

Measuring the performance of the Australian innovation system and the ability to communicate quickly and effectively to a broad audience was a key issue raised during this Review. Previous attempts on measuring the performance of Australia's innovation system and its reporting to date appear to have received limited use, except as point-in-time snapshots by the media and in briefings within Australian governments.

Constructing an insightful analysis of the performance of an innovation system is difficult because of gaps in the underlying data. However, there is merit in being able to provide a high-level overview of Australia's innovation system performance that is meaningful to a broad audience. This overview could even be complementary with existing dashboard monitors that are suited to those who work professionally in innovation policy or the academic and research community.

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[20] Cornell INSEAD WIPO, Global Innovation Index, viewed 11 November 2019, <https://www.globalinnovationindex.org/home>.

[21] OECD 2017, OECD Science, Technology and Industry Scoreboard 2017: The digital transformation, OECD Publishing, Paris, viewed 11 November 2019.

Innovation performance scorecards can provide an effective mechanism for quickly communicating complex ideas, particularly to a broad, non-technical audience. In this context, scorecards may act as a useful conversation starter to underpin public discussion about where Australian governments can usefully intervene to address a key issue of national priority. Participants in the Innovation Metrics Review International Workshop echoed this, stating that a scorecard is essential for stimulating dialogue with the public and with policymakers. A scorecard also aids the development of new measures that reflect the quality – rather than just the quantity – of innovation.[22]

An innovation metrics scorecard would provide an ongoing opportunity to raise the profile of innovation to Australian governments. Such a scorecard would play its most useful role if it was used consistently as part of annual messaging by the Australian Government in relation to its innovation system oriented policies. The intended audiences for a scorecard should be policymakers and analysts, industry stakeholders, and international organisations, e.g. the OECD. Consistent use of the scorecard would lead to it becoming recognised as a reliable tool for understanding the Australian national innovation system.

Determining the most meaningful approach to develop a Scorecard

In the early stages of the Review, an overarching Innovation Metrics Framework (the Framework) was adopted and is discussed in detail in the Review Process and Methodology. It is important to be able to measure the performance of the different aspects of innovation captured in the Framework.

However, in determining the most meaningful approach to develop a scorecard, which of necessity can include only a handful of the most important indicators, the Review sought to establish a performance measurement system for innovation which is responsive to the unique characteristics of the Australian economy, and empowering to Australian policymakers, whilst also enabling comparison where possible to international peers.

The overarching aim in developing the Scorecard is to inform policies that can boost Australian productivity and living standards, not to be top of an international innovation metrics ranking table.

Innovation is not an end in itself. It is undertaken within businesses in order to lead to outcomes, such as improved sales and profits, and in the public sector to improve services to citizens and advice to government. In the aggregate, the sum of innovations undertaken results in improvements in economic growth and living standards. Living standards are broadly defined to be analogous to well-being or welfare.

The Review therefore focused on aligning the measurement of innovation performance to where innovation policy can have the greatest impact on living standards. The Scorecard thus follows the structure of the Productivity Growth Framework, established by the Productivity Commission to look at how the economy, business environment and business activities each build on each other and drive productivity growth, discussed later in this chapter.

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[22] Innovation Metrics Review 2019, Workshop Proceedings, 13–14 March 2019, Australian Government, Canberra, viewed 11 November 2019.

There is a strong relationship between innovation, productivity growth and improved living standards

The realisation of improved living standards through innovation and links to productivity growth provides a meaningful approach to guide the development of an innovation metrics scorecard for Australia.

According to the Australian Government's current *Intergenerational Report*, there are three main factors that determine the quantity of goods and services (Gross Domestic Product) that a country produces: population, participation and [labour] productivity.[23] These three factors are often referred to as the '3Ps' framework to help explain the impact of government policies on economic growth over the long-term.

In the context of economic growth, the key component of population is considered to be the number of people over the age of 15 who may be available to work.

Participation is made up of three elements: how many people choose to seek work (the workforce participation rate), how many of them can get jobs when they do seek work (the employment rate) and the average number of hours worked by individuals who have jobs. Improvements in participation happen as more people choose to look for work, more of them are able to find work, and they are able to work more hours.

Productivity is a measure of how much is produced, on average, for every hour that is worked. Productivity is considered the most important driver for long-term economic and income growth, and an important factor in a country's standard of living.

> **'Productivity isn't everything, but in the long run it is almost everything'[24]**
>
> - **Paul Krugman**

An increase in productivity by one percentage point a year will double average living standards in 70 years; a two percentage point rise will achieve this level in 35 years; and three percentage point rise in 23 years.[25] Productivity growth is therefore considered a key indicator of a country's overall prosperity and is commonly used to benchmark international economic performance.

Innovation is a key source of productivity growth

Innovation can increase productivity through more efficient services and production processes, more effective workplace organisation, and by opening up new markets. Businesses boost productivity by investing in problem-solving

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[23] The Treasury 2015, 2015 Intergeneration Report – Australia in 2055, The Treasury, Canberra.

[24] P Krugman, 1997, The Age of Diminishing Expectations, third edition, book, MIT Press, United States, pp. 11–28

[25] MN Baily, 2016, Policies to enhance Australia's growth: A U.S. perspective, The Brookings Institution, Washington, DC. viewed 23 September 2019.

capabilities, collaborating with customers, suppliers and competitors, adapting existing technologies and processes to new uses, and creating solutions to meet customers' needs.

According to the OECD, innovation in its various forms accounts for a substantial share of economic growth across its member countries – often around 50 percent of total GDP growth over the long-term.[26] Innovation has also been reported as being the only way for most developed countries to secure sustainable long run productivity growth.[27]

Innovation can drive productivity growth in a number of ways. Figure 1.1 shows how innovation activities can contribute to improvements in GDP. Changes over time in GDP per capita (productivity) are, at least over the long run, almost wholly accounted for by changes in GDP per hour worked; that is, by labour productivity and labour utilisation.

Labour productivity is defined as output per worker or per hour worked. Growth in labour productivity is comprised of two components: growth in capital inputs per worker (referred to as the contribution from 'capital deepening') and the contribution from multifactor productivity (MFP) growth.

Capital deepening reflects the increase in the ratio of capital to labour, and allows more to be produced in each hour worked. Capital services are comprised of physical capital formation, such as buildings, machinery, equipment and computers, and intangible capital such as R&D, computer software and databases, artistic creations, and business processes. Labour services are comprised of human capital (labour quality) elements, such as education attainment and experience of workers.

MFP is the residual that reflects pure productivity improvements, where changes in outputs cannot be explained by changes in inputs (labour and capital). It captures all other factors that influence outputs, including the efficiency in which the key inputs of labour and capital are used to produce goods and services.

It is reasonable to regard some share of capital deepening as attributable to innovation. For example, IP may be embodied in new equipment. In addition, the introduction of new capital goods and the use of new technologies can raise returns on investment, which encourages capital deepening.

Innovation also drives productivity growth by moving out the productivity frontier, or by enabling businesses to catch up to the productivity frontier. According to the OECD, higher R&D collaboration is associated with a faster catch-up process for laggard businesses very far from the national productivity frontier, and with businesses close to this frontier keeping pace with it.[28] Process improvements, such as marketing and organisational innovation, improve business level productivity. The development of new final product

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[26] OECD 2015, The Innovation Imperative: Contributing to Productivity, Growth and Well-Being, OECD Publishing, Paris, viewed 23 September 2019.

[27] N Bloom, J Van Reenen, & H Williams H 2019, 'A Toolkit of Policies to Promote Innovation', Journal of Economic Perspectives, vol. 33 (3): pp.163–84.

[28] Andrews, D., C. Criscuolo and P. N. Gal, "Frontier Firms, Technology Diffusion and Public Policy: Micro Evidence from OECD Countries", OECD Productivity Working Papers, 2015-02, OECD Publishing, Paris.

innovation can improve productivity if it improves quality, or if the new products can be produced with fewer resources. New intermediate inputs can directly raise productivity.

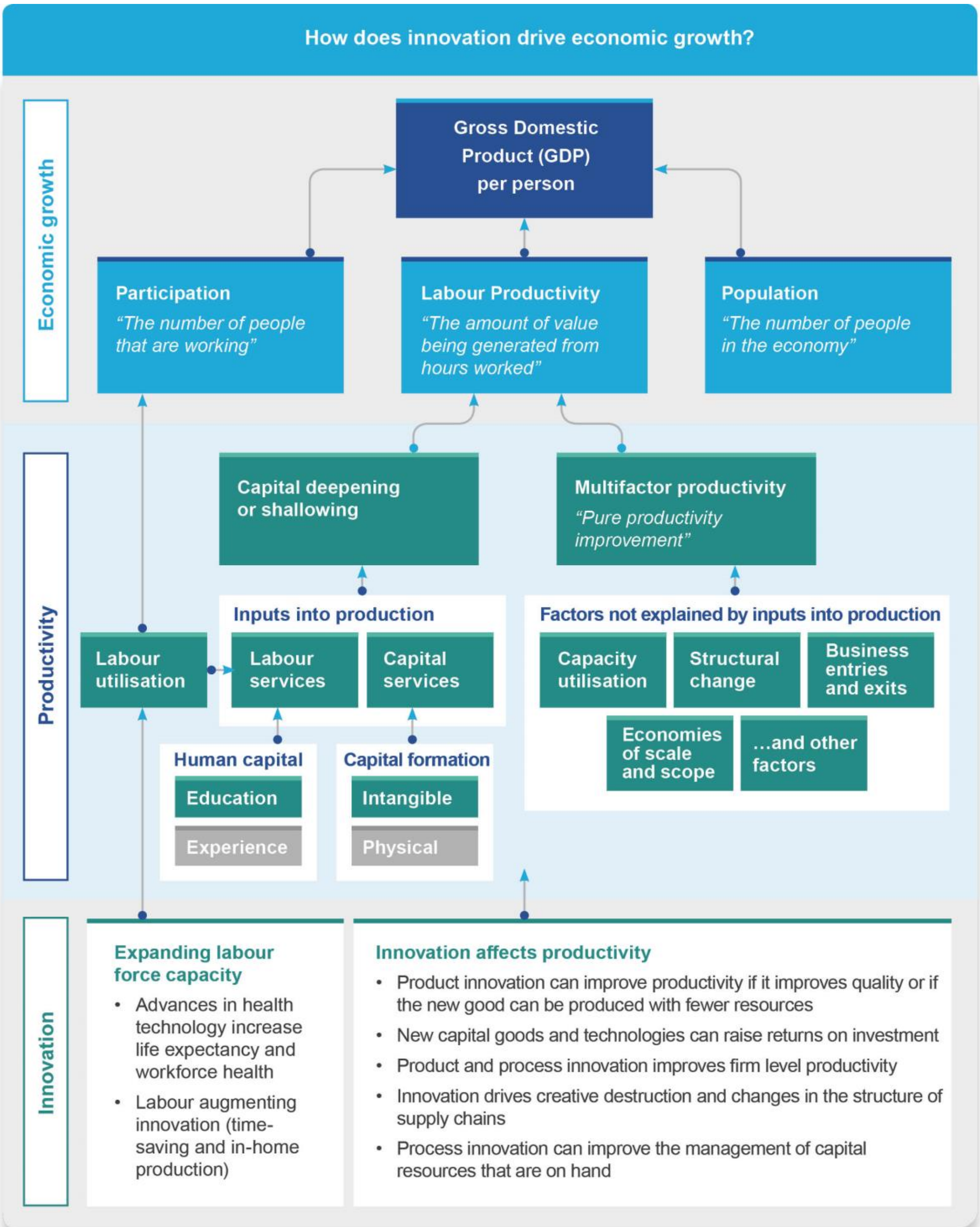
Innovation can also lead to new ways to correct market failures by reallocating resources from lagging to leading businesses. The OECD analysis found that leading businesses are not only more productive than laggard businesses but they are also more capital and patent-intensive, have larger sales and are more profitable.[29] Leading businesses can help markets to allocate resources to their best uses. Innovation can therefore also drive creative destruction and structural changes.

Labour utilisation is defined as the hours worked per person. An increase in hours worked per person means more goods and services can be produced.

Some growth in labour utilisation can be attributed to innovation through advances in health technology that result in increased life expectancy and workforce health. Technology advances also free up time from household tasks and allow more outsourcing of household tasks, facilitating increased formal labour supply.

[29] Ibid

Figure 1.1: How does innovation drive economic growth. Factors coloured green are influenced by innovation.



A conceptual framework for drivers of productivity growth

The Productivity Commission has outlined a framework (Productivity Growth Framework) for conceptualising the main drivers of productivity growth.[30,31]

The drivers or determinants of productivity growth comprise a mix of factors at the microeconomic level (business or individual), as well as broader macroeconomic conditions that reflect policy settings which can be affected by government. The Productivity Commission has identified the main drivers of productivity growth to include:

- *Immediate causes* (Business activities) that have close, tangible links to input/output relationships in production, often at the level of businesses or individuals. These are necessary to bring about productivity improvement but can be difficult to engender without policy changes at the macro level. Immediate causes of productivity change at the business level include:
  - Technological advances, such as better equipment that can enable better production techniques. Specialisation in production (economies of scale and scope) is also important in bringing about productivity improvements, for example, by allowing more efficient or new technologies to be adopted
  - Investment in physical and human capital, including knowledge-based capital, are seen as central and related in the development, application and refinement of innovation, which drives productivity improvements
  - Business organisational, management practices, and work arrangements, including organisational structures that enable collaboration, can be a major source of productivity improvement.
- *Underlying factors* (Business Environment) can have an indirect effect on productivity, as they can determine the extent to which the immediate causes of productivity growth come into play. These factors mainly include competition, openness of the economy to trade and investment, and demand and supply conditions. Appropriate levels of regulations are also an important factor. Regulations that are too burdensome can inhibit the adoption of different production methods and new technologies, whereas those that are too relaxed can fail to drive required changes. (In the finance and insurance services sector in particular, businesses reported a significant amount of innovation was being driven by regulatory charge.)
- *Fundamental influences* (National Environment) involve deeper policy, social and institutional factors that affect productivity in a very general and indirect fashion. They reflect the emphasis given by policymakers to different economic objectives that affect the development of productivity-enhancing capabilities, such as investment in education and infrastructure. The stability of policy settings through formal and informal institutions can affect the risks involved in making long-term investment decisions. Cultural and social factors also shape the orientation of people

[30] Productivity Commission 2017, 5 Year Productivity Review, Supporting Paper No. 1, Productivity and Income – The Australian Story, Productivity Commission, Canberra.

[31] Productivity Commission 2009, Australia's Productivity Performance: Submission to the House of Representatives Standing Committee on Economics, Productivity Commission, Canberra.

towards change that is required to achieve further development. For example, risk appetite of the community will affect the rates of technology adoption of things like autonomous cars, drones and artificial intelligence (AI).

> **‘Productivity is a major contributor to growth and prosperity over the long term’.[32]**
>
> - **Productivity Commission**

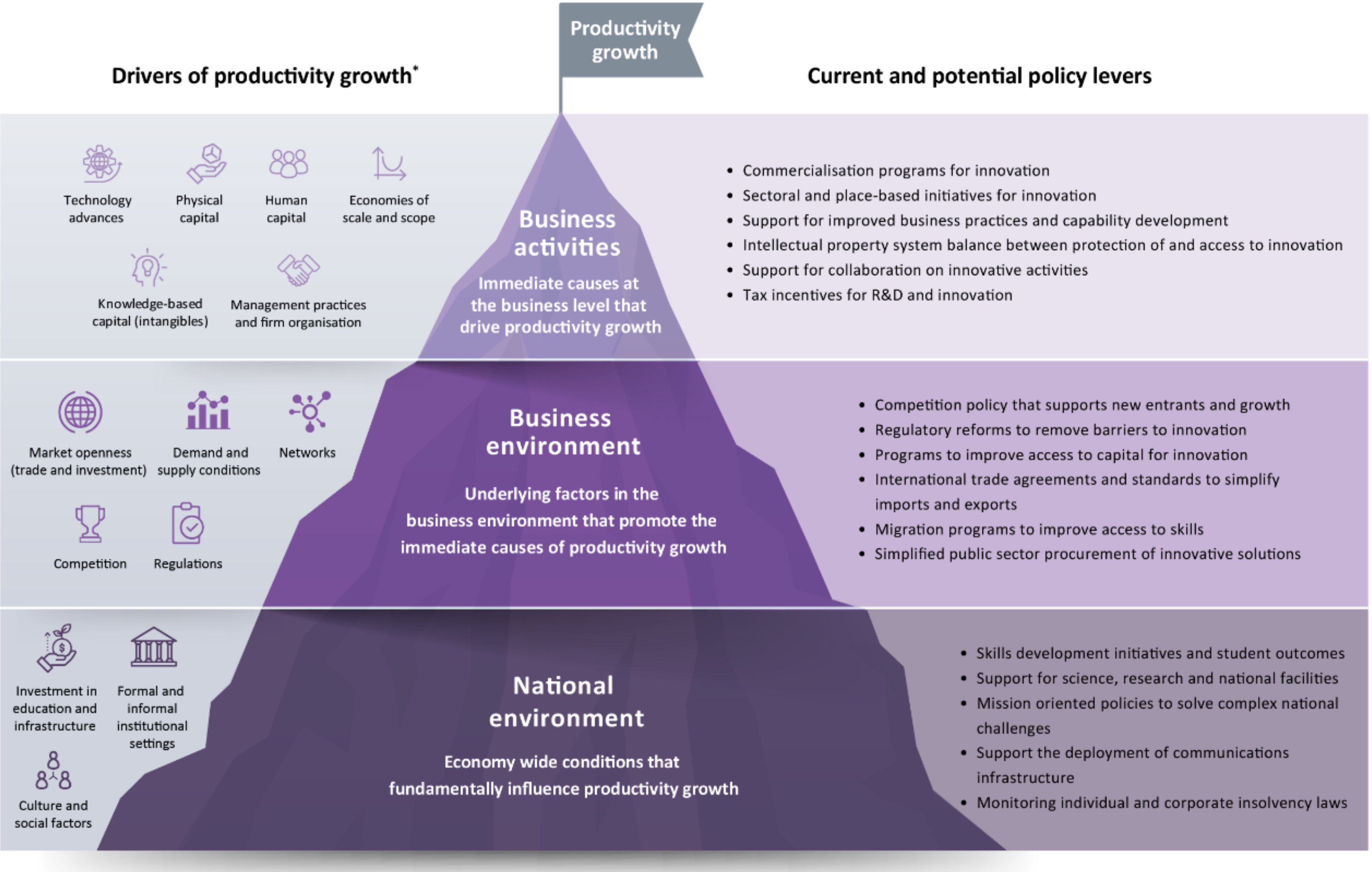
Policy levers that drive productivity growth through innovation

The Review has presented the Productivity Commission’s Productivity Growth Framework for the ‘drivers of productivity growth’ as a mountain (Figure 1.2) to illustrate how innovation feeds into productivity improvements at the economy level. The Review has also conceptualised the relevant ‘current and potential policy levers’ that can foster improvements in economic prosperity via the innovation system in Australia.

Below productivity growth are the ‘business activities’ that have close, tangible links to input and output relationships in production. The ‘business environment’ is the next layer down of the mountain, having indirect effects on productivity. Performance at this level can determine the extent to which the business activities of productivity growth come into play. The base of the mountain is the ‘national environment’ that involves deeper policy, social and institutional factors that affect productivity. This relationship is very general and has indirect influence on each of the layers above it.

[32] Productivity Commission 2009, Australia’s Productivity Performance: Submission to the House of Representatives Standing Committee on Economics, Productivity Commission, Canberra.

Figure 1.2: Productivity framework for innovation and policy levers to drive productivity growth through innovation



Notes: * 'Drivers of productivity growth' as per the Productivity Commission report (2009), Australia's Productivity Performance: Submission to the House of Representatives Standing Committee on Economics.

The Scorecard tracks key innovation metrics that drive productivity growth

This Review focuses on the economic impacts of innovation. The Review, guided by the Scorecard Expert Working Group, mapped innovation metrics to the 'drivers of productivity growth'. The Review adopted MPF growth rate as the ultimate measure of the impact of innovation due to its link with innovation. MFP growth rate is the growth in labour productivity not accounted for by capital deepening. It therefore represents improvement in the production process, or 'innovation', that is not an input into the production process.

It should be emphasised that measuring the environmental and social impacts of innovation are also high priorities – the Roadmap notes that further work is required in those areas to measure impact comprehensively.

The Scorecard (Figure 1.3) contains a handful of the most important indicators, based on the current data available, for monitoring innovation-driven productivity gains in the economy. The selected metrics for the Scorecard are also categorised as either innovation inputs or outputs to ensure impacts can be traced back to inputs in a method akin to evaluation using Program theory.[33]

However, the metrics represented in the Scorecard are inadequate, due to gaps in data. The Review has proposed a number of recommendations to develop new data sources and metrics, which should, in turn, provide opportunities to improve the metrics included in future scorecards. For example, the development of metrics for identified productivity drivers that are not represented in the current Scorecard. There are also instances where more suitable metrics would be appropriate but the data to support them is not currently available.

Definitions and descriptions of the innovation metrics used in the Scorecard and their sources are found in Appendix H.

For each metric, data for Australia and other OECD countries have been sourced and presented where available. The average result for the top five countries in each year was used to benchmark Australia's performance. The trend line shows Australia's performance over time, along with how it compares with the top five countries over the same period. For the latest available data, Australia's ranking amongst comparator countries has been compiled.

Australia's percentile rank has been calculated and colour coded to match this ranking. A green rating indicated that Australia is ranked in the first quartile (top 25 percent) of countries. A yellow rating shows that Australia's performance is in the second quartile (26–50 percent). A red rating shows that Australia is placed in the third or fourth quartile (51–100 percent) for performance.

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[33] SC Funnel & PJ Rogers, Purposeful Program Theory: Effective Use of Theories of Change and Logic Models, Jossey-Bass, San Francisco, 2011.

Figure 1.3: The Innovation Metrics Scorecard

Innovation Metrics Scorecard

Trend chart key:
- Average for top 5 countries (grey line)
- Australia (black line)

		Innovation metrics	Australia's latest score	Australia's trend	Average for top 5	Australia's ranking
Business activities	Inputs	1. Total expenditure on innovation by businesses, % of GDP (2017)	1.93	2010–2017	3.73	15 of 30
		2. Business expenditure on research and development (BERD), % of GDP (2017)	0.94	2000–2017	2.96	20 of 35
		3. Investment in knowledge-based capital (ICT, R&D and other intellectual property products), % of GDP (2017)	3.27	2000–2017	7.34	20 of 28
		4. Diffusion of selected ICT tools and activities in enterprises (cloud computing), % of all businesses with 10+ employees (2018)	60.1	2014–2018	57.8	2 of 26
		5. Businesses collaborating on innovation, % of all businesses with 10+ employees (2017)	12.6	2013–2017	31.4	23 of 35
	Outputs	6. Proportion of businesses with more than 25% of revenue from sales due to innovation, % of all businesses with 10+ employees (2017)	5.82	2015–2017	n/a	n/a
		7. High-growth enterprise rate based on sales growth, % of all businesses with 10+ employees (2016)	9.57	2008–2016	15.0	4 of 6
		8. Intellectual property rights filed overseas per billion GDP (constant 2010 US$) (2017)	37.1	2012–2017	140	26 of 37
Business environment	Inputs	9. Level of regulatory barriers to firm entry and competition — OECD Product Market Regulation (2018)	1.21	1998–2018	1.04	8 of 33
		10. Venture capital investment (funds invested in businesses), % of GDP (2018)	0.030	2006–2018	0.19	17 of 29
		11. Permanent migrants and non-student temporary entrants with higher education qualifications, % of the labour force (2016)	8.70	n/a	n/a	n/a
	Outputs	12. Birth rate of employing enterprises, % of business economy (2016)	11.8	2008–2016	17.4	10 of 27
National environment	Inputs	13. Total expenditure on educational institutions (primary to tertiary), % of GDP (2016)	5.82	2000–2016	6.23	8 of 36
		14. Gross expenditure on research and development (GERD), % of GDP (2017)	1.79	2000–2017	3.82	18 of 34
		15. Fixed broadband subscriptions per 100 inhabitants, by speed faster than 100 Mbps (2018)	1.88	2014–2018	25.5	30 of 34
	Outputs	16. Scores of students in mathematics — OECD PISA (2018)	491	2003–2018	522	24 of 35
		17. Quality-adjusted labour input (qualifications and experience), five year compound annual growth rate, % of total economy (2018)	0.65	2000–2018	0.88	5 of 36
		18. Proportion of population aged 25–34 with higher education, % (2018)	40.6	2014–2018	51.6	16 of 34
Impacts		19. Multifactor productivity change, five year compound annual growth rate, % (2017)	0.69	2000–2017	0.91	7 of 19

Australia's ranking key: First quartile (green) · Second quartile (yellow) · Third or fourth quartile (red)

Key insights from the Innovation Metrics Scorecard

Business innovation activities

In terms of innovation inputs made by business, Australia's performance has been in decline for the levels of business collaboration, investment in knowledge-based capital and expenditure on R&D. Of these metrics, Australia is ranked in the third or fourth quartile against comparator countries. Australia is ranked in the second quartile for total innovation expenditure which has stagnated. However, Australia is a leader in the business adoption of cloud computing, used here as a proxy for adoption of broader digital technologies tools.

Outputs of innovation for business are also stagnant. The proportion of businesses that have more than 25 percent revenue from sales is broadly steady, but the high growth enterprise rate and volume of IP rights filed overseas all rank Australia in the lower quartiles.

Business environment

Australia ranks in the top quartile for the levels of regulatory barriers that businesses operate in. This has flowed through to business entries where Australia ranks highly with consistent entry rates. However, Australian start-ups have access to relatively low amounts of venture capital (VC) in comparison to the rest of the OECD (see Figure 1.3, Scorecard metric 10).

National environment

Australia has a healthy mix of the foundational elements to support innovation. Australia ranks in the top quartile for educational investment. The level of investment has remained steady throughout the period. Despite this investment, the translation of this expenditure into educational outcomes is weak. The performance of students in mathematics – considered a key discipline for innovative capability – has been in gradual decline, with Australia recently ranked in the bottom quartile. Additionally, Australia's proportion of the population aged 25–34 with tertiary qualifications ranks in the second quartile of countries. In contrast, the quality adjusted labour input of Australians, which considers both the qualifications and experience of the workforce, is tracking well (top quartile).

However, there are issues to be addressed with infrastructure development for innovation where Australia ranks in the bottom quartile for the quality and quantity of broadband subscriptions in the population. There has also been a recent decline in investment in R&D by the economy as a whole (GERD). According to a recent analysis by AlphaBeta, the mining cycle and structural change in the Australian economy account for most of the decline in BERD, which is a significant proportion of GERD.[34]

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[34] Innovation and Science Australia 2019, Australian Business Investment in Innovation: levels, trends and drivers, a report prepared by AlphaBeta, Sydney. (forthcoming)

Productivity growth has been positive but subdued in recent times

Australia's performance in business activities is concerning, while the national environment and business environment for innovation show areas that need specific attention. There are many opportunities for improvement. Australia has experienced nearly a decade of slowed productivity growth, as measured through MFP change, from the year 2000. This trend has mirrored declines across the top comparator countries. Australia has since been able to arrest that decline, but recent MFP growth rates are well below the rates achieved in the period 1993–99.[35] Innovation-led productivity improvements will be key to ensuring continued long-term economic and income growth.

Box 1.1: Multifactor Productivity (MFP)

Measuring productivity

The measurement of productivity in itself, and particularly MFP, has three main measurement challenges:

1. Outputs in the non-market industries, such as public administration, education and health, are difficult to measure. Therefore, MFP is only based upon 16 market industries.
2. There is a lag in estimates because businesses struggle to adjust inputs to increases or decreases in demand. This results in reduced productivity in down years, and vice versa.
3. Some inputs, such as natural resources and intangible capital, are not measured well and may be excluded. This can distort MFP when there are changes in these inputs and outputs.

Source: Reserve Bank of Australia, 2019, Productivity, viewed 18 December 2019, <https://www.rba.gov.au/education/resources/explainers/productivity.html>

Future reviews and updates of the Scorecard will ensure it remains current and relevant

Given the dynamic and evolving nature of the innovation system and its components, and to take advantage of new sources of data, it is recommended that the Review's Scorecard be adopted and published online annually.

DIIS' *AIS Monitor* will continue to provide a comprehensive list of relevant innovation metrics for the Australian economy and should form the foundation for the development of the Scorecard moving forward. The *AIS Monitor* will focus on high-quality metrics from reputable sources with expert commentary and analysis. It also includes some exciting new features to improve the publication's utility, including interactive charts, downloadable datasets converted to a machine-readable format, and links to complementary analytical work.

[35] Productivity Commission, 2019, PC Productivity Bulletin, May 2019

This Review recommends that the Scorecard be periodically reviewed at intervals of around three years, commencing in the second half of 2022. The periodic review of the Scorecard should be conducted to:

- review the approach and methodology to reflect current priorities
- identify new data sources and metrics
- review and update the metrics as new sources of data becomes available.

RECOMMENDATION 1.1: INTRODUCE ANNUAL INNOVATION SYSTEM REPORTING

The Review recommends that an appropriate entity responsible for innovation measurement in Australia should produce an innovation metrics scorecard and provide a report to the Australian Government annually.

Every year the responsible entity should provide:

- a publicly available report on the performance of the innovation ecosystem in Australia
- an innovation metrics scorecard that measures progress domestically and benchmarks Australia's performance internationally.

The Scorecard developed by the Review should be adopted until improved innovation data becomes available (a minor update for some of the metrics will be needed in the second half of 2021).

Future periodic reviews should be undertaken from the second half of 2022, to inform the approach for developing an updated scorecard.

The following is a summary of scorecard metrics, relevant to the drivers of productivity, for future consideration by the entity responsible for innovation measurement.

Business activities

- Investigate the inclusion of an output metric on national frontier firms to understand the proportion of Australian businesses that are the most productive business in an international context (global frontier firms)
- Investigate the inclusion of an input metric relating to the management capabilities of businesses, such as the monitoring of key performance indicators and use of strategic planning in business decision making – this will depend upon whether underpinning data can be sourced at that time
- Investigate the inclusion of an input metric based on labour force skills, such as the proportion of the workforce that are innovation active, based on their occupation type – relevant work is currently being undertaken by the Department of Employment, Skills, Family and Small Business, but is yet to be completed

Business environment

- Investigate the inclusion of an input metric based on the government's procurement of innovation. As a major procurer of goods and services, this metric will show how the government is fostering innovative businesses. This metric will depend upon whether underpinning data can be sourced. The Review recommends action to ensure that it is sourced (in Chapter 2)
- Investigate the inclusion of an input metric based on innovation networks. 'Networks' is a very broad term. In this context, it is envisioned that networks be limited to a business's place in a supply chain, i.e. its suppliers, its customers, and related businesses that are co-located.

National environment

- When available, investigate the temporary substitution of the education output measurement from PISA to PIAAC to get a broader coverage of skills proficiency in the working age population. As PIAAC data are collected every 10 years, substitution between the metrics should be explored
- Investigate the adjustment of the input metric on broadband infrastructure subscription to address future technology developments in mobile and fixed broadband speed tiers.

2. Data and metrics for measuring innovation

Key points

- **Across the innovation system, data are used in policy and program formation and evaluation.**
- **There exists a variety of data sources but not all data are fit-for-purpose, particularly to inform policy decisions. Data quality is affected by the way in which data are collected and produced.**
- **The data landscape is evolving. Increased digitalisation is providing more opportunities to source innovation data.**
- **There are gaps in the information required to support analysis and understanding of the innovation system and to inform policy decisions. Key areas of data gaps include:**
  - **areas of the innovation system where the concepts and measures in place are fit-for-purpose, but there are gaps related to the frequency, granularity or availability of current data**
  - **areas where there is a sound conceptual basis for measurement, but measurement challenges impact data utility**
  - **areas where there are conceptual and measurement challenges.**
- **Many of the information gaps and emerging data needs highlighted by the Review are not unique to Australia.**
- **Addressing the information gaps and emerging data needs will require statistical, analytical and research solutions to be investigated and developed.**
- **Non-government data and new big data analytic techniques represent emerging opportunities to understand Australia's innovation landscape and to improve measurement of its performance.**

How data and metrics are used

A large amount of data and metrics exists across the innovation system that is relevant to innovation measurement and is heavily used in policy and program development, implementation and evaluation. Similarly, there is a large amount of analysis occurring to support evaluation of the innovation system.

As shown in Figure 2.1, innovation-related metrics and underlying data sources support evidence-based decision making by:

- informing innovation policy – good quality data are essential for Government to inform innovation-relevant policy advice, program delivery, service implementation and decision-making

- assessing innovation system performance – metrics enable policymakers to assess innovation system performance (refer Chapter 1 for detail on scorecards). Benchmarking and assessing innovation performance over time, industries and sectors, regions and countries provides valuable insight into the effectiveness of policies and the identification of factors that contribute to desirable innovation outputs and outcomes
- facilitating innovation research and analysis – fit for purpose data sources and metrics across all relevant areas of the innovation system is necessary to address the needs of users. Innovation analysis and research identifies linkages across, within and between various innovation activities, and provide insights on enablers of innovation activities. The analysis of data also indicates whether those data are fit for purpose and what data are the most useful to inform policymaking. Analysis is discussed further in Chapter 3.

Figure 2.1: How innovation-related data sources support evidence-based decision making

Sources of data and metrics

Assessing fitness for purpose

Assessing data sources for their suitability is an important first step in determining key innovation metrics that matter for government decision making.

The Review developed a set of principles for metrics selection (Table i.2) to assess the fitness for purpose of existing innovation data sources and metrics in the context of their ability to inform policy, assess innovation performance and facilitate innovation analysis and research for the phenomena of interest.

Types of data sources

The types of data sources examined by the Review (Table 2.1) are classified as being ‘government’ or ‘non-government’, and ‘structured’ or ‘unstructured’. Survey data and administrative and transactional data are both structured, and are entered into relational databases for easier analysis. Unstructured data needs to be analysed using Big Data techniques (e.g. Facebook and Twitter data).

Table 2.1: Types of data

	Survey data (structured data)	Administrative and transactional data (structured data)	Unstructured data
Government data	Government survey data (e.g. ABS surveys, such as the Business Characteristics Survey, Research and Experimental Development Survey, and the Census)	Administration and transaction data (e.g. Australian Taxation Office and government programs data)	Government data not entered into a relational database (e.g. official emails)
Non-government data	Non-government survey data (e.g. that produced by Newspoll)	Private sector data (e.g. that produced by LinkedIn, Seek, Burning Glass and Xero) Commercial databases (e.g. Orbis and Clarivate)	Non-government data not entered into a relational database (e.g. web scraping data collected by Burning Glass and Faethm)

Structured Data

Survey instruments

Survey instruments have long been a tool for research, marketing and official statistics. They can be administered online, by paper form, phone or face-to-face.

Surveys are used to collect information in order to answer a question or make a decision. They are also used to put a value onto some indicator or measure. In general, they are used when there are no other data sources available that can produce the required information. Careful survey design is required to provide quality indicators. This includes determining the population of interest, designing a representative sample and collection vehicle (i.e. questionnaire) through to quality assuring and disseminating results. Their key limitation is that respondents must be willing and able to answer the questions asked for them to produce quality data.

Surveys measure one or more characteristics of a population. These characteristics may be measured by surveying all members of the population, or a sample of the population. A sample survey is a survey of a subset of the population.[36]

The Australian Government currently uses national questionnaire-based surveys to produce data on innovation. Information is provided by survey

[36] Australian Bureau of Statistics 2018, Basic Survey Design , Australian Bureau of Statistics, Canberra, viewed 21 November 2019, <https://www.abs.gov.au/websitedbs/D3310114.nsf/home/Basic+Survey+Design+-+Introduction>.

respondents via a questionnaire aimed at collecting a specific set of data from a particular group of respondents (e.g. people or businesses).

Assessment of advantages (✓) and disadvantages (✗) of surveys

Relevance	✓ Surveys can be tailored to find out particular information of interest that may not be available through other sources
Accuracy and validity	✓ Surveys can be used to collect data from a target population of interest, e.g. businesses, people, and provide high representativeness ✗ Surveys can return responses of varying quality. Quality can depend upon respondents' interpretation of the question, or the availability of information. Survey questions must be designed to accommodate all respondents within the population of interest.
Reliability and precision	✓ Due to high representativeness, surveys are able to provide statistically significant results ✓ Surveys may obtain a high response rate if administered by government, particularly by the ABS, whose surveys can be made mandatory ✗ Some surveys may obtain a low response rate for various reasons, e.g. difficulties in establishing contact with participants, or respondents not appreciating the value of contributing. This may result in low representativeness of the data
Timeliness	✗ Surveys take time to administer and process. This impacts on the timeliness of results
Coherence and comparability	✓ Surveys are able to use standardised concepts and definitions to deliver coherent and comparable results over time and between sectors, regions and countries
Accessibility and clarity	✓ Depending on who is administering the survey, results are usually accessible with supporting explanatory materials containing methodology
Cost	✗ Surveys impose a burden on respondents as well as on the collecting entity.

Administrative and transactional data

Administrative and transactional data are collected as a by-product of administrative processes or trade, usually during the delivery of a service.[37] Prominent examples of government administrative data sources relevant to innovation include tax, business registrations, education, government program and grant application records.

Administrative data are becoming increasingly important in providing information to Australian governments, as access is unlocked and data are integrated and analysed. However, the value of government administrative data collections is yet to be fully realised. Access to datasets is a key issue for many inside and outside of government, including universities and researchers.

[37] Australian Bureau of Statistics 2018, Administrative Data Research for the 2021 Census, viewed 21 November 2019 <https://www.abs.gov.au/websitedbs/D3310114.nsf/Home/2021+Census+Administrative+Data+Research>.

This is partly due to the complex web of regulation across government agencies, as highlighted by the Productivity Commission's Inquiry Report, *Data Availability and* Use (May, 2017).[38]

There are an increasing number of private sector organisations that are realising the potential value to government of their structured data collections, and many have approached government looking to commercialise or otherwise provide their data sources. For example, Clarivate Analytics has a long history of providing data products to government on a fee-for-service basis – Clarivate's Web of Science citation databases are used and linked with data in Orbis to produce data about research publications produced by businesses.

Other private sector organisations, such as LinkedIn, offer analyses for public good purposes to government pro-bono. Non-monetary incentives for private sector organisations entering into such agreements with government include building their profiles and social licences to operate.

[38] Productivity Commission 2017, Data Availability and Use, Productivity Commission Inquiry Report No.82, Productivity Commission, Canberra.

Box 2.1: Government administrative data has the potential to provide valuable information, but is often inaccessible

Government innovation programs could potentially provide valuable data on the innovation system. These data are often of high quality as they are associated with funding allocation. Additionally, because the data already exists and are owned by government, they could potentially be made available quickly at low cost. The data are usually not available online, even when their public accessibility is not restricted in other ways (e.g. by the *Privacy Act 1988*).

In early 2016, the Productivity Commission was tasked to undertake a benefit cost analysis of options for increasing the availability and improving the use of public and private sector data by individuals and organisations. The Productivity Commission identified a 'lack of trust by both data custodians and users in existing data access processes and protections, and numerous hurdles to sharing and releasing data are choking the use and value of Australia's data', and recommended 'the creation of a data sharing and release structure that indicates to all data custodians a strong and clear cultural shift towards better data use that can be dialled up for the sharing or release of higher-risk datasets.'[39;40]

The Australian Government subsequently published its response to the Productivity Commission Inquiry into *Data Availability and Use*, agreeing to the majority of the proposed reforms.[41]

At the time of publication of this Review, the Australian Government had initiated reforms to increase data access and use within government and also with trusted users outside of government, while improving data privacy and security with strengthened, consistent safeguards. The Australian Government has:

- established a National Data Commissioner to implement and oversee a simpler, more efficient data sharing and release framework
- introduced legislation to improve the sharing, use and reuse of public sector data while maintaining the strong security and privacy protections the community expects
- introduced a Consumer Data Right to allow consumers to share their transaction, usage and product data with service competitors and comparison services
- established a new National Data Advisory Council to advise the National Data Commissioner on ethical data use, technical best practice, and industry and international developments.

[39] Productivity Commission 2017, Data Availability and Use, Productivity Commission Inquiry Report No.82.

[40] Department of the Prime Minister and Cabinet 2018, New Australian Government Data Sharing and Release Legislation: Issues paper, Department of the Prime Minister and Cabinet, viewed 21 November 2019, <https://www.pmc.gov.au/sites/default/files/publications/australian-government-data-sharing-release-legislation_issues-paper.pdf>.

[41] Department of the Prime Minister and Cabinet, The Australian Government's response the Productivity Commission Data Availability and Use Inquiry, Department of the Prime Minister and

Assessment of advantages (✓) and disadvantages (×) of administrative and transactional data

Relevance	× Administrative and transactional data are often collected for a specific purpose that may not align with the needs of users
Timeliness	× The timeliness of administrative and transactional data is usually better than that for surveys, but can still vary considerably from near real-time to quite dated (e.g. tax records are typically submitted well after a reporting period has ended)
Accessibility and clarity	× Administrative and transaction datasets are not usually publicly accessible and are in general not available to all, even within the entity that collected them. Often, only the entity that collected them will have access to any metadata and there may not be any documented guidance to assist interpretation. × Private sector datasets are not generally accessible to government, though businesses may choose to make them available through Memoranda of Understanding, sometimes, but not always, for a fee. It is usually the analytical products that are made available, sometimes, but not always, for a fee. Client consent may be required before data are shared. The private sector organisation is dependent on their user agreement.
Accuracy and validity	× Administrative and transactional data are often collected for a specific purpose. Making data available for research is usually a secondary consideration. The data may need cleaning before it is useable and may not be fit for certain purposes. × Data may only be available for certain groups within a population, or coverage may be variable (such that data has low representativeness due to bias)
Reliability and precision	? The precision of datasets used to allocate public funding is often high, but that of others may vary × Administrative datasets may be unreliable over time. They are usually collected to support a specific program or group of programs. Data collection processes may change radically or cease in response to changes to the underpinning government program, causing a series break or sudden absence of data ✓ Can provide large sample size for analysis × Administrative data are usually only available for small groups within a population (i.e. service or grant recipients) and thus may not be representative of the population × Transactional data often reflects the customer base of the collecting entity and may not be representative of the population × Analyses are only as good as the data they are based on
Coherence and comparability	× As administrative and transactional data are by-products, collection procedures are likely to have been developed without reference to an internationally agreed measurement framework, definitions, concepts, classifications and target population may change over time following amendments to program criteria or changes to business objectives. Transaction data are usually only collected while a good or service is being provided, which may result in an incomplete time-series for analysis.
Costs	✓ There are no additional data collection costs as data has already been collected

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Cabinet, viewed 29 November 2019. < https://dataavailability.pmc.gov.au/sites/default/files/govt-response-pc-dau-inquiry.pdf>.

Unstructured data

The data landscape is changing. Digitalisation and the internet has opened up new sources of data and novel ways of extracting this data. Unstructured data sources are increasingly being utilised for a variety of purposes, including the production of official statistics.

Big Data

'Big Data is commonly understood as the use of large scale computing power and technologically advanced software in order to collect, process and analyse data characterised by large volume, velocity, variety and value.'[42]

Interest in using Big Data has been largely driven by the rise of web-based platforms, digital technologies and increasing data storage capacity. These factors have hugely expanded the sources of available data and the variety of information that can be collected. Big Data can enable entities to learn about client age, gender, location, household composition, demographic profile, dietary habits, and even their personal biometrics.[43]

There are many organisations that provide Big Data analytics for a fee. For example, The Conversation is an international media organisation that provides a platform for scholarly communication that enables researchers to engage a global public audience with operations around the globe. Their unique database of researchers, readers, and media content enables production of new types of research engagement metrics, including media-influence metrics, and post-publication engagement metrics.

Public-private partnerships are also becoming more common, such as in Denmark, with the pioneering Danish Centre for Big Data Analytics Driven Innovation, launched by the Innovation Fund Denmark. This example of public-private partnership involves the computer science departments of three major universities, several IT companies with Big Data competencies, and public authorities.[44]

The *2017 Tracking Trends in Industry Demand for Australia's Advanced Research Workforce report* – a DIIS-funded collaboration between the Australian National University, CSIRO's Data61 and SEEK – is an Australian example of a public-private partnership.[45] This project involved the use of machine learning and natural language processing to analyse job

[42] OECD 2017, Big Data: Bringing Competition Policy to the Digital Era, OECD Publishing, Paris, viewed 21 November 2019, <https://www.oecd.org/competition/big-data-bringing-competition-policy-to-the-digital-era.htm>.

[43] ibid.

[44] S Planes-Satorra, & C Paunov, 'The digital innovation policy landscape in 2019', OECD Science, Technology and Industry Policy Papers, No. 71, 2019.

[45] I Mewburn, H Suominen, & W Grant, Tracking trends in industry demand for Australia's advanced research workforce, Australian National University, 2017, viewed 22 November 2019.

advertisements in order to better understand Australian industry demand for highly skilled researchers.[46]

Web scraping and text mining

Web scraping is the term used for extracting or downloading data from websites. Web scraping tools are required to perform these functions.

> 'Web mining, the application of data mining techniques to uncover relevant data characteristics and relationships (e.g. data patterns, trends, correlations) from unstructured web data, has been shown to be applicable in many fields of research'.[47]

Web scraping is also affected by the way websites are coded. Some businesses are increasingly designing their websites in a manner which makes web scraping harder.

The internet and increased data storage capacity have also given rise to large volumes of qualitative data. Text mining can be used to quantify this data. Text mining is a methodology that uses natural language-processing tools to automate the processing of text data (e.g. from responses to open-ended survey questions, large qualitative datasets and social media posts) into quantifiable data.[48]

The University of New England (UNE) has a particular interest in understanding agricultural technology innovation using text mining. The UNE work involves looking at keywords (by year and frequency) within patent datasets to reveal major players that UNE might consider partnering with. Thus it can help UNE to align its own research capability with emerging areas in industry, both domestically and overseas.

Assessment of advantages (✓) and disadvantages (✗) of unstructured data

Relevance	✓ May be able to provide new insights and illuminate parts of the innovation ecosystem where the government is currently lacking data to inform policy decisions
Reliability and precision	✓ A large amount of data are available, providing coverage of a wide range of issues ✗ Noise to signal ratio may be very high
Accuracy and validity	✗ Data quality, particularly representativeness of the data, may limit its use
Timeliness	✓ Data can be analysed in close to real-time data, allowing timely program and policy evaluation

[46] I Mewburn, H Suominen, & W Grant, Tracking trends in industry demand for Australia's advanced research workforce.

[47] J Kinne & J Axenbeck, Web mining of firm websites: A framework for web scraping and a Pilot study for Germany, Discussion Paper No. 18–033, 2018.

[48] OECD 2018, OECD Science, Technology and Innovation Outlook 2018, OECD Publishing, Paris, viewed 21 November 2019.

Coherence and comparability	× Data may not necessarily be logically connected, or consistent over time or across sectors, regions or countries
Accessibility and clarity	× Businesses do not usually put all their data into the public domain × There may be privacy and security concerns that limit data accessibility or cause data to become inaccessible over time.
Cost	✓ Data are already being collected, so there are no additional collection costs

Sources of data and metrics currently available

Appendix I provides a summary of the key innovation-related sources of data and metrics currently being used by Government, highlighting where there are opportunities to make changes to increase existing utility.

There are gaps in the measurement of innovation

To facilitate evidence-based decision making, users need innovation data sources and metrics to inform them about all relevant areas of the innovation system.

The Review's Framework (described in the Review Process and Methodology) was used to assess the coverage of measurement of the innovation system by identifying:

- activities occurring within the framework that should be measured
- the current state of measurement for these activities
- gaps in the current measurement that lead to innovation activity being underestimated
- deficiencies in the current measurement and how they might be addressed.

The mapping of metrics to the Framework identified gaps in the information required to support analysis and understanding of the innovation system and to inform policy decisions.

The literature review of innovation measurement undertaken by ATSE identified a clear demand for a range of new or improved innovation indicators. ATSE notes there are several reasons for the gaps observed in available innovation indicators including:

- the need for a better evidence base to support new policy issues and decisions
- existing indicators failing to keep up with new understanding about the nature of innovation
- the contribution that new indicators can make to improved learning
- the lack of coordination between actors involved in the innovation ecosystem.

The literature review also identified indicator gaps around innovation outputs and impacts, knowledge generation and flows, technological opportunity, entrepreneurship and capability (see Table 10 in Appendix E of the literature review). There are also gaps around the role of demand, culture and support measures. Specific gaps in Australian innovation indicators also arise from issues such as Australia's reliance on mining and agriculture, and the absence of large technology businesses.

Box 2.3: Global Innovation Index 2019 gaps

In line with the findings of this Review, the importance of quality data that underpins innovation metrics was highlighted in the 2019 edition of the GII. Globally there have been improvements in innovation metrics, however, there are still gains to be made in areas such as the state of entrepreneurship, the availability of VC, the nature of innovation linkages and the commercialisation of innovation.[49]

WIPO noted the steps that economies, including Australia, through this Review are making to improve the measurement of innovation. WIPO is active in helping policy and statistical offices monitor the state of innovation metrics through the provision of economy profiles. WIPO has highlighted Australian innovation data gaps that directly affect metrics of the GII. Due to the importance of internationally recognised innovation measurement frameworks, weight has been given to these findings, and they in turn have been utilised to inform the Review's own findings.

The Review notes that Australian GII gaps have primarily centred on the availability of timely R&D data, and has informed the Review's own finding on the state of R&D data. Other noteworthy gaps relate to apparent miscommunication of data availability. This gap serves to illustrate the need for better coordination on innovation data sources to ensure the most up to date innovation data are published or available.

The Review has identified various information gaps that can be grouped as follows:

- **Areas of the innovation system where concepts and measures in place are fit for purpose, but where there are gaps related to the frequency or availability of current data**

These are areas of the innovation system where there are opportunities to improve the utility of current data. Policymakers have some level of information to aid with evidence-based decision making, but the utility of current data could be improved if it were produced more frequently, i.e. for timelier data, or presented in a different way.

- **Areas where there are sound conceptual grounds for measurement, but where measurement challenges reduce data utility**

These are areas of the innovation system where work has been done, either domestically or internationally, to develop conceptual frameworks for

[49] Cornell INSEAD WIPO 2019, Global Innovation Index 2019 Report, Cornell INSEAD WIPO, pp. 13, viewed 11 November 2019.

measurement. However, there are measurement challenges recognised domestically or internationally that negatively impact data quality.

- **Areas where there are conceptual and measurement challenges**

These are areas of the innovation system that require significant work to be undertaken to define and develop conceptual frameworks and also address complex measurement issues, before meaningful indicators or metrics can be developed. For the most part, these conceptual and measurement issues are not limited to the Australian context and are acknowledged internationally as problematic. Policymakers have very limited or no information to aid with evidence-based decision making.

Gaps where the concepts and measures are in place and fit for purpose, but data needs are not being met

Measures of Expenditure on Research and Experimental Development

Why this is important

More than one-third of the Australian Government's $9.6 billion support for science, research and innovation in 2018–19 occurred through the R&D Tax Incentive (RDTI) program. Measures of BERD allow the Government to assess the effectiveness of the RDTI program.

Expenditure data on R&D across all sectors of the economy (GERD) and businesses (BERD) are commonly used by governments and international organisations as metrics to compare countries' innovation systems. This data allows Government to:

- inform policy briefings and analysis
- adjust policies and programs in response to trends in innovation and R&D
- undertake and evaluate new policy development.

What information do policymakers need?

Access to annual indicators of total expenditure on R&D across all sectors (GERD) and businesses (BERD) would allow policymakers to be responsive in adjusting policies and programs related to R&D in a timely manner.

In addition, more granular information on the Field of Research (FoR) and Socioeconomic Objective (SEO), would enable policy analysts to align the strategic research priorities of the publicly funded research sector with business direction and track research and innovation in sectors that are considered strategic priorities for the country.

Collecting BERD data annually would enable the ABS to model GERD data annually.

Current state of play

Australian data on R&D expenditure is collected and published every two years on asynchronous collection between sectors (business, higher education, government and private non-profit institutions (NPIs). Internationally, most NSOs collect and publish annual R&D expenditure statistics across all sectors.

In addition, the time lag between the reporting reference period and publication of some R&D estimates for business (BERD) and higher education expenditure on research and development (HERD) is currently 15 months. Under current circumstances, policymakers may have to make decisions based on data that is up to four years old.

Future outcomes sought

Based on consultation with users of R&D expenditure information, the Review recommends changes that will allow policymakers to access timely indicators of R&D expenditure. Specifically, the Review recommends that the ABS' Survey of Research and Experimental Expenditure:

- is administered annually
- uses a sample size that enables FoR and Socio-Economic Objective data to be published at the four digit level (the second level of the Australian and New Zealand Standard Research Classification hierarchy, providing more granularity in relation to field and purpose of research)

RECOMMENDATION 2.1: IMPROVE MEASURES OF EXPENDITURE ON R&D

The ABS should produce annual indicators of Gross Expenditure on Research and Development (GERD) and Businesses Expenditure on Research and Development (BERD), including estimates of R&D expenditure at a more granular level than is currently available.

Measuring business use of digital technologies

Why this is important

The ongoing diffusion of new digital technologies across the economy is one of the key enablers of business innovation. However, measurement tools do not sufficiently capture the extent of their adoption, use, benefits, or role they play in innovation. Emerging technologies include a selection of digital technology tools that are considered important for innovation, such as AI, the Internet of Things, global positioning technology, Big Data analytics, robotics and 3D-printing.

Additionally, digital infrastructure that is currently well measured is evolving, and adjustments that reflect demand are needed, e.g. measurement of the quality of mobile broadband technologies and fixed broadband infrastructure.

What information do policymakers need?

Access to timely, high-quality and reliable statistics that reflect the contemporary and dynamic nature of the role digital technologies plays in innovation to inform decision making by government, industry and individuals.

Measures that capture the extent and impacts of business adoption and use of digital technologies.

Current state of play

Current ABS survey content related to business digital technologies usage covers a limited scope of digital technologies. There is opportunity to review and update the content to reflect technological advancements.

Internationally, a significant amount of work is being progressed to develop measures that provide policy guidance and analysis related to digital activities, such as the OECD's *Going Digital* project.[50] There may be scope for Australia to leverage off this work to improve current scope and measurement of digital activities.

New sources of data, such as from web scraping, data integration, use of Big Data analytics, and data from the private sector, may have potential to improve the frequency and quality of data available on business adoption and the use of digital technology.

Future outcomes sought

The Review recommends that the Australian Government:

- update current measures of business usage of digital technologies to reflect new digital technologies used
- work collaboratively with international organisations to contribute to the body of knowledge related to digital activity and develop measures that are internationally comparable
- develop measures to quantify the lag between a new technology becoming available and being adopted – an indication of how fast Australia is adopting new technologies.

RECOMMENDATION 2.2: IMPROVE MEASURES OF BUSINESS USE OF DIGITAL TECHNOLOGIES

The ABS should update current survey content related to business use of digital technologies to reflect new technological advancements, and measure the extent of technology diffusion and its impact on business performance

The ABS should also leverage work being done internationally that measures the link between the diffusion of these new technologies and their impact on innovation

The responsible entity should investigate the feasibility of accessing and using alternative sources of data (e.g. Big Data analytics, administrative and transactional data) to provide new and complementary indicators of the extent of business adoption and use of digital technologies.

Gaps where there is a sound conceptual basis for measurement but measurement challenges impact data utility

International comparability of business innovation indicators

Why this is important

Australia currently contributes data to two key OECD publications that compare a range of business innovation indicators across countries and across time – the STI Scoreboard and the MSTI.

[50] OECD 2019, OECD Going Digital, OECD, Paris/Eurostat, Luxembourg. 2018, < https://www.oecd.org/going-digital/>.

Indicators of innovation in Australian businesses are important to researchers and policymakers in building an understanding of the drivers and impacts of innovation and understanding how Australian rates of innovation compare internationally.

What information do policymakers need?

Policymakers need to be able to make meaningful comparisons of Australian and international estimates of business innovation to evaluate Australia's relative innovation performance.

Current state of play

Australia collects business innovation indicators through the ABS' BCS. The BCS collects core indicators of innovation annually, with more detailed content on innovation collected every two years.

Australian and international measures of business innovation activities are developed using statistical concepts and underlying methodology defined by the Oslo Manual.[51] However, direct comparisons between Australia and other countries are difficult to undertake because of a number of factors, including different reference periods, scope, response rates, and survey frequency.

Methodological challenges related to international comparisons have been highlighted in work by the ABS.[52] The ABS developed an experimental methodology that used BCS data collected for a single reference year to estimate the proportion of Australian businesses that were innovation-active over a three-year reference period. This work was valuable but was not able to address all survey differences and provide directly comparable indicators.

The most notable difference is that Australian business innovation data are currently collected using a single financial year reference period, whilst innovation surveys in most other countries use a two or three-year reference period. This makes it difficult to compare international scorecards and rankings in a meaningful way, as the results presented are not like-for-like. If all else is equal, countries with longer reference periods are more likely to have higher rankings than those with shorter ones.

A one-year reference period, however, may also not be an ideal timeframe for measurement of innovative activities, i.e. in the 2016–17 reference year, approximately 25 percent of businesses reported that it was too early to measure the benefits of introduced innovation. This finding was confirmed in consultations undertaken to inform the Review's sectoral case studies – only the finance and insurance services sector was generally able to measure impacts of an innovation in a one-year period.

However, moving to a three-year reference period, as used by most countries at present, is also not ideal. A –longer time period time impacts on respondents' ability to recall and provide quality information. This was evident in cognitive testing conducted by the ABS and Statistics Canada during the Review's consultation process.

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[51] OECD/Eurostat, Oslo Manual 2018.

[52] Australian Bureau of Statistics 2017, Research Paper: Experimental Estimates of a Multi-Year Innovation Rate, cat. No. 8158.0.55.003.

The OECD has indicated that the use of a common observation period would considerably improve international comparability.[53] The Review supports the OECD's position. The Review notes that Statistics New Zealand (Stats NZ) currently has a two-year reference period, and its Business Operations Survey is administered two yearly, and Statistics Canada is also considering moving its Survey of Innovation and Business Strategy from a three to a two-year reference period.

In addition to the differences in reference period used, most international business innovation surveys are standalone innovation collections, whereas Australia collects business innovation indicators through the BCS – a large omnibus collection. Other topics collected on the survey relate to business characteristics and business use of information technology (BUIT).

A number of potential benefits have been identified with moving innovation survey content from a larger omnibus collection to a standalone innovation survey. These include:

- increased opportunity to change or add innovation question content in response to policy needs. The current length of the BCS limits the scope to make changes due to the anticipated effect on respondent burden and response rate
- increasing opportunity to produce more detailed outputs related to innovation and BUIT, and the relationships between them
- increased harmonisation of innovation survey methodology between Australia and the rest of the world
- over the life of the BCS, the innovation estimates have been described as having a 'saw-tooth pattern'. This pattern is shown in Figure 2.2. Historical results show that in a BUIT-focused year, a greater proportion of businesses report being innovation-active compared to an innovation-focused year, where they are required to answer questions about the drivers, barriers and costs of innovation. By introducing a standalone innovation survey, the collection instrument will no longer be a potential driver of change in innovation estimates.

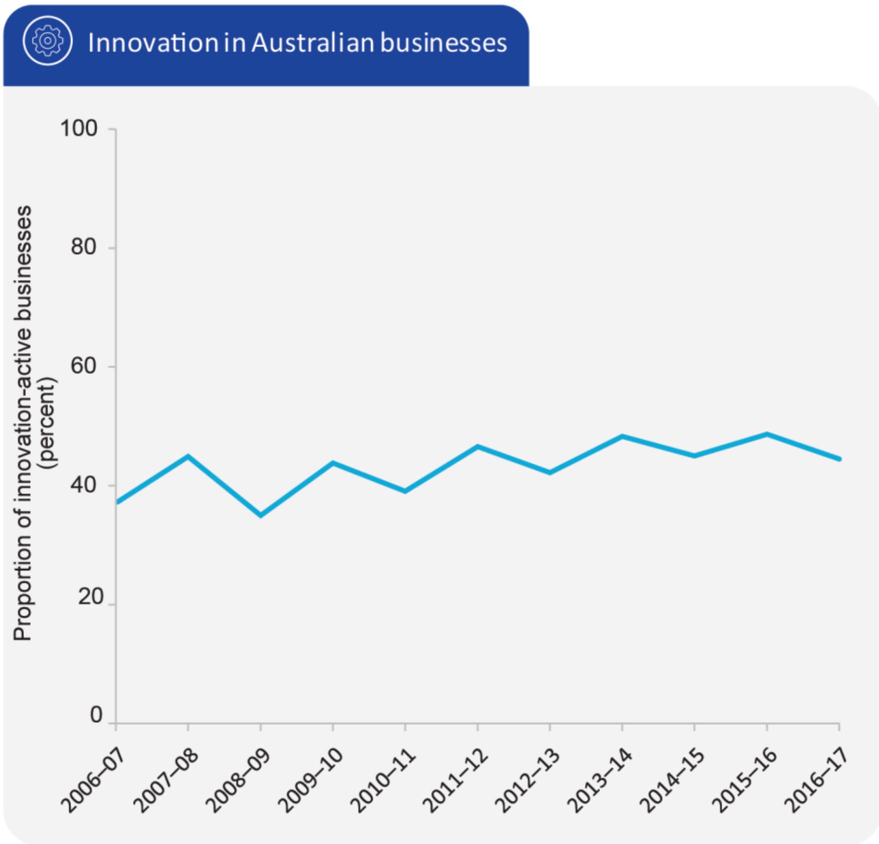
Future outcomes sought

The Review recommends a standalone Australian innovation collection, administered every two years using a two-year reference period, alternating with a two-yearly standalone business use of digital technologies survey, would be preferable to the current annual BCS. These changes would lead to:

- increased harmonisation of business innovation measures internationally
- more meaningful international comparisons of business innovation indicators
- more detailed outputs related to innovation and business use of digital technologies and the relationships between them
- more flexibility to change or add innovation question content in response to policy needs.

[53] OECD/Eurostat, Oslo Manual 2018,

Figure 2.2: Innovation activity in Australian businesses, 2006–07 to 2016–17



Source: ABS 8166.0 Summary of IT use and Innovation, <http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8166.0>

RECOMMENDATION 2.3: IMPROVE MEASURES OF BUSINESS INNOVATION ACTIVITIES

The ABS should review the collection of business innovation data and make sure it aligns better with that of other countries so that direct comparisons can be made.

The ABS should ensure any changes made continue to meet the needs of other users of the data and are useful in the context of the Australian economy. In particular the ABS should:

- introduce a standalone Australian business innovation survey, administered every two years using a two-year reference period, to enable more meaningful international comparisons to be made. This survey would be mandatory, as is the practice with other ABS business surveys.

Expenditure on non-R&D innovation

Why this is important

There has been increasing demand to have meaningful measures of business innovation-related expenditure that go beyond expenditure on R&D.

Measures of innovation have focused largely on expenditure on R&D. However, the Review's sectoral case studies reveal that R&D accounts for only a proportion of 'all innovation-related activities'.

The level of expenditure on 'all innovation-related activities' by businesses provides useful information to policymakers on the scale of investment that businesses are making into innovation and the types of activities they are investing in. This information provides an evidence base for policymakers to determine whether or where interventions are needed.

If non-R&D innovation investment can be better quantified, it will assist with informing decision for policymakers.

What information do policymakers need?
Indicators of business expenditure on innovation, including and excluding BERD.

Information to support policy analysts to determine the relative importance of investments in various innovation activities, for example, R&D vs non-R&D investment.

Current state of play
While the Oslo Manual[54] provides a clear framework for the measurement of innovation expenditure, collecting relevant information from businesses is problematic because innovation activities are not a line accounting item and therefore are not easily separated from other business activities.

In Australia, estimates (in expenditure ranges) of innovation expenditure that are collected through the BCS are of limited utility – collecting data that would support the production of a value estimate instead of a range would be preferable from a user perspective.

Future outcomes sought
Provide policymakers with an improved evidence base for understanding business expenditure on innovation-related activities.

RECOMMENDATION 2.3: IMPROVE MEASURES OF BUSINESS INNOVATION ACTIVITIES

The ABS should review the collection of business innovation data and make sure it aligns better with that of other countries so that direct comparisons can be made.

The ABS should ensure any changes made continue to meet the needs of other users of the data and are useful in the context of the Australian economy. In particular the ABS should:

- investigate ways to increase the utility and meaningful measurement and analysis of total business innovation expenditure.

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[54] OECD/Eurostat, Oslo Manual 2018.

Collaboration

Why this is important
Networking and collaboration are fundamental to any innovation system as businesses rarely innovate in isolation. With innovation recognised as a complex and uncertain activity, collaboration allows businesses to share risk, resources and ideas for innovation. These arrangements can allow businesses to increase the scale and scope of their activities and speed up the innovation process.

There is a strong government policy focus on business collaboration for the purpose of innovation, particularly with universities and higher education institutes, government agencies, and other research bodies.

What information do policymakers need?
Policymakers need to understand the extent to which businesses are collaborating with each other and other entities for the purpose of innovation, including the types of collaborative arrangements used and the collaboration partners.

Current state of play
The Review notes that in 2018 the OECD clarified its guidance regarding the definition of collaboration. The ‘collaboration’ indicator published by the OECD in the STI Scoreboard for Australia is of concern to a number of stakeholders who have expressed that Australia’s relative ranking with other OECD members does not reflect their experiences.

Current indicators of business collaboration for the purpose of innovation (collected through the BCS) exclude fee-for-service arrangements. This is in accordance with the international framework and definitions.[55] The Review’s sectoral case studies found evidence that arrangements with some collaborative characteristics such as risk and IP sharing were either conducted predominantly on a fee-for-service basis, or else remained entirely informal, with no contractual arrangements in place. Examination of this issue is needed to determine if this is a minor or significant issue in the Australian context. Such arrangements should be reported separately, so that Australia is still able to report in accordance with the Oslo Manual.

Future outcomes sought

Provide policymakers with a more complete picture of the extent to which businesses are working together for the purpose of innovation, including the types of arrangements used and their partners.

[55] OECD/Eurostat, Oslo Manual 2018.

RECOMMENDATION 2.3: IMPROVE MEASURES OF BUSINESS INNOVATION ACTIVITIES

The ABS should review the collection of business innovation data and make sure it aligns better with that of other countries so that direct comparisons can be made.

The ABS should ensure any changes made continue to meet the needs of other users of the data and are useful in the context of the Australian economy. In particular the ABS should:

- investigate the feasibility of developing broader measures of how businesses work together for the purpose of innovation, including fee-for-service arrangements.

Understanding business innovation measures in the context of economic contribution

Why this is important
There is interest in understanding businesses innovation activities in the context of the relative reach or impact of those activities on the broader economy. Since a larger business is likely to have a larger economic contribution relative to a smaller business, it would be useful for policy makers to have an understanding of innovation activities in the context of the size of the businesses undertaking them. A recent study on external benefits of R&D shows that the average business in the whole economy benefits more from external R&D from large businesses than from SMEs or very large businesses.[56]

What information do policymakers need?
Policymakers need measures that complement existing indicators and enable policymakers to understand business innovation activities in the context of the relative economic contribution of business undertaking these activities.

Current state of play
Current measures of business innovation activities used internationally use the business as a unit of measurement in the production of aggregate estimates of innovation activity.

Aggregate estimates of innovative activity in business are therefore provided as a proportion of all businesses, which allows policymakers to understand the extent to which businesses are engaging in innovative activities, but not in the context of the relative economic contribution of the businesses engaged in the activities.

Existing indicators may be complemented with business innovation measures that use employment size or turnover as a proxy to weight businesses based on their likely economic contribution.

[56] A Balaguer, A Parangkaraya, T Talgawatta, E Webster, 2019. R&D external benefits in Australian Industries, Department of Industry, Innovation and Science, 2019. (forthcoming).

This would provide a more comprehensive picture of innovative activities in Australian businesses, enabling policymakers to understand business innovation activities better in the context of the relative economic contribution of innovation-active businesses.

RECOMMENDATION 2.3: IMPROVE MEASURES OF BUSINESS INNOVATION ACTIVITIES

The ABS should review the collection of business innovation data and make sure it aligns better with that of other countries so that direct comparisons can be made.

The ABS should ensure any changes made continue to meet the needs of other users of the data and are useful in the context of the Australian economy. In particular the ABS should:

- provide a more complete picture of the impacts of innovation activities occurring in Australian businesses.

Hidden innovation

Why this is important

The term 'hidden innovation' is used to refer to types of innovation or innovation activity that are not visible through innovation indicators.

The complex nature of the innovation system and activities that occur within it pose significant challenges for measurement. A number of factors make it difficult to achieve complete coverage of the activities occurring, including:

- the innovation system is extremely complex and activities are diverse
- innovation activities occur in different ways across different parts of the economy
- some aspects of the innovation system are difficult to measure, both conceptually and statistically, and in a way that is useful for government policy and program development.

What information do policymakers need?

An innovation measurement framework that provide comprehensive coverage of the diverse innovation activities occurring across different sectors of the Australian economy.

Current state of play

The concept of innovation covered in the Oslo Manual[57] definition is very broad. Businesses can apply their own lens to questions asked in surveys, which can result in the information collected being different from the information that the survey question was designed to collect.

Interviews conducted as part of the Review's sectoral case studies found that ABS R&D survey data are very reliable. However, the interviews indicated systemic under reporting of all non-R&D innovation activities, particularly with regard to continuous improvement. The R&D and non-R&D components of innovation expenditure were reported in 2017-18 and 2016-17 respectively as

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[57] OECD/Eurostat, Oslo Manual 2018.

being similar in size. It is thus possible that expenditure on non-R&D innovation activity may be more significant in size than expenditure on R&D innovation activity. AlphaBeta notes that nationally, more businesses engage in non-R&D innovation expenditure than R&D innovation expenditure.[58]

Apart from continuous improvement, which was under reported in the four sectors examined, the nature of under reporting varied by sector. This may be because businesses consider the continuous improvement activities as business as usual and not as "new or significantly improved" products or processes. For example, in mining, de-risking activity was generally not reported as innovation, whereas in agriculture, extension was generally not reported as innovation.

Experimentation may be required to improve measurement of non-R&D innovation activities. Differences between sectors make it challenging to capture everything in a whole of economy survey. The Review notes that there has been a lot of research to highlight hidden innovation but relatively little on developing appropriate solutions.

Future outcomes sought

- A comprehensive innovation measurement framework that provides comprehensive coverage of the innovation activities occurring, including better data on cost savings, economic benefits and productivity improvements resulting from innovation
- Contribute to the international body of knowledge related to innovation measurement.

RECOMMENDATION 2.4: CONDUCT AN ANNUAL SECTORAL ANALYSIS

The responsible entity should commission an annual large-scale sectoral study to develop a better understanding of the nature of innovation in those sectors that are important to the Australian economy. This study should:

- draw comparisons with a selection of countries that are relevant to the sector being analysed (e.g. for the mining sector, comparator countries should include those with major mining activity)
- start with a sector that is important to the Australian economy and rotate annually to a different sector.

Existing occupation classifications do not reflect current practice

Why this is important

The ANZSCO is a joint product of the ABS and Stats NZ, and provides the basis for the standardised collection, analysis and dissemination of economic data on an occupation basis.

ANZSCO provides an integrated framework for storing, organising and reporting occupation-related information. The nature of the labour market is rapidly changing. New and emerging occupations are expected to continue to expand and have increasing importance, particularly in the areas of:

[58] AlphaBeta 2019, Investment in Innovation: levels, trends and drivers. (Forthcoming)

information technology; the green economy; the digital economy; and skilled agriculture, construction, and disability occupations.

What information do policymakers need?

Policymakers require an occupation classification system that allows policymakers to understand innovation in the modern economy. For example, determining those employed in innovation-related positions allows a better understanding of the absorptive capacity of business.

There is also a requirement to identify new and emerging occupations in the economy and better inform policymakers targeting new jobs. Consultations have indicated that understanding talent flow is of policy relevance because governments are frequently concerned with whether there is sufficient talent flow to meet the needs of the Australian economy, and if not, how to attract it.

Current state of play

Stakeholders have expressed concern that ANZSCO does not reflect the rapidly changing nature of labour market occupations and how this impacts the economy. ANZSCO was last updated in 2013.

The International Standard Classification of Occupations (ISCO) was last updated in December 2007, does not meet Australian and New Zealand needs, and there is no realistic prospect of having this updated in a manner likely to meet Australian and New Zealand needs in the foreseeable future. This means that if Australia and New Zealand want a usable occupation classification system, they will have to update ANZSCO.

Future outcomes sought

- Improved ability to understand innovation in the modern economy
- Support informed policy decisions and government programs reliant on contemporary Australian skills and occupation information
- Improved ability to identify new and emerging occupations in the economy and inform policymakers targeting new jobs better
- Facilitate analysis and insight into new and emerging industries, skills and occupations that reflect the economic activities in the modern economy.

RECOMMENDATION 2.5: UPDATE OCCUPATION CLASSIFICATION SYSTEM

- The ABS should review and update the Australian and New Zealand Standard Classification of Occupations (ANZSCO) for new and emerging occupations that are expected to have increasing importance.

Existing industry classification does not reflect changes in the modern economy

Why this is important

The ANZSIC is a joint product of the ABS and Stats NZ, and provides the basis for the standardised collection, analysis and dissemination of economic data on an industry basis within Australia and internationally. ANZSIC is also is used to classify businesses in the collection and dissemination of innovation and R&D statistics.

ANZSIC is widely used by government agencies, industry organisations and researchers for policy, administrative, regulatory, taxation and research purposes. Such information is vital for policy development, as there are marked differences between industry sectors in terms of how they innovate, the role that R&D plays in their innovation activities, and their capacity to export, amongst other things.

What information do policymakers need?

An industrial classification system that allows policymakers to understand innovation in the modern economy.

The ability to identify new and emerging industries in the economy and better inform policymakers targeting new industries.

Current state of play

Stakeholders have expressed concern that the current industry classification, published in 2006, does not reflect changes that have occurred in the economy over the last decade, and that the lack of an update makes it difficult to understand innovation in the modern economy.

Conducting reviews of major statistical classifications is resource and time intensive, requiring additional funding to develop and implement, as they underpin all key economic and social statistics' time series, including the Australian National Accounts, the Australian Population Census and the Labour Force.

It would be better to do this internationally and regularly, rather than just Australia and New Zealand as a one-off review. However, stakeholders have emphasized the need for a timely update.

Future outcomes sought

- To support informed economic and micro-economic industry policy decisions, better contemporary Australian industry information is required
- To ensure the industrial classification system reflects the modern economy and facilitates analysis
- To provide policymakers with insight into new and emerging industries
- To ensure that industrial classification activities are periodically reviewed to reflect the emerging economic activities in the modern economy
- Australia and New Zealand, as the co-owners of the Australia New Zealand Standard Industry Classifications, potentially to align this with the ISIC.

RECOMMENDATION 2.6: UPDATE INDUSTRY CLASSIFICATION SYSTEM

The ABS should continue to engage with the United Nations Statistical Commission regarding the International Standard Industrial Classification (ISIC), with a view to influence any update to:

- better reflect the Australian economic structure
- facilitate meaningful sector analysis
- aid evidence-based decision-making.

The ABS should continue to engage with the United Nations Statistical Commission and the Organisation for Economic Cooperation and Development to influence the development of a more streamlined and flexible way of conducting updates of industry classifications.

The ABS should review and update the Australian and New Zealand Standard Industrial Classification (ANZSIC) after the 2021 Census.

Existing research classifications do not reflect current practice

Why this is important

The 2008 Australian and New Zealand Standard Research Classification (ANZSRC) was developed to meet the dual needs for a comprehensive description of today's research environment, as well as the ability to compare R&D statistics internationally.

The ANZSRC is the collective name for a set of three related classifications developed for use in the measurement and analysis of R&D) undertaken in Australia and New Zealand.

There are three classifications in the ANZSRC:

- Type of Activity (TOA)
- Fields of Research (FoR)
- Socio-economic Objective (SEO).

The use of the three constituent classifications in the ANZSRC ensures that R&D statistics collected are useful to governments, educational institutions, international organisations, scientific, professional or business organisations, business enterprises, community groups, and private individuals in Australia and New Zealand.

What information do policymakers need?

Research classifications that reflect current practice and, capture emerging areas of research and remain responsive to change in the research sector

Current state of play

The ARC, ABS, Stats NZ, and the New Zealand Ministry of Business, Innovation and Employment (MBIE) are currently undertaking a joint Review of the ANZSRC to ensure that research classifications reflect current practice and remain responsive to change in the sector.

Future outcomes sought

- Research classifications are updated to reflect current practice and international comparability

- Research classifications that remain responsive to change in the research sector.

Options to be considered
Not required. Review of ANZSRC is already underway.

Measuring innovation related to diversity

Why this is important
Diversity information is vital to inform policy development and facilitate business utilisation of potentially underutilised resources. Various forms of diversity, such as gender, ethnicity, age, sexual orientation, disability, and types of experience may impact on economic outcomes. Hsieh et al (2019) reports that an eight percent of growth in US GDP per person and 56 percent of growth in US labour force participation between 1960 and 2010 was explained by reduced labour market discrimination.[59] The Grattan Institute has estimated that an extra six percent of women in the workforce could add up to $25 billion to Australia's GDP.[60]

What information do policymakers need?
High priority data requirements related to measuring female participation across the Australian science and innovation ecosystems include:

- small business owners by gender
- entrepreneurs (including start-up founders) by gender
- principal managers by gender
- women in vocational education and training (VET) and Higher Education-trained professions
- women in research, including research masters degrees, PhDs, post-docs, and ARC grants.

Data are also needed for other diversity groups to assist policy and program development around participation and inclusion in innovation. Diversity data will assist with evaluating the contribution diversity groups make to innovation development in the Australian economy more broadly, and if Australian government programs are genuinely equally accessible to all, or their design favours certain groups.

Current state of play
There are gaps in the collection of diversity data in businesses and management. The BCS Management Capability Module of 2015–16 was the first time the ABS asked about the gender of the principal manager of the business. However, this data set has not been collected again. Other than in this instance, ABS business surveys do not generally collect diversity information about the business owner.

There are gaps in innovation diversity data related to human resources dedicated to research, R&D and innovation. Many OECD countries report on

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[59] T Hsieh, Hurst, Jones & Klenow 2019, The Allocation of Talent and U.S. Economic Growth, Econometrica, vol. 87, no. 5, pp. 1439–1474.

[60] J Daley, C McGannon, & L Ginnivan, Game-changers: Economic reform priorities for Australia, Grattan Institute 2012, Melbourne, viewed 24 October, 2019.

the number of researchers in FTE terms (available in the MSTI database). This is a similar definition to that used by the ABS. The gender composition of the research workforce is reported in headcount terms. Australia does not produce equivalent data for the gender composition of the research workforce.

Future outcomes sought
Improved data and statistics in the area of human resource and business diversity are necessary for underpinning the development of new policies and programs, and for evaluating the effectiveness of those that currently exist.

The Review has not made specific recommendations on the additional diversity data to be collected but identifies this as an area for future research.

Gaps where there are conceptual and measurement challenges

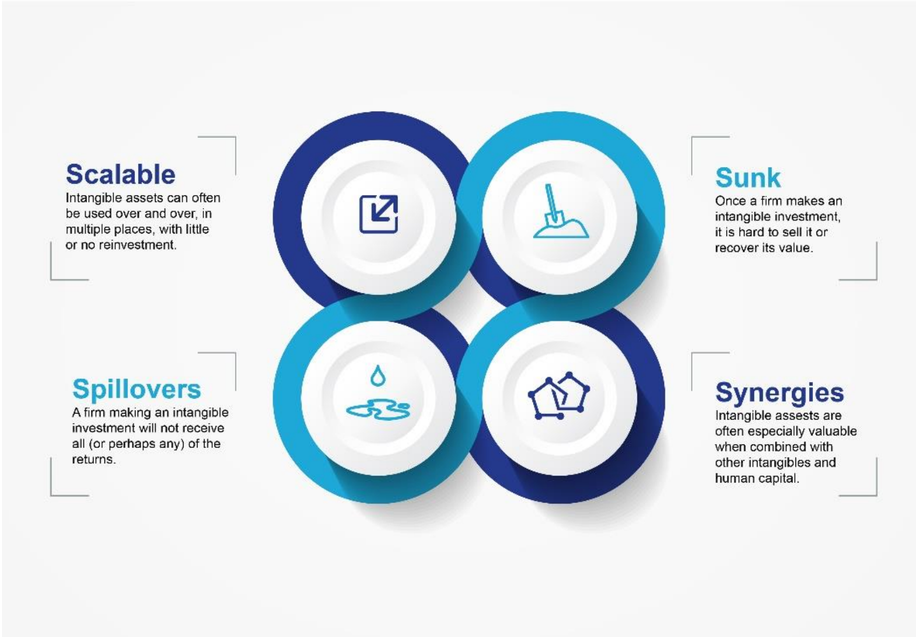
Measures of intangible capital

Why this is important
The world has changed; the way we produce and consume has changed. The production of goods was relatively easy to observe and measure in the twentieth century. Assets such as buildings, machinery and computers were built, and this physical capital was combined with labour, raw materials and intermediate goods to produce output. Business investment in modern information technology tools is going beyond physical computer equipment into software and databases. Businesses are investing more in organisational capabilities, to develop their brand, implement business models and improve processes. They are relying less on physical material and more on intangible assets.

Intangible assets are those without a physical form, such as R&D, software, databases, artistic creations, designs, branding, and business processes. They are not new, but the increased scale of their use in production and their high level of international mobility are impacting developed economies worldwide. Intangibles are fast becoming the most important investment occurring.

The Review found that whilst not all intangible investment necessarily represents innovation, new ideas, new designs and new methods are increasing features of the innovation ecosystem, so intangibles are potentially a key source of underlying economic growth.

Figure 2.3: Properties of Intangible Assets – the four S's



Source: S Westlake & B Mitra-Kahn, 'Intangibles', Innovation Metrics Review Workshop Proceedings 13–14 March, 2019, pp 25–27, adpapted from J Haskel & S Westlake 2018, Capitalism without capital: The rise of the intangible economy, Princeton University Press.

The properties of intangibles are fundamentally different from those of tangibles, so this change matters. Intangibles have four notable economic properties: they are more likely to be sunk (as they are seldom saleable separately from the business that owns them), based on synergies, scalable (non-rival), and often involve spillovers (where much of the benefits of an investment may accrue to others), as shown in Figure 2.3).

The Review's Intangibles Expert Working Group noted that intangibles are also mobile and present difficulties to current tax authorities. The significant impact of intangibles is highlighted by Societas Privata Europaea (SPEs), a form of limited company that exist solely to hold IP on behalf of a parent company, changing residency for tax reporting purposes and leading to Ireland's real GDP jumping by more than 25 percent in 2015.[61] The impact of such mobility puts pressure on countries to lower corporate tax rates.

Understanding the impact of intangible investment may help explain some of the peculiar features of the modern economy, including rising inequality and slowing productivity.[62] Work has been undertaken in an Australian context that provides evidence of the role that intangibles play in the economy. It shows that a broad range of business sector intangibles can significantly affect productivity

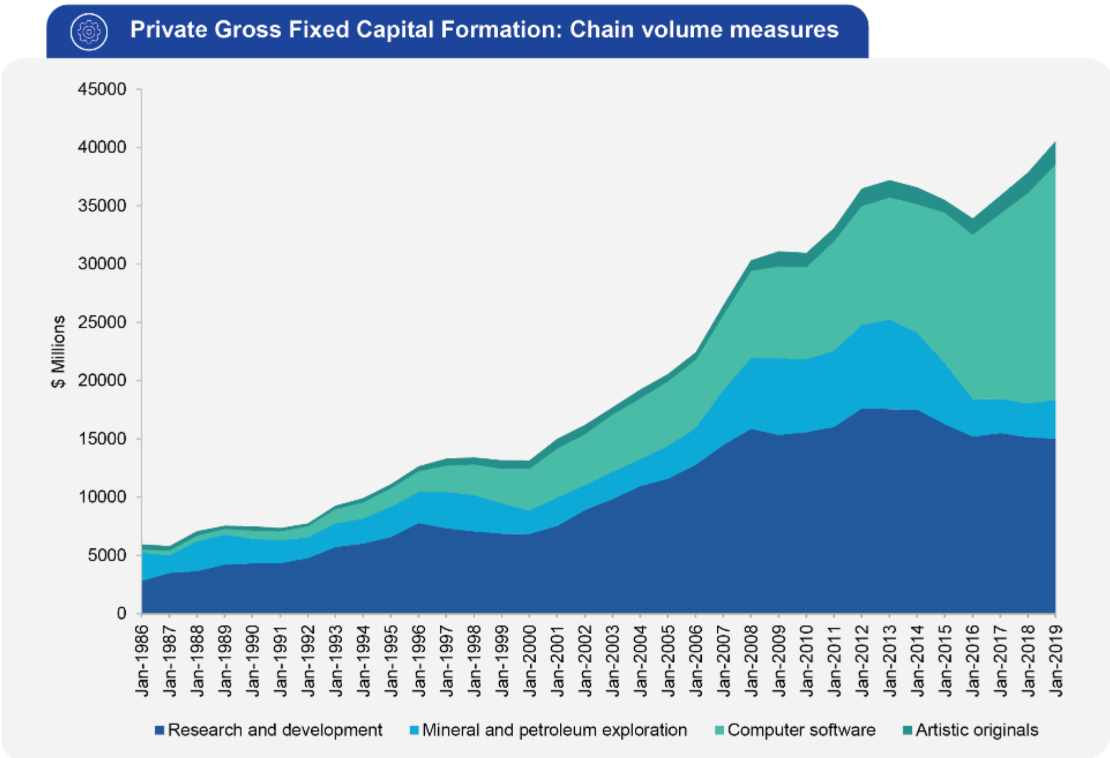
[61] OECD 2016, Irish GDP up by 26.3% in 2015?, OECD Publishing, Paris, viewed 19 December 2019. < http://www.oecd.org/sdd/na/irish-gdp-up-in-2015-oecd.pdf>

[62] M Wolf, The challenges of a disembodied economy, Financial Times, 28 November 2017, viewed 18 October 2019.

and that there is a role for public support of research and innovation in the Australian economy.[63]

The level of intangible investment varies internationally. Some developed economies, such as Sweden, the US, the UK and Finland, have already seen the share of intangible investment overtake that of tangible investment when academic estimates of non-National Account intangibles are taken into account.[64] In other developed economies, including Australia, the relative share of intangibles is rising (see Figure 2.4) but has not yet overtaken tangibles.

Figure 2.4: The increasing investment in intangibles as captured by the System of National Accounts



Source: Australian Bureau of Statistics 2019, Australian National Accounts: National Income, Expenditure and Product, cat. no.. 5206.0.

Haskel and Westlake argue that government support is a key factor in the variation across countries. Where businesses are not able to appropriate the benefits of investment, they will tend to underinvest. Governments may choose to intervene by providing more public investment in intangibles, to encourage a total level of investment at, or closer to, the optimum for their economies. For

[63] A Elnasri & K Fox, The contribution of research and innovation to productivity and economic growth', September 2014, viewed 18 October 2019.

[64] European Commission 2016, European Economic Forecast, Winter 2016, Institutional Paper 020, pp 53–56, viewed 22 November 2019.

example, government spending on R&D is an important determinant of private sector investment.[65]

Intangible capital is harder to value, and much harder to borrow against, due to its sunk nature. Investment in intangible capital is generally longer term and higher risk than investment in tangible capital, and thus is more suited to equity than debt financing.[66,67] Equity holders are generally long-term investors who are willing to take risks and require no collateral, while credit markets can limit loans when faced with strong asymmetric information between those inside and outside a business, due to adverse selection and moral hazard problems.[68]

Knowledge spillovers and information asymmetry affecting financing choices are classic market failures associated with investment in intangible capital. They have implications for government innovation policy. Theory suggests: providing clear, stable IP rights; creating a favourable environment for infrastructure investment (including telecommunications and urban development) that encourages spillovers are worthwhile. Creating tax credits for equity financing, or alternatively taxing debt interest payments but lowering overall tax rates to compensate, deploying national funds in particular ecosystems, and implementing policies to tackle the economic impacts of increased investment in intangibles, such as the increase in inequality that may be created, would also need to be considered.[69]

Evidence to evaluate the effectiveness of policies to address these market failures is slowly emerging. Bloom, Van Reenen and Williams (2019) outlined some of the main innovation policy levers and described the available evidence on their effectiveness. These included tax policies to favour R&D, government research grants, policies aimed at increasing the supply of human capital focused on innovation, IP policies and pro-competitive policies.[70]

A number of countries are using some of these policy levers. For example, Singapore's Productivity and Innovation Tax Credit provides tax deductions for: the acquisition and leasing of IT and automation equipment; the training of employees; the acquisition and licensing of IP rights; the registration of patents, trademarks, designs and plant varieties; R&D activities; and costs incurred to create new products or industrial designs where the activities are primarily undertaken in Singapore.[71]

The Review's sectoral case studies found clear evidence that some Australian businesses are not able to capture the full benefits of their investments in

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[65] J Haskel & S Westlake 2018, Capitalism without capital: The rise of the intangible economy, Princeton University Press.

[66] OECD Economics Department Workshop Papers, No. 1547, Productivity Growth and Finance: The Role of Intangible Assets – A Sector Level Analysis, p.11.

[67] V Acharya, & Z Xu, 2017, Financial dependence and innovation: The case of public versus private firms, Journal of Financial Economics, vol. 124 (2), pp.223–243.

[68] JE Stiglitz & A Weiss, 1981, Credit rationing in markets with imperfect information, The American Economic Review, vol. 71 (3), pp.393–410.

[69] J Haskel & S Westlake 2018, 'Capitalism without capital: The rise of the intangible economy', Princeton University Press.

[70] N Bloom, J Van Reenen, & H Williams H 2019, 'A Toolkit of Policies to Promote Innovation', Journal of Economic Perspectives, vol. 33 (3): pp.163–84.

[71] Inland Revenue Authority of Singapore 2018, Six Qualifying Activities under PIC, Inland Revenue Authority of Singapore, Singapore, viewed 30 October 2019.

intangibles. Some of these businesses were attempting to solve upcoming industry-level problems through co-operative funding arrangements, which were creating intangibles designed to address these issues. The good created by these intangibles, while not public in nature, was the joint property of all those participating in the industry and expecting to continue to do so, rather than those specific businesses which invested in the intangibles. Those negotiating such arrangements noted that businesses tend to underinvest in this context. Others were attempting to solve the problems faced by their particular business, but were underinvesting because they were aware that they could lose their intangibles investment if their business failed, or if the ideas they generated were used by others. Small business owners were underinvesting in training because of concerns that employees could use their new abilities to demand higher salaries, either within or outside of the business that paid for the training, hence the value of the investment could be lost.

At present, policymakers do not have a solid evidence base to understand current trends in the growth of intangible capital in the Australian economy. Evidence is also important to evaluate whether the right policy levers are in place to foster the accumulation of intangibles, and thus encourage productivity growth.

What information do policymakers need?

Through the consultation process, the Review was able to determine that there is increasing demand from stakeholders for more comprehensive measurement of intangible investment. As the proportion of investment allocated to intangible – rather than tangible – capital rises, it becomes more important to measure intangible investment well.

More comprehensive measures would better equip policymakers to understand how and where intangibles are contributing to economic growth, by providing an evidence base to respond to changes and determine where policy intervention might be appropriate (e.g. through refinements to tax treatments, competition and other policies), to maximise potential growth and well-being in the modern Australian economy.

Current state of play

Conceptually, intangibles include a broad spectrum of assets. Work has been undertaken internationally to develop a framework for the measurement of intangible assets. Corrado and Haskel et al. (2012) categorise intangible assets under the following types.[72]

- Computerised information
- Software
- Databases
- Innovative property
- Mineral exploration
- R&D
- Entertainment and artistic originals

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[72] C Corrado, J Haskel, C Jona-Lasinio, & M Iommi, Intangible Capital and Growth in Advanced Economies: Measurement Methods and Comparative Results, IZA Discussion Paper No. 6733, July 2012.

- New product/systems in financial services
- Design and other new product/system
- Economic competencies
- Brand equity (e.g. advertising, market research)
- Business-specific resources (e.g. training, organisational structure).

Some of these are difficult to measure.

While all countries account for investment in tangible assets in their gross domestic product (GDP) statistics, no country currently includes a comprehensive estimate of business investment in intangible assets in their official accounts.[73]

The current System of National Accounts (SNA) includes some intangible capital formation – R&D; mineral and petroleum exploration; entertainment, literary and artistic originals; computer software; and ICT investment. It excludes other types – design and other product development; training; market research and branding; business process re-engineering; the value of data collected and network formation. It does not capture the value of data created, just the cost of collecting or creating it.

All intangibles in scope of the SNA are currently measured in the Australian National Accounts. However, the data sources and underlying assumptions covering new investment data, price deflators and capital stock have not been reviewed for some time, and there would be merit in doing so.

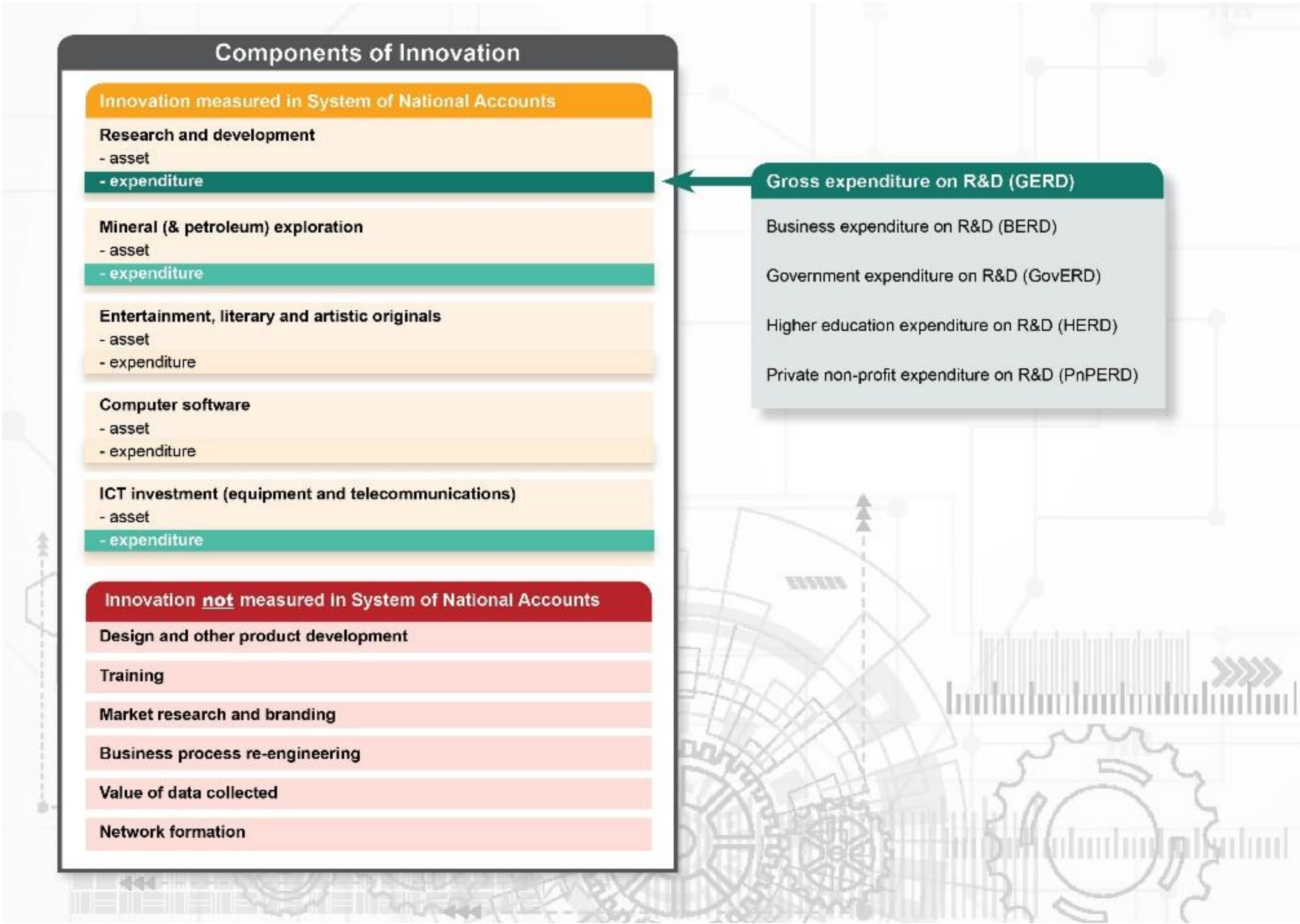
Internationally, work is underway on attempting to identify and measure intangibles that sit outside of the current scope of the SNA. Statistics Canada and the UK Office for National Statistics, for example, are developing experimental estimates that cover a broader spectrum of intangibles.

At present, Australia is not measuring intangibles that are outside the current scope of the SNA.

The Intangibles Expert Working Group of the Review provided input to the components of innovation diagram shown below (see Figure 2.5).

[73] A Aizcorbe, C Moylan, & C Robbins, Toward better measurement of innovation and intangibles, BEA Briefing, January 2009, viewed 23 December 2019. < https://apps.bea.gov/scb/pdf/2009/01%20January/0109_innovation.pdf>

Figure 2.5: Components of innovation that are measured in the System of National Accounts



Experimental work is needed, building on that undertaken by national statistics offices internationally, to measure intangible capital more comprehensively.

The Review's Intangibles Expert Working Group noted the difficulties associated with measuring intangibles:

'…the lack of observable transactions, business accounting valuation rules, and other factors mean that NSOs may need to use second and third order approximations of market value, such as sums of costs, which are the observable amounts that are spent to create intangibles. Nonetheless, in using such approximations, it is important not to lose sight of the underlying principle of market value.'

It also offered the following advice.

'…the ABS should trade-off errors of commission against errors of omission in trying to measure intangibles. Measuring intangibles is very hard, but only measuring what is easy to measure accurately is not particularly useful to policymakers. The ABS should aim for less accuracy and more utility' in relation to the measurement of intangibles.[74]

Future outcomes sought

1. Leverage the work currently being progressed internationally in the measurement of intangibles to develop experimental estimates of intangible capital for Australia outside of the SNA.
2. Review and update the data sources and assumptions underlying intangible capital measurement within the SNA.

RECOMMENDATION 2.7: INTRODUCE AND IMPROVE MEASURES OF INTANGIBLE CAPITAL

The ABS should develop experimental estimates of intangible capital items not covered within the System of National Accounts (SNA)

The ABS should review and update the data sources and assumptions underlying intangible capital measurement within the SNA.

Measuring the impact of digital activities in the economy

Why this is important

Rapid advancements in digital technologies in recent years have significantly transformed the ways in which households, business and governments interact with each other. Digital activities have grown rapidly and become an important contributor to economies around the world. As a result, the demand for data about the digital economy and its measurement is becoming increasingly important for governments, businesses, and academics.

Australian governments need information on where and how the Australian economy has been most impacted by digitalisation, to enable them to

[74] Intangibles Expert Working Group, 'Minutes of the Intangibles Expert Working Group Workshop' Canberra, 19 February 2019.

understand impacts, respond to changes and ensure the right policy levers are in place to maximise future economic growth.

What information do policymakers need?

Over recent years, there has been growing discussion internationally focused on developing a framework for measuring the digital economy, including exploration of a satellite account.

Stakeholders have indicated that development of an Australian digital satellite account would provide a basis for policymakers to respond to questions regarding digital activities in the economy and its impacts. However, it was established that policy needs could be partially met though development of measures of components that may contribute to a future digital satellite account. This is more achievable in the medium-term.

As a priority, policymakers are interested in understanding:

- the total value of e-commerce (digitally ordered goods and services) and its links with data flows, which relate to global supply chains
- the level of investment in digital technologies (such as cloud computing) occurring in the economy
- the total value of services provided by intermediary platforms as a separate proportion of the overall value of goods and services being provided by the producer
- the imputed value of free services (including data) that are not currently captured by the ABS within the SNA.

Measures in those areas would provide an evidence base to better equip policymakers to understand how and where digital activities are contributing to the economy and determine if and where policy intervention might be appropriate, to maximise potential growth and well-being in the digital era.

Current state of play

The digital economy poses significant measurement challenges for macroeconomic statistics. Many aspects of the Australian digital economy are captured in the National Accounts. However, this does not separately identify all digital activities, nor trace the estimated aggregate economic performance to its digital origins. It is recognised internationally that producing these data is challenging, due to definitional, classification and measurement issues:

- As highlighted by Ahmad and Ribarsky[75] (OECD, 2018), the multi-dimensional nature of the digital economy creates difficulties in defining it. As a result, there is a lack of a commonly understood definition.
- The occupational and industrial classification systems in current use reflect a pre-digital world.
- There is currently no conceptual framework in place to identify and value digital activities occurring in the economy separately.

[75] N Ahmad & J Ribarsky, U.S. Bureau of Economic Analysis, Towards a Framework for Measuring the Digital Economy, September 2018

A considerable amount of research has been undertaken by international organisations, most notably by the OECD, to address these measurement challenges and develop appropriate measures.

For example, in March 2019, the OECD hosted a ‘Going Digital Summit’[76] which was the culmination of a two year project looking into policy development and measurement in the digital space. At the summit, the OECD released ‘Measuring the Digital Transformation: A Roadmap for the Future’[77] that identifies gaps in the current measurement framework, assesses progress made towards filling those gaps, and sets-out a forward-looking measurement roadmap.

A G20 summit held in Argentina in late 2018 produced a toolkit for measuring the digital economy.[78] The toolkit proposes potential measurement approaches which support policymaking and diagnose challenges and opportunities in relation to the digital economy. The toolkit is also intended to serve as a guide for countries wanting to align and adopt some standard measurement activities.

There has been significant discussion internationally on the development of a digital satellite account that delineates key digital actors and transactions within the National Accounts Framework.

The Australian Government has ongoing engagement with international organisations such as the OECD and the G20 through the ABS and the DIIS on the development of digital economy measures.

In 2018, the OECD released a proposed framework for Digital Supply-Use Tables to enable the creation of a digital satellite account that could provide a broadly holistic view of digital activities in the economy. At present, no NSO has adopted the framework, although a number of them are assessing it. The level of investment that would be required, and the suitability of the framework for adoption in the Australian context, is currently unknown.

The ABS has published experimental estimates of digital activity in Australia[79] based on methodology developed by the US Bureau of Economic Analysis (BEA).

There is an opportunity to leverage the work that has already been undertaken, however, further development of such methodologies will require additional investment.

Future outcomes sought

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[76] Going Digital Summit 2019, webcast, OECD, Paris, 11–12 March 2019.

[77] OECD 2019, Measuring the Digital Transformation: A Roadmap for the Future, OECD Publishing, Paris, viewed 21 November 2019.

[78] Steering committee of international organizations 2018, Toolkit for Measuring the Digital Economy, OECD Publishing, Paris, viewed 21 November 2019.

[79] Australian Bureau of Statistics 2019, Measuring digital activities in the Australian economy, Australian Bureau of Statistics, Canberra, viewed 21 November 2019, <https://www.abs.gov.au/websitedbs/D3310114.nsf/home/ABS+Chief+Economist+-+Full+Paper+of+Measuring+Digital+Activities+in+the+Australian+Economy>.

- Address information gaps related to digital activities occurring in the Australian economy
- Provide Australian governments with an evidence-base regarding the impacts of digitalisation of the economy
- Enable Australian governments to undertake and evaluate new policy related to digitalisation and encourage potential growth in the digital economy
- Develop measures that can contribute to a future digital satellite account
- Contribute to the international body of knowledge and influence the development of internationally comparable indicators related to measurement of the digital economy.

RECOMMENDATION 2.8: INTRODUCE AND IMPROVE MEASURES OF DIGITAL ACTIVITIES IN THE ECONOMY

The ABS should leverage work being undertaken internationally and assess how digital activity measures can be developed, prioritising the following information needs:

- The total value of e-commerce (digitally ordered goods and services)
- The level of investment in digital technologies (such as cloud computing) occurring in the economy
- The total value of services provided by intermediary platforms as a separate proportion of the overall value of goods and services being provided by the producer
- The imputed value of free services (including data) that are not currently captured within the System of National Accounts.

In the longer term, these measures may contribute to a future digital satellite account.

Measuring government innovation procurement

Why this is important
Government procurement can act as a significant driver of innovation within Australian businesses. Increasing government procurement of innovative new products and services would be expected to have a positive effect on national innovation performance, however, improved data are necessary if such effects are to be measured and demonstrated.

Recommendation 15 of the ISA 2030 Plan is to:

'Increase the use of innovative procurement strategies to improve outcomes and optimise government operations by establishing programs that promote, track and report on progress towards procurement practices that drive innovation (including identifying impediments raised by industry, and measuring participation of businesses by age and stage) across all levels of government'.[80]

[80] Innovation and Science Australia 2017, Australia 2030: Prosperity through Innovation.

There is considerable work underway to develop challenge-based approaches in government procurement processes to identify and encourage innovation. For example, the Business Research and Innovation Initiative (BRII), administered by DIIS, provides small to medium-sized enterprises with competitive grant funding to develop innovative solutions for government policy and service delivery challenges. The awarding of contracts is important as contracts encourage business engagement with the public sector whereas grants encourage research.

What information do policymakers need?

Data that will enable evaluation of the impact of innovative procurement strategies now, and how and where to target investment to obtain best value for money.

A measurement approach that enables international comparison of performance.

Current state of play

There is a gap in measurement relating to Australian, state and territory government procurement (see Table 10 in Appendix E). At present, contracts and grants for new or significantly improved goods and services are not earmarked as different from those for goods and services that are already available within government procurement processes.

Internationally, there is work being undertaken by the European Commission to develop measures on government procurement for innovation.

Future outcomes sought

- Provide policymakers with data that will enable them to evaluate the impact of innovative procurement strategies now, and how and where to target investment to obtain best value for money
- Adopt a measurement approach that enables international comparison of performance.

RECOMMENDATION 2.9: MEASURE GOVERNMENT INNOVATION ACQUISITION

The Australian Government regularly enters into arrangements to acquire new or significantly improved products (goods and services) and processes. At present it does not distinguish arrangements for acquisition of those innovative products and processes from other products.

Investigation, organised by the responsible entity, is needed to determine how data on government acquisition of innovative products and processes could be collected, in order to measure their worth and effect on encouraging innovation. Ideally, an approach that enables international comparison of performance should be adopted.

Measures of entrepreneurship: start-ups and spin outs

Why this is important

New business formation has a key role in the generation of employment and the diffusion of knowledge. Innovation-based and growth-oriented start-ups are a form of business experiment that can discover new opportunities for value creation. Such businesses can have major impacts on innovation, employment, industry development and structural change, and have a vitally important role in times of rapid change, when they are key sources of learning and dynamism. It is important to be able to distinguish between innovative and replicative start-ups (see Appendix E).

It is recognised that entrepreneurship, in particular, is a key economic driver and has strong linkages with innovation. Entrepreneurship is seen as the critical link between new knowledge and economic growth, as it facilitates the transfer of knowledge.[81]

Australian governments invest significant resources into programs designed to support entrepreneurship activity. There is increasing demand for measures that support both domestic analysis of policy and program effectiveness (including comparisons between Australian jurisdictions) and international comparison.

What information do policymakers need?

Internationally comparable indicators that enable conclusions to be drawn about the level of entrepreneurial activity in Australia and other countries.

Indicators that provide meaningful measures of:

- entrepreneurial activities
- enablers and drivers of entrepreneurship (e.g. access to finance, capabilities)
- the impact of entrepreneurship on economic performance
- the dynamic nature of entrepreneurship and the resulting business dynamics.

Indicators should specifically capture the innovative nature of entrepreneurship.

Current state of play

The Review recognises entrepreneurship is an area of innovation activity where current measures are limited. Current international rankings do not provide meaningful measures that can guide policy-making.

There are a number of challenges when it comes to measurement of entrepreneurship:

- Entrepreneurship is a dynamic and complex activity that is difficult to measure.
- Entrepreneurship is a concept that encompasses a number of different activities of which there are no clear definitions.
- Separating entrepreneurial activities from other business activities is often difficult.

The Global Entrepreneurship Monitor (GEM) is currently the primary source of entrepreneurship data and is collected through two streams: the Adult Population Survey (APS) and the National Expert Survey (NES). The OECD publication, *Entrepreneurship at a Glance,* cites GEM as being a key data source for metrics in entrepreneurial capabilities and entrepreneurship culture.

GEM has been funded by DIIS in the past and is generally used because there is no alternative that provides a similar level of coverage and claimed

[81] K Kukoc K & D Regan, 2017, Measuring Entrepreneurship, The Australian Treasury, pp 17-26.

comparability. However, the Review notes the limitations of GEM data, due to its small sample size and limited coverage.

There is currently work being undertaken internationally on developing methods to aid measurement. For example, the OECD has launched two projects, MultiProd and DynEmp, which rely on cutting-edge techniques and business-level data to better understand the relationship between policy and productivity, and the role that start-ups have in boosting productivity, creating jobs and raising innovation in the economy.[82]

In Australia, the ISA is funding consultation work with key stakeholders to build on the information about user needs for data in this area that was reported to the Review, and enable specification of the data that should be collected in future.

In Australia, there is no national consensus on the most appropriate definitions to use to collect data and produce metrics to measure the success of government policies and programs targeting start-ups. At present, each Australian government department is trying to make sense of disparate sets of data generated by its own programs and by private data providers in isolation.

Once Australian, state and territory governments and ecosystem leaders have agreed on the data needs they have in common with regard to entrepreneurship, start-ups and spin-outs, this data should be captured and reported upon.

Future outcomes sought

- Provide policymakers with measures that facilitate meaningful analysis of entrepreneurship activity
- Provide internationally comparable indicators that enable conclusions to be drawn about the level of entrepreneurial activity in Australia and other countries.
- Enable evaluation of the effectiveness and impacts of policy and programs designed to promote entrepreneurship activity.

RECOMMENDATION 2.10: INTRODUCE AND IMPROVE MEASURES OF ENTREPRENEURSHIP; START-UPS AND SPIN OUTS

Work is needed to define the conceptual basis for measurement and development measurement systems that enable conclusions to be drawn about the level, performance and drivers of entrepreneurial activity in Australia and other countries

The responsible entity should coordinate this work drawing on expertise from the international and domestic research community, relevant policy areas, and other stakeholders.

Business access to finance for start-ups

Why this is important

New business formation is vitally important to realise new opportunities for value creation. As noted in the DIIS's 2017 AISR, a lack of funds for the higher

[82] OECD 2017, Productivity and business dynamism, viewed 17 December 2019, <https://www.oecd.org/sti/ind/pbd/>

risk early stages of innovation may impose significant limitations on the growth potential of innovative and disruptive businesses in Australia.

What information do policymakers need?
Policymakers are interested in understanding business access to finance and other forms of investment (VC, angel investors, crowd sourced equity funding, grants, accelerators, venture debts) for start-ups.

There is a strong preference for internationally comparable data.

Current state of play
In Australia, a primary source of data on access to finance for innovative start-ups businesses is the VC&LSPE, collected by the ABS. This survey is funded by the DIIS. The survey of VC&LSPE does not cover all forms of company investment (it excludes angel-investment, crowd-sourcing, and accelerators) because there is currently no way to identify and create a survey frame to include them.

There is currently no internationally agreed upon definitions of VC, which precludes meaningful international comparison of data. Many NSOs don't collect venture capital information.

Future outcomes sought
- Provide policymakers with data that will enable them to evaluate business access to finance and other forms of investment (VC, angel investment, crowd sourced equity funding, grants, accelerators, venture debts) for start-ups
- Enable international comparison of Australian data on access to finance by start-ups.

RECOMMENDATION 2.11: IMPROVE MEASURES OF ACCESS TO FINANCE FOR START-UPS

The responsible entity should investigate the compilation and connection of alternative public and private data sources for the measurement of access to finance; including use of angel investment, crowd-sourcing and accelerators. The investigation should assess whether there is an alternative to the VC&LSPE Survey to meet the need for data on access to finance over the longer term

In the interim, the ABS should continue to undertake the VC&LSPE Survey.

Measures of labour force skills, rather than qualifications

Why this is important
Employers have long used qualifications and experience as a proxy for skills. As tasks within jobs change, employers are increasingly seeking employees who have qualified more recently (e.g. those with only three to five years of experience since obtaining a tertiary qualification). Employers are also demanding employees with digital skills to work with the latest technology. Those skills are not taught as part of formal qualifications.

Ongoing investment in developing workforce capability can generate significant dividends for sponsoring businesses in the long run, including improved productivity, the delivery of better quality products and services, and enhancement of business growth prospects.

Manager and director skills are also contributors to business profitability and growth.[83,84]

What information do policymakers need?

Policymakers need to know what skills the Australian workforce has, and what skills Australian employers are seeking, to address the gap through training or net immigration.

Policymakers need improved accuracy and granularity of the data it collects on business workforce training. Measures that link investment in skills with the subsequent performance of the business will also enable an assessment of whether skills needs are being met (see Table 10 in Appendix E).

Current state of play

The ABS collects data on qualifications and occupations but there is currently no way of linking demand and supply data.

The Department of Employment, Skills, Small and Family Business (DESSFB) is working on developing a new skills-based approach to labour market analysis to explore the relationship between jobs, skills and education. The work is intended to support individuals, employers and education providers to make more informed decisions and improve the policy responses of Government by enabling occupation and qualification data to be linked.

The Jobs and Education (JEDI) project integrates disparate and isolated labour market and education data to produce meaningful and accessible information, features and insights and tools.

DESSFB is mapping jobs to qualifications based on skills, understanding skills transferability, upskilling and identifying skills supply and demand mismatches in the economy which would lead to the identification of skills emerging in the labour market.

The OECD's PIAAC survey measures adults' proficiency in key information-processing skills and gathers information and data on how adults use their skills at home, at work and in the wider community. PIAAC was conducted by the ABS in Australia in 2011–2, and a second cycle is in planning and development, to be conducted in 2021–2.[85]

Future outcomes sought

- When DESSFB has completed its skills classification work, an indicator based on skills should be investigated for addition to the innovation Scorecard
- An understanding of the broader coverage of skills proficiency in the working age population.

Options to be considered

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[83] R Agarwal, C Bajada, PJ Brown, W Li, X Shao, S Pugalia, R Green, A Abbasi Shavazi, & O Majeed, 2019, Management capabilities and firm performance: a study of Australian firms, Department of Industry, Innovation and Science, Office of the Chief Economist Research Paper (forthcoming)

[84] R Agarwal, C Bajada, PJ Brown, W Li, X Shao, S Pugalia, R Green, A Abbasi Shavazi, & O Majeed, 2019, Management capability and employment growth, Department of Industry, Innovation and Science, Office of the Chief Economist Research Paper (forthcoming)

[85] Australian Council for Adult Literacy 2018, 'The second cycle of PIAAC – What's the story', 5 August 2018, < https://acal.edu.au/the-second-cycle-of-piaac-whats-the-story/>.

- Work with DESSFB to ensure the latter's work also meets the innovation ecosystem's need for skills data
- Recommendation 15 of the Senate Inquiry for the Australian Government to work with the ABS and the National Centre for Vocational Education and Research to investigate and establish a research instrument to enable analysis of employer investment in the development and training of their workforces[86]
- When available, investigate the substitution of the education output measurement from PISA to PIAAC.

Location-based innovative activities (e.g. state and territory-level innovation indicators, innovation clustering)

Why this is important

There is increasing demand from state and territory governments for indicators that allow policymakers to evaluate innovation policies and programs implemented at jurisdictional and lower levels. Capturing information from businesses on the location of innovative activities would improve understanding on the relationship and impact of specific innovation initiatives.

What information do policymakers need?

Innovation measures that provide an understanding of the relationship between location and a range of innovation activities. For example, state and territory-level innovation indicators or indicators of innovation clustering.

Current state of play

There is currently no source that allows evaluation of innovation activities within, or across, jurisdictions, let alone at lower levels. There is interest in regional analysis and in assessing the impact of innovation precincts..

There has been increasing demand for business innovation indicators to be provided at a state or territory level. However, there are challenges for collecting this information from businesses, particularly for businesses operating in multiple locations and in multiple jurisdictions.

Given this, it is important that government administrative and transactional data collections include location information wherever possible. This may enable some answers to be found by data integration through BLADE.

Future outcomes sought

- Provide jurisdictions with an improved understanding of the relationship between location and a range of innovation activities.
- Enable policymakers to evaluate innovation policies and programs implemented at the state and territory level.

[86] Legal and Constitutional Affairs References Committee 2019, Inquiry into the effectiveness of the current temporary skilled visa system in targeting genuine skills shortages, Legal and Constitutional Affairs References Committee, Canberra.

RECOMMENDATION 2.12: MEASURE LOCATION-BASED INNOVATION

The responsible entity to investigate solutions, by working with the ABS and other relevant parties, to build location-based capability into Australian innovation data. Data custodians should be encouraged to collect location data that supports analysis of location-based innovative activity.

Measuring business capability to implement innovation

Why this is important

There is growing evidence that links business management capabilities to innovation performance and productivity outcomes. This is noteworthy, considering a recent Australian Institute of Company Directors innovation report indicated that innovation is often missing from boardroom agendas.[87] Business management capabilities can influence a business's ability to undertake innovation activities, introduce innovations, and generate innovation outcomes.

The relationship to innovation is indirect and relates to business' ability to identify and transform new knowledge (i.e. absorptive capacity), effectiveness of resource use (most notably human resources), and the value of assets.

Capturing information on management capabilities in Australian businesses, particularly with respect to absorptive capacity, would assist the development of policies and programs targeted at improving management capability.

What information do policymakers need?

Internationally comparable data that measures the management and organisational capabilities in Australian businesses, including relationship capital and overall absorptive capacity (see Table 10 in Appendix E).

Current state of play

The ABS was funded by DIIS to conduct a Management Capabilities Module (MCM) of the Business Characteristics Survey (BCS) in 2015–6. This survey module was designed to support international comparisons of management practices and the analysis of the impact of different levels of management sophistication on business productivity and performance.

Currently, the international comparability of this data is limited. A similar survey was run in the United States (US) in the manufacturing sector (2011 and 2016), but the MCM was the first national survey to collect this type of information across a whole economy. The Review understands that the UK, Canada and Germany intend to (or have already) developed survey content relating to management and organisational capabilities. It is not currently known how their measures will align with those produced for Australia.

Users have indicated that minor changes could be made to the survey content of the MCM. The MCM provides meaningful measures that would support policy development in this space. They have also indicated that some questions are much more valuable than others in generating policy-relevant information.

[87] Australian Institute of Company Directors 2019, Driving Innovation: The Boardroom Gap, Australian Institute of Company Directors, Sydney, viewed 21 November 2019.

Alternative options to measure business capabilities to innovate (outside of surveys) have not been identified and would require further investigation.

It may be advisable to wait until more is known about the approaches currently being progressed internationally and their relative effectiveness before proceeding further in this space. In the meantime, very high value questions could be considered in the context of the standalone innovation survey and business use of digital technologies survey.

Future outcomes sought

- Provide policymakers with measures that facilitate meaningful analysis of the management and organisational capabilities of Australian businesses
- Assist with evaluation of policies and programs targeted toward improving management and organisational capabilities of Australian businesses and understanding of the impact of different levels of management sophistication on business productivity and performance
- Provide the international community with an evidence base for the effective measurement of management and organisational capabilities, enabling greater international comparability of data going forward
- Data with a balance of short-term and long-term performance objectives in corporate governance (see Table 10 in Appendix E of the literature Review)
- Develop approaches to identify the significance of high performance in multiple capabilities simultaneously (i.e. cumulative capability).

Options to be considered

- Develop statistical solutions that will facilitate meaningful analysis of the management and organisational capabilities of Australian businesses; including absorptive capacity.[88]

Research commercialisation activities

Why this is important

The commercialisation of research is the generation of a commercial benefit from research to contribute to Australia's economic, social and environmental well-being.

An effective and timely diffusion process is necessary for the knowledge created by research institutions to find its way into market applications. There is an increasing government focus and investment on knowledge transfer and collaboration through government policies that have an increasing focus on tracking performance and return on investment.

What information do policymakers need?

To be able to monitor the performance of research institution commercialisation partnerships to track the success of publicly funded research organisations (PFRO) in terms of research translation and commercialisation.

Current state of play

There is currently no international conceptual framework for the measurement of research commercialisation activities. Internationally, surveys are run by AUTM. AUTM is an association of technology transfer professionals, formerly known as the Association of University Technology Managers, until its scope increased to include research centres, hospitals, businesses and government organisations, as well as universities in the US and Canada. AUTM measures trends and shares research commercialisation insights about the technology transfer industry and those who work within it.[89] In addition, current measures focus on start-ups, spinouts and licensing agreements. However, there is an increasing body of evidence that suggests academic engagement and impact can be measured through contract research and consultancies.[90]

User consultation has determined that the National Survey of Research Commercialisation (NSRC) collects some innovation data, modelled on internationally comparable data, deemed important by stakeholders and not available through other channels. It collects data that enables some system-level performance monitoring of PFRO. These data are used in prominent innovation collections, as well as internal benchmarking by – and external promotion of – PFRO.

Most research organisations now have a strong focus on knowledge transfer and collaboration activities, due to government policy. They need to monitor the performance of research institution commercialisation partnerships to track the success of PFRO in terms of translation and commercialisation.

The NSRC only partially meets this need.

Comments

- High quality data are necessary to deliver a worthwhile evidence base for decision-making to support research commercialisation
- There are significant data quality issues impacting on the utility of those aspects of the current survey used for public good purposes (and the Australian Government should not be funding aspects used for private purposes, or to generate public good data that can be readily obtained in another way).

Future outcomes sought

- Before undertaking any further work, a commitment should be obtained from the subset of PFRO whose systems do not collect high quality data to improve that data (for example, by developing the ability to identify when multiple collaboration projects occur with the same business)
- If such a commitment is given, then further work should be undertaken, given the increasing government focus on – and investment in – knowledge transfer and collaboration through government policies that require tracking performance and returns on investment
- Over the longer term, it would be desirable to have internationally comparable indicators that enable conclusions to be drawn about research commercialisation activities in Australia and other countries

[89] AUTM 2019, Sharing Trends and Insights, AUTM, Washington, DC, viewed 21 November 2019.

[90] M Perkmann, V Tartari, M McKelvey, E Autio, A Broström, P D'Este, R Fini, A Geuna, R Grimaldi, A Hughes, S Krabel, M Kitson, P Llerena, F Lissoni, A Salter & M Sobrero, 2013, Academic engagement and commercialisation: A review of the literature on university–industry relations, Research Policy, 42(2), pp.423-442.

- There is currently no international conceptual framework for the measurement of research commercialisation activities, and there are a number of challenges related to its measurement
- A conceptual framework should be developed, preferably in conjunction with international counterparts, or at least shared with them upon completion
- This framework should focus on the success of PFRO in terms of translation and commercialisation of ideas in conjunction with the business community and draw on existing concepts where possible
- A revised survey could be implemented, either by a private sector or government entity with the appropriate expertise. This should leverage existing administrative data collected through the Watt Review's recommendations and sources such as joint grant, tax relief and IP applications.[91] The main benefit of such a survey comes from sharing unit level information. While the ABS can release the unit level data of entities with their written permission, it is not well set up to do so on a large scale. There are other entities, such as LH Martin, KCA and the Australian Institute of Health and Welfare, which may be better situated for this work. Tenders could be sought once the aims of the new survey had been fully determined, following completion of the conceptual work
- The objective of the revised survey would be to enable users to evaluate the effectiveness and impacts of policies and programs designed to promote research commercialisation.

RECOMMENDATION 2.13: IMPROVE MEASURES OF RESEARCH COMMERCIALISATION

The collection of data through the National Survey of Research Commercialisation by the Department of Industry, Innovation and Science should be discontinued

The responsible entity should coordinate the development of a conceptual framework for the measurement of research commercialisation activities. This should focus on measuring the success of publicly funded research organisations, in commercialising their ideas in conjunction with the business community

The responsible entity should commence the collection of hitherto unavailable research commercialisation data. The entity will ensure this data can be properly measured and is important to stakeholders.

There are gaps in the understanding of networks

Why this is important

The increasing role of external interactions in innovation means that businesses are now embedded in 'innovation networks' (see page 24 in Appendix E). The extent and quality of innovation networks is an external resource of significance for business-level innovation capacity. Inter-organisational relations in innovation networks include market and non-market

[91] Department of Education and Training 2015, Review of Research Policy and Funding Arrangements – Report November 2015, viewed 19 December, 2019.

interactions for which trust and social capital are important foundations. Such networks are increasingly international, due to the globalisation of value chains, the rise in international investment, and the wider dispersion of research and innovation capacity.[92]

Networks are also present between public and private institutions.

Innovation does not take place in isolation. Maintaining the correct balance of these networks allows innovation actors to thrive. Too tight and actors become blind to opportunities; too weak and there are insufficient capabilities to act upon these opportunities.[93]

What information do policymakers need?
Policymakers need to be able to understand the knowledge and supply linkages in the economy better to be able to reveal the full impacts of innovation. They need to understand how networks fail and thrive to determine when inputs are necessary to support innovation-linked productivity improvements.

Current state of play
There are significant gaps in innovation measurement related to flows, networks and clustering of human resources within Australia's innovation ecosystem (see Table 10 in Appendix E).

LinkedIn and other private sector data sources have investigated the identification of flows of skills, relationships between organisations and sectors, the innovation capabilities of businesses, and the existence of clusters. Such data could also enable an increased ability to measure changes in demands for various types of skills over time, and within various geographical locations.

Future outcomes sought
- Improve the ability to undertake and evaluate new policy development related to networks and clusters of innovation by improving the evidence base
- Improve indicators to enable a closer understanding of research-industry links
- Identify the role of supply chains and clusters in innovation knowledge flows and inducement.

Options to be considered
- The Australian Government should work with LinkedIn and other data providers to develop new metrics related to human resources, networks and knowledge flows.

There are gaps in the measurement of public sector innovation

Why this is important
Governments exist in an environment of fiscal restraint and are constantly searching for ways to deliver more, better or cheaper services to the public. In

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[92] SJ Herstad, HW Aslesen, & B Ebersberger, 2014, On industrial knowledge bases, commercial opportunities and global innovation network linkages. Research Policy, 43(3), pp.495-504.

[93] RK Woolthuis, M Lankhuizen, & V Gilseng, 2005, A system failure framework for innovation policy design, Technovation, 25, pp.609–619.

Australia, the public sector contributes to over 20 percent of GDP (see page 27 of Appendix E). The key difference between a government unit and a public corporation is that the former do not charge economically significant prices for their goods or services.

Governments set the underlying environment that allows private sector innovation to drive the economy.

What information do policymakers need?

While it is relatively simple to measure inputs, it is far more difficult to measure outputs and outcomes.[94] For example, from a human capital perspective, it is not enough to know if participants were satisfied with a training course. The need is to understand how individual performance or business outcomes improved as a result of the training course. Measures of innovation in the broader workplace can be similarly flawed if they focus on the number of new ideas generated, rather than the number that were developed and implemented to deliver benefits.

The Australian Public Service has many useful input measures for understanding the workforce, but few output measures to allow it to determine the impact of its investment in workforce capability. This does not involve merely picking up the measures used by the business community or other sectors and applying them to the public sector. Whilst much can be learned from other sectors, there is also much that is distinctive about the public sector, including innovation in the public sector. Consequently, there is a need to build an evidence-based understanding of public sector innovation from the data that is available to government entities.

Current state of play

There is currently no internationally comparable collection of public sector innovation data. Arundel *et al.* recently reported that 'The fourth edition of the Oslo Manual provides a universal definition of innovation that is applicable to all sectors covered by the SNA, and includes a brief discussion of the value of collecting data on public sector innovation.'[95] The authors proposed a framework for the measurement of public sector innovation that goes beyond – but is broadly compatible with – the Oslo Manual, and would permit benchmarking innovation activities between the public and business sectors.

A key difference is the Oslo Manual does not require a change to be normatively better than existing products or processes for it to be considered an innovation, whereas the work of Arundel et al. does.[96] Restructuring in the public sector is relatively common and is not considered as an innovation unless there is an improved outcome or benefit.[97]

Future outcomes sought

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[94] Australian Public Service Commission 2011, State of the Service Report, State of the Service Series 2010-11, viewed 21 November, 2019.

[95] A Arundel, C Bloch & B Ferguson, 2019, Advancing innovation in the public sector: Aligning innovation measurement with policy goals, Research Policy, 48(3), pp. 789–798.

[96] ibid.

[97] A Arundel, 2014, Final Report of the OECD Cognitive Testing Results for Innovation in the Public Sector. Mimeo.

- Provide policymakers with data that will enable them to evaluate the impact of public sector innovation in the economy
- Adopt a measurement approach that enables international comparison of performance.

Options to be considered

- Further investigation is needed to determine how data on government innovation impacts and outputs could be collected. Ideally, an approach that enables international comparison of performance should be adopted.

There are gaps in the understanding of the impacts of innovation

Why this is important

"Innovation helps businesses improve the way they work, solve everyday problems and drive long-term job creation. It is also a key driver of productivity growth and economic renewal."[98] Innovation within the business, research organisation or government has spillover impacts on industries, regions, and across the entire economy.

While the Review has limited its attention to the economic benefits arising from innovation, a much broader range of impacts are taking place and are capable of being examined and evaluated. These include social, environmental, cultural and other impacts, both positive and negative.

Different approaches to innovation measurement could be used to offer an improved understanding of the impacts of innovation that occurs in Australian businesses (including the cost savings, economic benefits and productivity improvements resulting from innovation).

What information do policymakers need?

A need exists to examine the social, health, environmental and other public spillover benefits arising from innovation. A number of overseas bodies are considering these broader impacts as part of their innovation policy, and the Australian Government should do so as well.

Determination of the flows of particular innovations throughout the sector to investigate their impacts.

Current state of play

The current 'subject-based' approach to capturing data within the BCS (which focuses on the business and collects data on all of its innovation activities) is likely to be blind to a number of important aspects of the innovation activities of businesses.

For the first time, the fourth edition of the Oslo Manual (2018) includes a chapter on the object-based approach to measurement of innovation. The chapter outlines how the current approach can be complemented with additional information by collecting data on a single "focal" innovation.

Future outcomes sought

- Understanding the impacts of innovation that go beyond those that are economic-based

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[98] Department of Industry, Innovation and Science, Australian Innovation System Monitor.

- Quantify the extent to which spillover benefits occur within the economy.

Options to be considered

- Expanding the scope of ongoing innovation measurement Reviews to consider the impacts of innovation that go beyond economic impacts
- A research project on the 'object-based' approach to innovation should be conducted on behalf of the body responsible for ongoing measurement of innovation. This piece of work should form part of any roadmap for future measurement of innovation.

There are gaps in the understanding of sources of innovation (including capability)

Why this is important

Innovation is increasingly interactive and distributed across organisations, fields of knowledge, and regions, in a complex division of innovative labour. Hence, a focus on innovation at the business level is not adequate. Businesses' capabilities for innovation are also developed outside the context of specific innovation projects through flows of knowledge through personnel and other mechanisms. Studies also show that the majority of the knowledge flows from external sources are informal, through non-market mechanisms, and hence are not priced (see page 28 in Appendix E).

What information do policymakers need?

Up to date innovation measures that provide an understanding of the relationship between the sources of innovation location and a range of innovation activities. Further knowledge is also required on the type of innovation being brought into Australia by multinational corporations.

Current state of play

There is a gap in information available about R&D funded by overseas sources. Until 2008–09, GERD was estimated every second year. Following ABS work program changes, from 2010–11, it was no longer possible to derive a comparable estimate of GERD in the same manner. The current predictive model used to estimate GERD at the total expenditure level prevents the source of funds to be derived.

The Review's case study determined that there are various sources for innovation. While these activities are qualitatively determined through surveys, such as the BCS, businesses could not quantify the scale of this activity, as there are no measures in place at the business level.

As described above, the DESSFB is mapping jobs to qualifications based on skills, understanding skills transferability, upskilling and identifying skills supply and demand mismatches in the economy, which would lead to the identification of skills emerging in the labour market.

Future outcomes sought

- Provide stakeholders with an improved understanding of the relationship between the sources of innovation and a range of innovation activities.

Options to be considered

- Annual indicators of total expenditure on R&D across all sectors (GERD) and businesses (BERD) to allow the determination of R&D financed abroad

- Conduct sectoral analyses to gain a better understanding of innovation in that sector and how that innovation is sourced
- Work with the DESSFB to ensure the work also meets the innovation ecosystem's need for capability sources data.

There are gaps in understanding of the inputs into the innovation systems operating environment

Why this is important

The innovation system has many diverse actors who interact to produce and spread innovations that have economic, social and environmental value. The composition of the innovation system changes, as actors join and leave, and the intensity of activity also changes as investments and risk appetites rise and fall.

However, understanding the inputs into the innovation system's operating environment is difficult. There are many diverse areas that enable innovation activities to occur and have impact, such as entrepreneurship, digital technologies and digital infrastructure, research infrastructure, measures of skills, business capabilities, and business' access to finance, networks and educational structure. For example, there is a need to have a better understanding of the professional and educational characteristics of teachers, as they are a key determinant of student outcomes. Teachers teaching in-field (those who teach subjects and year levels for which they are qualified) are understood to produce higher quality teaching compared to teachers who teach outside of their field, leading to superior educational outcomes.

What information do policymakers need?

As the Australian economy continues to change and develop, inputs into the innovation system continue to evolve. There is a need for ongoing Review of the inputs into the innovation system to enable the most relevant measurement of the innovation system to be undertaken.

Current state of play

Responsibility for Australia's innovation ecosystem, and for measuring its progress, is currently split across Australian, state and territory agencies. This makes the development of a national strategic approach for measuring innovation more difficult and time consuming.

In 2016, ISA was tasked with a performance Review of the Australian innovation system. This Review formed the basis of ISA's innovation, science and research strategic plan for Australia – the 2030 Strategic Plan. ISA will review the performance of the innovation system every five years.

Future outcomes sought

- Ensure that current and new aspects of the innovation system are identified and addressed as the economy continues to evolve
- Enable Government to develop a more efficient, strategic national approach to innovation measurement
- Enable the tracking and reporting of the internationally comparable performance of the Australian innovation system.

Options to be considered

A responsible entity should undertake a Review of the operating environment for innovation, to be updated every three years starting in the second half of 2022. This Review timeframe is shorter than the current Innovation Science Australia directive for performance Reviews every five years. This is because the Review is expecting the underlying data used to assess the operating environment to improve more frequently as recommendations are implemented.

3. Analysis

KEY POINTS

- **Analysis of data is important to identify linkages across, within and between various innovation activities. Data and metrics alone are not enough to provide a complete evidence base of the innovation ecosystem and its performance**
- **Analysis can also provide valuable insights on innovation and its links to outcomes, such as jobs, productivity growth, and social and environmental impacts**
- **A significant amount of innovation-related research and analysis is being undertaken by government, academia, the private sector and international organisations**
- **The Business Longitudinal Analysis Data Environment (BLADE) is being used to provide valuable insights that are used to inform policy decisions. The Longitudinal Linked Employer-Employee Database (LLEED) has the potential for broader use, including to provide answers to location-based policy questions**
- **There is a groundswell of emerging opportunities to link existing datasets and utilise big data analytics to provide new insights to understand the Australian innovation landscape and innovation performance better**
- **Barriers that prevent or limit research and analysis from being undertaken include visibility and accessibility of innovation-related data sources, analytical capability and capacity**
- **Progressing innovation-related research and analysis requires a whole-of-government approach to develop solutions that can address such barriers**
- **A coordinated approach to innovation-related research and analysis would enable the Australian Government to:**
  - **identify whole-of-government requirements and priorities**
  - **draw on capabilities across Australian, state and territory government agencies, academia and the private sector to create a critical mass of resources and analytical capability.**

Analysis of innovation-related data is important

The Australian innovation ecosystem is complex and dynamic, with many components and diverse actors who interact to produce and spread innovations that benefit Australia. This complexity is illustrated by the Framework discussed in the Review Process and Methodology (see Figure i.4 and Table i.1).

The Review has identified gaps in the information that is required to support analysis and improve understanding of the innovation system to inform policy decisions. These findings, and potential solutions for improving the data that underpins innovation measurement, were discussed in Chapter 2. However, improving the data alone is not enough to provide a complete evidence base for the innovation ecosystem and its performance.

Analysis of data is important for several reasons:

To provide deeper insights on innovation system performance and impacts

Data and metrics alone are not enough to assess the performance and impact of innovation with sufficient clarity.

There is a need to identify linkages across, within and between various components of the innovation ecosystem.

Likewise, there is a need to understand enablers of innovation activities that are of critical importance to outcomes such as jobs, productivity growth, and social and environmental impacts.

To assess existing innovation measures and identify new and emerging needs and information gaps

Data analysis and policy has a reflexive relationship – understanding which data are of policy relevance is aided by the analysis of data.

The analysis of existing data can help to identify those datasets that are fit for purpose and the data that are most useful to inform policy-making.

Analysis of data is important to indicate emerging needs and information gaps within existing datasets.

Changes in the Australian economy and emerging global trends, raises new measurement issues, research questions, and information requirements to inform policy development.

To maximise the value of the large amounts of data being generated

Vast amounts of data are being generated with increased digitalisation of the economy including in key areas of science, technology and innovation.

Research and analysis of data enhances the value of this data, and is useful to inform policy.

Opportunities exist to enhance the value of existing and new data sources through linkage of datasets.

A significant amount of research and analysis is currently being undertaken

A significant amount of innovation-related research and analysis is being undertaken by Government, academia and the private sector to inform policy. The following section provides an overview of the activities being undertaken.

Analysis undertaken by the Australian Government

The Australian Government is a major source of innovation-related research and analysis. Australian Government departments and agencies are engaged in a range of research and analysis, from regular innovation system reporting, such as the DIIS's *AIS Monitor*, IP Australia's *Australian IP Report*, the Australian Research Council's *Engagement and Impact Assessment*, and the Australian Small Business and Family Enterprise Ombudsman's *Small Business Counts* report, through to specialised agency-relevant analytical projects and research.

Recent investments in BLADE (Box 3.1) and LLEED (Box 3.2) have enabled the Australian Government to deliver valuable insights on the economy. BLADE (Box 3.1) enables the correlation of factors associated with changes in performance, innovation, job creation, competitiveness and productivity to be assessed. LLEED (Box 3.2) has the potential to be used to answer a wide range of policy questions, notably those relating to locational questions.

Box 3.1: The Business Longitudinal Analysis Data Environment (BLADE)

What is BLADE?

BLADE is an important statistical asset that has received significant investment and is used heavily across government to provide information on a range of economic research questions.

BLADE enables business datasets to be linked, using the Australian Business Number (ABN) as the identifier. It combines business tax data and information from ABS surveys over time to provide a better understanding of Australian businesses and the economy.

The current BLADE asset contains data on all active businesses from 2001–02 to 2016–17, sourced from:

- the Australian Taxation Office (ATO): Business Activity Statements (BAS), Business Income Tax (BIT) filings and Pay as You Go (PAYG) summaries
- ABS surveys: BCS and MCM, Economic Activity Survey (EAS), Business Expenditure on Research and Development (BERD), Private Non-Profit Expenditure on Research and Development (PNPERD), Survey of Research and Experimental Development, Government (GOVERD)
- IP Australia: Intellectual Property Longitudinal Research Data (IPLORD).

How is BLADE currently being used?

Authorised researchers working on approved projects can use BLADE data to study how businesses fare over time and the factors that drive performance, innovation, job creation, competitiveness, and productivity. BLADE demonstrates how combining existing public data can help to deliver evidence based policy making.

BLADE has been used by a number of agencies for research and program impact analysis. It is useful for analysing business performance and dynamics, business demography and characteristics.

The Department uses BLADE to:

- track the performance of actively trading businesses and trends in entries and exits over time
- provide insights into the size and industry distribution of government program participants, and the impact these programs have
- explore business characteristics, such as export status, foreign ownership status or innovation status.

A list of approved research projects that use BLADE data can be found on the ABS website.[99]

Box 3.2: The Longitudinal Linked Employer-Employee Database (LLEED)

What is LLEED?

LLEED is an important tool that is being developed by Treasury and the Department of Education.

LLEED includes personal and employer-level information provided to the ABS by the ATO and the Registrar of the Australian Business Register (ABR). It is a cross-sectional database comprised of a person file, a job file, and an employer file. Currently, it can be used to analyse more than 100 million tax records between 2011–12 and 2016–17.

LLEED also enables analysis of business and employment dynamics. Changes at the business-level that can be identified include: business entry and exit; growth and decline; mergers and acquisitions; and changes in workplace practices. Employment dynamics include: transitions between jobs; wage changes; geographical mobility; and movement in and out of the labour force.[100]

This may enable the identification of some of the effects of innovation in small areas, which is not presently possible through other means. For example, productivity – of which innovation is reported as being the only way for the most developed countries to secure sustainable long run productivity growth – is affected by the characteristics of employees and employers at the business, industry and economy-wide level. LLEED could be used unpack the characteristics of leading businesses that lead to high rates of productivity growth, relative to the overall average performance of lagging

[99] Australian Bureau of Statistics 2019, Business Longitudinal Analysis Data Environment (BLADE) Research Projects, Australian Bureau of Statistics, Canberra, viewed 29 October 2019, <https://www.abs.gov.au/websitedbs/D3310114.nsf/home/Statistical+Data+Integration+-+BLADE+Research+Projects#Academic>.

[100] M Forbes, & P Jomini, 'A rationale for developing a Linked Employer-Employee Dataset for policy research', Productivity Commission, Canberra, October 2019.

businesses.[101] It could also test the effects of human resource management practices on business and workplace-level productivity and performance.[102] As it contains information about employee location, it has the potential to be used to answer questions about the spatial impact of innovation.

Under the legislation in place at the time of publication, this data can only be analysed by Australian Government analysts employed by the ATO.

Through the Data Integration Partnership for Australia (DIPA) (Box 3.3), Australian Government agencies are able to integrate program and transactional data into BLADE, providing them with a powerful tool to evaluate the effectiveness of existing policies as well as provide an evidence base for development of new policies and programs. Linking additional datasets would enhance analytical capabilities further. However, there are currently long lead times, due to the complexity of integrating new data sources, and the limited resources available to do so.

Box 3.3: The Data Integration Partnership for Australia (DIPA)

What is DIPA?

DIPA is a whole-of-government collaboration of over 20 Australian agencies that is maximising the use and value of government administration and transactional data assets.[103] DIPA is doing this by improving technical data infrastructure and data integration capabilities across the Australian Public Service (APS). DIPA ensures the privacy and security of sensitive data is preserved by providing access only to controlled, de-identified and confidentialised data for policy analysis and research.

DIPA is composed of several components including:

- data infrastructure and integration
- data assets
- data analytical units
- communication and engagement on data initiatives
- technical review and advice.

Individual agencies are responsible for the delivery of their individual components. A Deputy Secretary-level DIPA Board provides strategic oversight and coordination and reports to the Secretaries' Data Group.

[101] OECD, 2015, 'The Future of Productivity', Joint Economics Department and the Directorate for Science, Technology and Innovation Policy Note, July 2015.

[102] F Andersson, C Brown, B Campbell, H Chiang, & Y Park, 'The Effect of HRM Practices and R&D Investment on Worker Productivity', The National Bureau of Economic Research, University of Chicago Press, Chicago, 2008, pp. 19-43.

[103] Department of Prime Minister and Cabinet 2019, Data Integration Partnership for Australia Department of Prime Minister and Cabinet, Canberra, viewed 29 October, 2019, <https://pmc.gov.au/public-data/data-integration-partnership-australia>.

A large amount of innovation-related research and analytical work has also been progressed by Australian Government agencies outside the purview of DIPA and BLADE, including:

- The Department of Education's 'uCube', which provides access to multi-dimensional time series data based on selected data collected through the Higher Education Statistics Collection[104]
- The DESSFB's 'Labour Market Information Portal' (LMIP), which publishes industry and employment trends based on research in the areas of skill shortages, recruitment experiences, labour and skills needs.[105]

The ABS has also enhanced the value of census data through data integration to leverage more information from the combination of individual datasets than is available from the separate datasets. For example, the ABS has linked Census data with data from the Department of Home Affairs on migrant settlement and temporary entrant visa holders. [106,107]

Analysis undertaken by state and territory governments

The focus of innovation-related analysis and research undertaken by state and territory government agencies is on understanding innovation activity and impacts at the state and territory level, and sometimes in smaller areas, to provide an evidence base for state and territory-based programs and initiatives.

The NSW Innovation and Productivity Scorecard is an example of a state-based innovation system reporting mechanism, and is discussed further in Chapter 1.[108] This analysis is meeting a demand not generally met through other means, since there is limited state and territory-level innovation-related information currently available.

Analysis undertaken by academia

The academic community is an important source of knowledge and analytical capability and a significant contributor to innovation-relevant research.

With regard to the Australian Government's BLADE projects, a number of academic institutions have been involved, including the Australian National

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[104] Department of Education, uCube – Higher Education Data Cube, 2019, Department of Education, Canberra, viewed 29 October, 2019, <https://www.education.gov.au/ucube-higher-education-data-cube>.

[105] Department of Employment, Skills, Small and Family Business 2019, Labour Market Information Portal, Department of Employment, Skills, Small and Family Business, Canberra, viewed 29 October, 2019, <http://lmip.gov.au/>

[106] Australian Bureau of Statistics 2019, Insights from the Australian Census and Temporary Entrants Integrated Dataset.

[107] Australian Bureau of Statistics 2019, Understanding Migrant Outcomes – Insights from the Australian Census and Migrants Integrated Dataset.

[108] New South Wales Innovation and Productivity Council 2018, 2018 and 2019 NSW Innovation and Productivity Scorecards, News South Wales Innovation and Productivity Council, Sydney, viewed 29 October 2019.

University (ANU), Swinburne University of Technology, the University of New South Wales (UNSW), and the University of Technology, Sydney (UTS). There is an opportunity for Australian governments to enhance the effectiveness of academic capability through improved access to the data held by Australian governments, as discussed later in Chapter 4.

Analysis undertaken by private sector

The digitalisation of data globally is changing the data landscape and presenting new opportunities for analysis. There are an increasing number of private sector organisations who have access to data that could be valuable for public good purposes. Many of these organisations may be interested in making information available to Australian governments. The *Proceedings from the Innovation Metrics Review Workshop* (at Appendix D) discusses policy-relevant innovation related research and analysis that is being undertaken by the private sector. [109]

Analysis undertaken by international organisations

Various international organisations undertake analytical work to contribute to evidence needed by policymakers to inform decision-making. Organisations such as the OECD undertake analysis work that often involves cross-country studies to complement national level studies. A range of OECD work is engaging with (sometimes confidential) business-level data across OECD countries to explore innovation and productivity performance. Such cross-country analysis can complement national studies, as national studies alone cannot identify whether findings for a particular country are only applicable for that country or part of a broader pattern. For example, ongoing OECD work on R&D tax credits, covering more than 20 countries (including Australia), has identified new patterns in the role of R&D tax credits and direct support across countries.[110]

Barriers exist to progressing research and analysis

The Review found some common themes across different stakeholders in relation to barriers that prevent or limit innovation-related research and analysis from being undertaken.

Coordination of research and analysis is lacking

While there has been Australian Government progress in regards to innovation-related research and analysis, because responsibilities are split across agencies, analysis work is largely progressed based on individual agency needs and resource availability, although the DIPA process means projects using BLADE are coordinated and prioritised between participating agencies. Often these activities are undertaken without a national view of priorities. In

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[109] Department of Industry, Innovation and Science 2019, Proceedings from the Innovation Metrics Review Workshop, Department of Industry, Innovation and Science, Canberra.

[110] S Appelt, F Galindo-Rueda & A. González Cabral 2019, Measuring R&D tax support: Findings from the new OECD R&D Tax Incentives Database, OECD Science, Technology and Industry Working Papers, No. 2019/06, OECD Publishing, Paris, <https://doi.org/10.1787/d16e6072-en>

addition, there are limited channels for stakeholders to communicate data and research needs, and to coordinate and set whole-of-government research priorities.

While DIPA (Box 3.3) provided some initial investment to improve the data infrastructure for research and analysis, ongoing investment is required to maintain and improve the capability of infrastructure, including making analytical tools available to researchers. Existing innovation datasets are currently linked according to the priorities set by DIPA. These priorities are set on a whole-of-government basis and there is no prioritisation of projects outside the purview of DIPA.

Limited engagement with the OECD and other international bodies is reducing the opportunity for Australia to leverage international work

There is an incentive for individual agencies to reduce costs by limiting their engagement in international work. This means that Australia is not being quick to leverage international work of relevance to Australian issues, and is not contributing its experiences to cross-country studies. The Review identified some Australian innovation measurement issues that should have been addressed before now in the light of international experiences (such as the importance of comparable reference periods), and instances where Australian involvement could have added value more broadly (for example, by stressing the importance of non-R&D innovation expenditure, where lack of visibility of this issue in some countries has impacted on the OECD's ability to attract funding to undertake work in this area).

Lack of visibility and access to innovation-related data sources is a barrier to analysis for many stakeholders

The consultation process highlighted problems related to both visibility and accessibility of innovation-related data sources.

Not all government datasets are visible or accessible to analysts, or even to government analysts in the same level of government, i.e. Australian, state or territory, and sometimes even within the same organisation or entity. Consequently, an enormous amount of existing data is not being utilised for analysis because analysts are not aware that the data exists or they are unable to obtain the data.

Limited access to linked datasets, e.g. via BLADE, and to unlinked government administrative datasets, are hindering data analysis, thus limiting the value of this data for policy and program design and evaluation. For example, analysis undertaken by universities and researchers is limited by current restrictions on accessing BLADE. This is reflected in the low number of academic institutions that are involved in BLADE projects.

Additionally, there are a limited number of state and territory government agencies utilising data integration tools, such as BLADE. State and territory government users require a greater focus on geographical location.

The Productivity Commission's public inquiry on data availability and use suggested that there was a large potential for data linkage and integration at the Australian level that had not been realised due to complex efforts required to work around conflicting legislative and internal policy requirements.[111]

Access to ABS microdata has been streamlined in the past 12 months to deliver more timely access in a safe and secure way. In March 2019, the ABS implemented non-secondment access to BLADE microdata for government employees, government contractors, and individuals sponsored by government departments for approved projects. Some stakeholders are still unaware of this and there would be merit in promoting it further through the academic community.

There are trade-offs being made in relation to the increased value of data that is shared for use in additional analysis and the need to limit access to protect the rights of those that supply it and the integrity of the data, given that many of the government datasets that analysts seek access to are sensitive in nature. This is a complex issue, expected to be addressed by new legislation in the near future.

Limited analytical capability and capacity to undertake research and analysis on innovation in the government sector

There is limited analytical capability and capacity to undertake research and analysis in the government sector.

More analysis is needed, but there is a lack of people with the skills to perform it. Data inaccessibility is causing a 'chicken and egg' problem with regard to analysts, both within and outside of the government sector – analysts are unable to gain access to innovation-relevant data and are therefore not able to develop the skills needed to analyse the data.

This also impacts upon the pool of skilled analysts that are able to provide training on how to analyse innovation-relevant data. For analysts who have developed digital capability and mathematical skills in other fields, there is no clear pathway to develop innovation-relevant data analysis skills.

A whole-of-government approach to research and analysis is needed

RECOMMENDATION 3.1: TAKE A WHOLE-OF-GOVERNMENT APPROACH TO INNOVATION RESEARCH

The responsible entity should take a whole-of-government approach to innovation research, drawing on capabilities across Australian, state and territory government agencies, academia and the private sector.

The aim would be to build strong analytical capability regarding of Australia's innovation ecosystem.

[111] Productivity Commission 2017, Data Availability and Use, Inquiry Report No. 82, Productivity Commission, Canberra.

Ongoing investment is needed to provide infrastructure with sufficient capability and capacity to support research

While DIPA provided for some initial investment to improve the data infrastructure for research and analysis, ongoing investment is required to maintain and improve the capability and capacity of infrastructure to support research, including making analytical tools available to researchers.

Analysis and research of innovation-relevant data is essential to inform policy decisions.

There is a need to progress policy research and analysis to address whole-of-government innovation-relevant information priorities effectively and efficiently.

To do this, the following is needed:

- ability to identify whole-of-government innovation-related research and analysis requirements, and their relative priorities
- access and visibility of the innovation-related data sources to support research and analysis
- ability to enhance the analytical value of data sources and statistical assets
- a critical mass of analytical capability, capacity and development to undertake research and analysis.

Ability to identify whole-of-government innovation-related research and analysis requirements and their relative priorities

As the Review has established, there are a large number of stakeholders and users of innovation-relevant data, analysis and research. A coordinated approach would enable the Australian Government to identify whole-of-government requirements and to draw on capabilities across Australian, state and territory government agencies, academia and the private sector to create a critical mass of resources and analytical capability.

In addition, many of the identified information gaps and emerging data and analysis needs are not unique to Australia. There may be opportunities to collaborate internationally to develop solutions.

Access to and visibility of innovation-relevant data sources to support research and analysis

Existing innovation datasets are currently linked according to the priorities set by DIPA. There is no whole-of-government prioritisation of projects outside the purview of DIPA. There is a need to establish a process for prioritising access to innovation datasets. The datasets of greatest value for innovation measurement should be available for integration through tools such as BLADE.

Preparing data for integration to ensure the privacy and confidentiality of sensitive data is protected is a costly process. Not all government administrative and transactional data are considered valuable enough to warrant such treatment. However, the potential gains from integrating the more valuable datasets – such as the trade data that has recently been added to BLADE – are large enough to justify incurring such costs.

Ability to enhance the analytical value of data sources and statistical assets

There is an opportunity to leverage existing official statistical assets, such as BLADE (Box 3.2) and the LLEED (Box 3.3).

The analytical utility of BLADE could be enhanced through integration of additional appropriate data sources and the inclusion of location-based data where possible.

There would be merit in allocating resources specifically to enhance the analytical value of innovation data sources through making them more accessible.

Similarly, LLEED is of considerable analytical value, particularly in understanding the innovation system, linkages and impacts. Accelerating the development of LLEED would be of significant value to further inform the understanding of 'human capital' in innovation, and of the locational impacts of innovation.

There are also opportunities to present existing data in new ways.

The Review has also identified opportunities to present existing data in new ways, to provide a more complete picture of innovative activities and their impacts.

Australia currently collects business innovation indicators through the BCS.[112] This is a large omnibus collection of questions designed for different purposes, some of which are administered annually and some every two years. Internationally, some countries have developed 'innovation profiles' using 'Community Innovation Survey' [113] data (the European equivalent of BCS data) to provide deeper insight on the styles and modes of innovation and innovative capabilities within businesses, industries and the broader economy.[114] The profiles determine if businesses are 'strategic', 'intermittent', 'adaptive' or 'adoptive' innovators. As highlighted by Arundel et al. (2019), 'innovation profiles might explain much better different innovation performances of economies – and would point more precisely to different policy measures that

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[112] Australian Bureau of Statistics 2019, Characteristics of Australian Businesses,

[113] Eurostat, European Commission, 2019, Community Innovation Survey (CIS), European Commission, Eurostat, viewed 29 October 2019, <https://ec.europa.eu/eurostat/web/microdata/community-innovation-survey>.

[114] A Arundel & H Hollanders, EXIS: An exploratory approach to innovation scoreboards, Maastricht Economic and Social Research Institute on Innovation and Technology Maastricht University, European Commission, Enterprise Directorate-General, Brussels, March 2005. viewed 16 December 2019 <https://pdfs.semanticscholar.org/8f1c/b1917d76623f78a3c66a9d28eb1a5326b094.pdf >

would be effective to increase it in each context'.[115] Australia could undertake similar analysis using existing BCS data – with no increase in provider burden – to enable new insights into the innovative behaviours of Australian businesses.

There are emerging opportunities to analyse alternative sources of data.

As highlighted in Chapter 2, there are an increasing number of private sector organisations who hold data that could be valuable for public good purposes and who may be interested in making information available to Australian governments at a summary level. In general, such businesses are not willing to share the records of individuals or businesses – to protect customer privacy and confidentiality – but are willing to share aggregates or run programs and the findings of specific analyses conducted for public good reasons, sometimes as a public service and sometimes for a fee.

There are also opportunities to use existing data to provide benchmarking tools

System level benchmarking tools, such as the Scorecard, are an effective mechanism for comparing the broader performance of aspects of the innovation system.

However, system level benchmarking tools are of limited use for individual businesses wanting to know how they are performing in comparison to others in the same sector and of similar size. There are opportunities to engage directly with the business sector about innovation using existing data to provide benchmarking tools. This has been a focus in many other countries, including in Canada, where the Government implemented a report builder that is able to compare the financial data of a particular business with industry averages.[116] A similar innovation performance benchmarking toolkit for Australia could benefit businesses by helping them to understand:

- how their innovation activities and other characteristics compare to others in their sector or of their size
- government support that they may be eligible to receive.

In addition, benchmarking tools can be useful to incentivise businesses to keep records and report on their innovation activities.

Recent research by BizLab in DIIS found that businesses could benefit from the use of such benchmarking tools, particularly if they are easy to find and well-publicised amongst those that commonly advise businesses, such as accountants.[117]

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[115] Community Innovation Survey Task Force, 'Task Force Meeting on the Community Innovation Survey – Innovation Profiling in the EU based on CIS data – State of Play', European Commission, Eurostat, Luxembourg, 9–10 April 2019.

[116] Government of Canada 2015, Financial Performance Data, Government of Canada.

[117] Department of Industry, Innovation and Science, Digital and Data-driven Innovation Project Report, 2019. (forthcoming)

A critical mass of analytical capability and capacity

There is a shortage of skilled analysts available in the government sector to undertake the analytical work required, in terms of both capability and capacity. There is, however, a large amount of analytical capability, skill and knowledge available in academia and the private sector. Greater cooperation with university and the private sector could help provide the critical mass needed to progress research and analysis. This would also provide a channel for innovation stakeholders to transfer knowledge, communicate data and research needs, and respond to and influence whole-of-government research priorities.

A coordinated approach to innovation research would also create a critical mass of resources, including infrastructure development, through leveraging capabilities across Australian, state and territory government entities, academia and the private sector.

This could also be a function of the lead entity with regard to the measurement of the Australian innovation ecosystem (see Chapter 4).

4. Leadership on innovation measurement

Key points

- **There are a large number of stakeholders and users of innovation data across Australian, state and territory government agencies, the research and academic communities, and the private sector**
- **Stakeholders are playing important roles in measuring and monitoring Australia's innovation system, and each has different – and sometimes competing – needs**
- **At present, there is no single body with responsibility for leadership on innovation measurement in Australia. As a result, the innovation measurement system is fragmented**
- **A lack of a coordinated approach to innovation measurement in Australia makes the development of a national strategic approach to measuring innovation difficult and unnecessarily resource-intensive**
- **As the Australian economy continues to change and develop, new requirements for data, metrics, and analysis of issues relevant to innovation are emerging. Strong leadership will make it easier and cheaper to meet these needs by reducing the costs of transitioning to new ways of working**
- **National leadership on innovation measurement is therefore needed to establish priorities and timeframes to address key innovation measurement issues.**

There are a large number of innovation measurement system stakeholders with differing and competing priorities

There are many stakeholders playing important roles in measuring and monitoring Australia's innovation system. Stakeholders and users of innovation data are spread across Australian, state and territory government agencies, the research and academic communities, and the private sector, each having different and sometimes competing priorities. For example, stakeholders have relationships ranging from supply and use of innovation-related data, research and analysis, and delivery and evaluation of innovation-related policies and programs. In reality, however, these interactions and relationships are much more complex.

Each of these stakeholders have responsibility for measuring key areas of the innovation ecosystem. However, their roles, needs and priorities can differ substantially, and are sometimes competing. The following section provides an overview of the roles of some of the key innovation system stakeholders.

Australian Government agencies

Table 4.1: Australian Government agencies

Australian Bureau of Statistics (ABS)	
Description	The ABS is Australia's national statistical agency, providing trusted official statistics on a wide range of economic, social, population and environmental matters of importance to Australia.
Key role(s)	**Collection and dissemination of key innovation related data** ▪ The role of the ABS includes providing statistical information, and coordinating and advising official bodies on statistics, including developing – and ensuring compliance with – statistical standards ▪ The ABS carries out a number of activities for measuring innovation in Australia. These include conducting key national surveys designed to collect data on innovative activity in Australian businesses, such as the suite of Research and Experimental Development surveys, the BCS, and the VC&LSPE Survey. **Data integration** ▪ As an Accredited Integrating Authority, the ABS has a key role in DIPA to combine public data, as authorised by law, provide access to authorised users and expand existing Australian data integration projects to include new data, including the Multi-Agency Data Integration Project (MADIP), and BLADE. **Research and analysis** ▪ The ABS conducts research and analysis across a range of topics related to innovation. **International reporting** ▪ The ABS has international reporting obligations with international bodies, such as the OECD, International Labour Organization (ILO), and the United Nations, Educational, Scientific and Cultural Organisation (UNESCO).

Department of Industry, Innovation and Science (DIIS)	
Description	DIIS is the Australian Government agency responsible for innovation policy. Portfolio agencies include: ▪ Australian Nuclear Science and Technology Organisation (ANSTO) ▪ Commonwealth Scientific and Industrial Research Organisation (CSIRO) ▪ Geoscience Australia ▪ IP Australia ▪ National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) ▪ Northern Australia Infrastructure Facility (NAIF).
Key role(s)	**Innovation policies and programs** ▪ DIIS has responsibility for a number of key innovation policies and programs, including the Research and Development Tax Incentive (RDTI), Entrepreneurs Program, Industry Growth Centres and Cooperative Research Centres (CRC) ▪ DIIS needs quality measures to be able to evaluate the impacts and effectiveness of its policies and programs. **Collection of innovation related data** ▪ Through delivery of its programs and other functions, DIIS collects data that can be used in evaluation, research and analysis ▪ DIIS produces the Science, Research and Innovation Budget Tables and the NSRC. **Innovation system performance monitoring** ▪ Since 2010, DIIS has been publishing the annual *Australian Innovation System Report* (now the *AIS Monitor*). The publication brings together a body of evidence on the structure and performance of Australia's innovation system, based on a range of key indicators from new and existing sources. The Monitor explores the impact of innovation on business, industry and national performance, and also outlines challenges and future opportunities for Australian innovation. **Research and analysis** ▪ DIIS conducts research and analysis across a range of topics related to innovation to provide an evidence base for development and evaluation of policy and programs. **Data Integration Partnerships for Australia (DIPA)** ▪ DIIS has a leadership and coordination role with regard to the Economic Data and Analysis Network (EDAN) which is funded under DIPA.

Innovation and Science Australia (ISA)	
Description	Innovation Science Australia (ISA) is an independent statutory board of entrepreneurs, investors, researchers and educators which has a whole-of-government remit on innovation. Under the Industry Research and Development Act 2016, ISA has responsibility for providing independent strategic advice to the Secretary, the Minister and other Ministers in relation to innovation matters. Under the Act, ISA is also required to do anything incidental or conducive to the performance of its legislated functions, and may receive written directions from the Minister with portfolio responsibility for ISA. These written directions are delivered to the ISA Board via a Statement of Expectations, to which ISA responds with a Statement of Intent. While ISA has a whole-of-government remit on innovation matters, its role currently does not include providing leadership on innovation measurement.
Key role(s)	**Innovation system performance monitoring** ▪ ISA has published two key documents with relevance for innovation measurement, namely the Performance Review of the Australian Innovation, Science and Research System (2016), and Australia 2030: Prosperity through Innovation, a national roadmap to strengthen Australia's ability to innovate (2018) ▪ Through the above publications, ISA has developed scorecards to monitor the performance of the Australian innovation system, drawing on metrics and data from a range of sources. **Research and analysis** ▪ ISA commissions research across a range of topics related to innovation to enable it to provide strategic advice related to innovation matters.

Department of Education and Training (DET)	
Description	DET is the Australian Government agency responsible for national policies and programs related to early child care and childhood education, school education, higher education, international education and research.
Key role(s)	**Innovation policies and programs** ▪ DET needs to be able to evaluate the impacts and effectiveness of its policies and programs. **Collection of innovation related data** ▪ Through delivery of its programs, DET collects data that can be used in evaluation, research and analysis ▪ DET is responsible for the Higher Education Research Data Collection (HERDC). **Research and analysis** ▪ DET conducts research and analysis relevant to education, skills and training, and the role of higher education in the innovation system. **International reporting** ▪ DET has international reporting obligations with regard to the OECD. **Data Integration Partnerships for Australia (DIPA)** ▪ DET is a Member of the Social Health and Welfare Analytical Unit (SHWAU), which is funded under DIPA.

IP Australia	
Description	IP Australia is the Australian Government agency that administers IP rights and legislation relating to patents, trademarks, designs and plant breeders' rights.
Key role(s)	**Collection of innovation-related data** ▪ Through service delivery, IP Australia collects and disseminates key innovation-related data, e.g. IP Government Open Data (IPGOD) and IPLORD. **Research and analysis** ▪ IP Australia conducts research and analysis to enable it to contribute to the innovation system more broadly by providing advice to government and Australian businesses to make the most of their IP. **International engagement** ▪ IP Australia works with the World Intellectual Property Organization (WIPO) and a range of international agencies to build and strengthen the IP rights system. **Data Integration Partnerships for Australia (DIPA)** ▪ IP Australia data are linked to BLADE.

Other key Australian Government stakeholders to the innovation measurement system include (but are not limited to):

- Agencies with a whole-of-economy perspective on the impacts of innovation, such as Treasury and the Productivity Commission
- Agencies with more focused perspectives on the impacts of innovation such as: the Department of Defence; the Department of Communications and the Arts; the DESSFB; and the Department of Infrastructure, Transport, Cities and Regional Development
- Research agencies, such as the CSIRO and Geoscience Australia
- Research Councils, such as the Australian Research Council (ARC) and the National Health and Medical Research Council (NHMRC).

State and territory government agencies

Table 4.2: State and territory government agencies

State and territory government agencies	
Description	A number of state and territory government agencies carry out various innovation measurement activities. These activities are carried out by government departments directly or via specific agencies that are designated to undertake innovation related activities.
Key role(s)	**Innovation policies and programs** ▪ Delivery and evaluation of state and territory government innovation policies and programs. **Collection of innovation-related data** ▪ Collection of innovation-related data through program delivery. **Innovation system performance monitoring** ▪ State and territory government agencies carry out various innovation measurement activities. For example, the New South Wales (NSW) Innovation and Productivity Council provides a snapshot of the state's innovation and productivity performance in comparison to other states and selected international economies.[118] **Research and analysis** ▪ State and territory level agencies also undertake research and analysis. For example, LaunchVic is Victoria's start-up agency that was established by the Victorian Government in March 2016 as an independent agency responsible for developing Victoria's start-up ecosystem. The agency undertakes research in relation to the start-up ecosystem in Victoria. ▪ South Australian and NSW already have some BLADE access to facilitate research and analysis, and the Queensland Government was arranging access at the time this report was being finalised to facilitate research and analysis work by the Queensland University of Technology staff.

[118] NSW Innovation and Productivity Council 2018, NSW and Productivity Scorecard,

Academic and research community as well as the private sector

Table 4.3: Academic and research community and the private sector

Universities	
Description	As a key part of the research system, universities play a role in both the supply of data and in conducting research and analysis.
Key role(s)	**Data supply** ▪ Universities provide data to some key innovation-related collections such as HERDC and the R&D survey. **Research and analysis** ▪ A significant amount of innovation-related research is conducted by the academic and research community across a range of topics.
Private sector	
Description	The private sector is also a significant part of the innovation ecosystem, with businesses being the unit of measurement for a number of innovation metrics.
Key role(s)	**Data supply** ▪ Businesses provide data to some key innovation-related collections, such as the BCS and the R&D survey. **Collection of innovation-related data** ▪ There are private sector organisations that collect innovation-related data through service delivery. **Research and analysis** ▪ A number of private sector organisations also contribute to innovation-related research and analysis.
Organisation for Economic Cooperation and Development (OECD)	
Description	The OECD is an international organisation that provides a knowledge hub for data and analysis, exchange of experiences, best-practice sharing, and advice on public policies and global standard-setting.
Key role(s)	**Measurement frameworks** ▪ The OECD has developed international frameworks for the measurement of innovation-related subjects (e.g. the Oslo Manual and the Frascati Manual). **Collection and dissemination of innovation-related data** ▪ The OECD collects and publishes innovation data from member countries. Key publications include the STI Scoreboard and the MSTI. **Innovation system performance monitoring** ▪ Vis its publications, the OECD enables international comparison of innovation indicators. **Research and analysis** ▪ The OECD conducts a significant amount of analysis related to innovation across a range of topics.

Responsibility for measurement of the Australian innovation system is fragmented

The policy and research communities which shape the demand for innovation indicators are becoming more diverse and sophisticated. While innovation is a core issue for economic development, it is also a whole-of-government issue and relevant to all areas of administration and policy.[119]

Responsibility for Australia's innovation measurement system is currently split across Australian, state and territory government agencies, and the ABS.

At present, there is no single body with responsibility for leadership on innovation measurement in Australia. As a result, the innovation measurement system is fragmented, and Australia's understanding of international measurement developments is limited.

Lack of leadership poses a number of issues for the measurement of innovation:

- Decision-making is occurring in silos, with stakeholders focused on progressing their own needs without taking a whole-of-government perspective into account. The fragmented nature of the system is not aiding appropriate prioritisation or development of a national strategic approach to measurement of innovation, therefore, the current innovation measurement system is not functioning as well as it could
- As the Australian economy continues to change and develop, new requirements continue to emerge. There is currently no system to establish priorities to address new and emerging information gaps relating to innovation
- There is a lack of coordination across the innovation measurement system. The OECD has observed high personnel rotation in what should be in principle stable roles and the challenges arising from restrictions to participation in OECD meetings. A key issue for the OECD (and other international entities) is that there is no easy way for them to identify which entities and staff should be contacted as part of international engagement regarding measurement of innovation
- The OECD is keen for Australia to engage with the international community with regard to innovation, science and technology measurement. At present, Australia's involvement in international work has been limited
- Similarly, there is no single point of contact – or even a single starting point – for international engagement on innovation measurement. The Review found several instances where international entities had inadvertently cited old data or incorrectly said that Australian data was not available, because the researchers compiling international data did not know where to look for the most recent and relevant Australian innovation data. Frequent machinery of government changes and changes of roles make Australian innovation ecosystem measurement responsibilities largely opaque to

119 L Georghiou, 'Challenges for Science and Innovation Policy' ResearchGate, March 2013, pp 233-246.

international researchers. This, in turn, impacts on Australia's access to valid international comparisons.

International examples of leadership of innovation measurement

Australia is not the only country grappling with providing leadership on innovation measurement. Other countries also seem to have fragmented responsibilities and accountabilities in this regard. There are some countries that have an established leadership (or even partial leadership) of innovation measurement. Different leadership examples in the US, the United Kingdom (UK) and Germany are discussed below. The entities in these examples support, coordinate and provide leadership for innovation measurement (albeit to varying degrees).

The United States

The National Science Foundation (NSF) is an independent US federal agency whose mission includes support for all fields of fundamental science and engineering, except for medical sciences.[120] It is the only federal agency with a whole-of-government remit. The NSF supports scientists, engineers and educators directly through their own home institutions.

The policies of the NSF are set by a 24 member National Science Board (NSB) within the framework of applicable national policies set forth by the President and the Congress. The NSB identifies issues that are critical to NSF's future and approves NSF's strategic budget directions. Among its functions, the NSB publishes a biennial report, Science and Engineering Indicators (Indicators), which provides comprehensive, policy-neutral information on the nation's science and engineering enterprise. In addition to the main report, the NSB produces a suite of related resources.[121]

The National Center for Science and Engineering Statistics (NCSES) was established within the NSF. Its mandate is the collection, interpretation, analysis, and dissemination of objective data on the U.S. science and engineering enterprise.[122] As one of 13 federal statistical agencies, NCSES designs, supports, and directs periodic national surveys and performs a variety of other data collections and research. Other agencies collecting innovation related information include the Bureau of Labor Statistics (BLS), the Census Bureau, the BEA, the National Institute of Standards and Technology (NIST), and the Economic Research Service at the Department of Agriculture. The National Center for Education Statistics is also relevant as it collects data on STEM education and publishes comprehensive information on education in its 'Digest of Education Statistics'.

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[120] National Science Foundation, About the National Science Foundation, Alexandria, Virginia, viewed online 8 October 2019, < https://www.nsf.gov/about/>.

[121] National Science Foundation, National Science Board, Alexandria, Virginia, viewed 8 October 2019, < https://www.nsf.gov/nsb/about/index.jsp>.

[122] National Science Foundation, About the National Center for Science and Engineering Statistics (NCSES), Alexandria, Virginia, viewed 8 October 2019, <https://www.nsf.gov/statistics/about-ncses.cfm>.

The United Kingdom

The UK has separate entities that are responsible for leadership on innovation matters. UK Research and Innovation, together with its research councils, work in partnership with universities, research organisations, businesses, charities, and government to create the best possible environment for research and innovation to flourish.[123] Measurement of innovation is conducted by government departments, including the Department of Business, Energy and Industrial Strategy (BEIS). The UK Innovation Survey[124] is conducted on behalf of BEIS by the Office for National Statistics.

The leading thinking on innovation measurement in the UK continues to be from the National Endowment for Science, Technology and the Arts (Nesta). Established in 1998 as a Charity, Nesta is an innovation foundation that acts through a combination of programmes, investment, policy and research, and the formation of partnerships, to promote innovation across a broad range of sectors.

Recent work undertaken by Nesta includes development of new ways to use UK administrative data to map innovation activity in Wales. Nesta has also used the data for sectoral mapping analysis, as defined with high level groupings of industry code data. The outputs of this work, 'Arloesiadur is an innovation dashboard for Wales', which is a collaboration between Nesta and the Welsh Government. Nesta has used the new data to measure and visualise Wales' industry, research, and tech networks with the goal of informing policies that drive growth.

Germany

Germany's approach to leadership on innovation measurement is undertaken by the Commission of Experts for Research and Innovation (EFI). The EFI advises the German Federal Government on innovation performance in Germany.

A key task for EFI is to provide a comprehensive analysis of the strengths and weaknesses of the German innovation system in an international context, based on latest comparison data. It also coordinates the priority and indicator studies of the involved scientific institutions and integrates its key findings into commission reports.[125] Furthermore, Germany's perspectives as a location for research and innovation are evaluated on the basis of the latest research findings. The EFI also presents proposals for national research and innovation policy, including the presentation of an annual report.

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[123] UK Research and Innovation, About Us, Our Councils, London, viewed 8 October 2019, <https://www.ukri.org/about-us/our-councils/>.

[124] Office for National Statistics, UK Innovation Survey, United Kingdom, viewed 15 October, 2019, <https://www.ons.gov.uk/surveys/informationforbusinesses/businesssurveys/ukinnovationsurvey>.

[125] Expertenkommission Forschung Und Innovation, Office tasks, Berlin, viewed 15 October, 2019, <https://www.e-fi.de/en/geschaeftsstelle/aufgaben/>.

EFI members are appointed by the German Government, however the EFI is independent in its action.[126]

An opportunity for Australian leadership

The experience in other countries, and the feedback received through the Review, suggests that the Australian model, and indeed most models, are insufficient to coordinate the measurement of innovation well. In general, responsibility and accountability are split between too many parties for best results.

Assigning responsibility for leadership on innovation measurement

RECOMMENDATION 4.1: ASSIGN RESPONSIBILITY FOR LEADERSHIP OF INNOVATION MEASUREMENT

Appoint a single entity with a whole-of-government remit, to provide national leadership for innovation measurement and reporting.

This leadership role will entail:

- collaborating with stakeholders to identify and address data and metrics gaps, and ensure the continued relevance of innovation data and metrics taking into account Australia's changing economy, society and environment
- reporting to the Australian Government on the progress of the implementation of recommendations proposed in this Review
- ensuring Australia is represented in international efforts to improve innovation, science and technology measurement
- being a single point of contact to facilitate international engagement on innovation measurement issues
- allocating work through contract management to enable it to perform these functions.

This leadership role will not entail:

- collecting data directly
- conducting research directly.

The entity would collaborate with the ABS to ensure new data and metrics were consistent with international work where appropriate.

A single entity could be assigned responsibility to provide national leadership of innovation measurement and reporting. The complexity of the innovation system necessitates that the responsible entity has a whole-of-government remit.

[126] Expertenkommission Forschung Und Innovation, Law on Appointment of the Commission of Experts, 2006, Berlin, viewed 8 October, 2019, <https://www.e-fi.de/1/expertenkommission/einrichtungsbeschluss/>.

The responsible entity would also report annually on the performance of the innovation ecosystem in Australia as part of an innovation metrics scorecard (see Chapter 1).

Assigning responsibility for leadership to a single entity would provide significant benefits, such as:

- enabling Government to develop a more efficient, strategic national approach to innovation measurement
- improving collaboration amongst innovation system stakeholders
- ensuring that data gaps in key areas of the innovation system are addressed
- ensuring that new and emerging data needs are identified and addressed as the economy continues to evolve
- providing a single point of contact for tracking and reporting on the internationally comparable performance of Australia.

With regard to the single point of contact function, it is not envisaged that this entity would have all current innovation data available for dissemination. Rather, it should know where the data are kept and which organisational unit in each particular entity should be contacted to obtain access to the most recent and relevant data.

5. Roadmap for change

Key points

- **The roadmap for change discusses issues in relation to the priority and timing of the implementation of recommendations**
- **It also discusses future work that was beyond the scope of this Review but could usefully be undertaken in future.**

Implementing the recommendations of the Review

The Review has made a number of recommendations to improve the measurement of the Australian innovation ecosystem, as listed earlier in this Report. However, they are not all of equal priority or equally time-sensitive.

Relative priority of recommendations

There are recommendations that have a very high priority. This is due to them having high expected returns on investment on information infrastructure for Australia if the outcomes of those recommendations are delivered.

These recommendations include the responsibility for leadership on innovation measurement (Rec. 4.1) and annual innovation system reporting (Rec. 1.1) that are necessary for the proper implementation of other recommendations. Others are opportunities to change the measurement of the innovation landscape significantly for the better, namely:

- a standalone Australian Business Innovation survey (2.3)
- improving measures of intangible capital (Rec. 2.7)
- annual R&D measures of expenditure (Rec. 2.1)
- measures of business use of digital technologies (Rec. 2.2)
- measuring digital activities in the economy (Rec. 2.8)
- taking a whole-of-government approach to innovation research (Rec. 3.1)
- sectoral analyses (Rec. 2.4)
- measuring government acquisition of innovation (Rec. 2.9).

The two recommendations on classifications review (ANZSCO and ANZSIC) are a high priority. They are both large, complex recommendations that would be expensive to implement. Nevertheless, the expected benefits to the innovation measurement system as a result of their implementation are expected to be large, through supporting better analysis. The ANZSIC review (Rec. 2.6) is the only recommendation that should not be commenced immediately, if supported. Instead, it should be commenced a year after the commencement of the ANZSCO review (Rec. 2.5). The ANZSCO review is the higher priority of the two recommendations and it will be easier to implement than the ANZSIC review, which is a much larger job.

If the ANZSCO review commences a year prior to the ANZSIC review, it is expected that the ABS will be able to use staff who have acquired skills during the development phase of the ANZSCO review to conduct the development phase of the ANZSIC review. It is therefore recommended that these commence a year apart, with the ANZSCO review occurring earlier.

The Review's remaining recommendations indicate the direction required to improve the measurement of Australia's innovation ecosystem. Further work will be required in these areas after they have been implemented to optimise innovation measurement, namely:

- measures of entrepreneurship (Rec. 2.10)
- business access to finance for start-ups (Rec. 2.11)
- location-based innovation (Rec. 2.12)
- research commercialisation (Rec. 2.13).

The relative priorities of the recommendations are outlined at Appendix J.

Assessment of the potential impact of the Review's proposed recommendations

The Review has made an assessment of the current state of a wide range of data and metrics that are relevant to innovation measurement and are heavily used in policy and program development, implementation and evaluation (see Figure 5.1). Data and metrics that had no issues identified with them that would affect their use were assessed as 'green'. Those with some measurement issues were assessed as 'orange'. Those with significant measurement issues were assessed as 'red'. The Review has the expectation that the successful implementation of its recommendations will greatly improve the status of innovation-related data. Figure 5.1 summarises these expected changes.

Figure 5.1: Assessment of Australian innovation system data

Assessment of Australian innovation system data

Innovation ecosystem characteristic	Present state				Future state		
	Conceptual basis	Measurement issues	Data utility issues	IMR Recommendations	Conceptual basis	Measurement issues	Data utility issues
Intangible capital	SNA has limited coverage of types of intangible capital	Some types of intangibles are not measured	Not used as unavailable		Improved coverage	Unknown at this point	Unknown at this point
Digital activities in the economy	Unable to separate digital activities from otheractivities	Severe measurement issues	Limited data available		Steps towards an agreed framework	Unknown at this point	Unknown at this point
Government acquisition of innovation	No data published	Severe undercount	Not used as data unavailable		Steps towards understanding Govt. acquisition	Severe undercount	Not used as data unavailable
Research commercialisation	No conceptual framework	Definitions applied inconsistently	Existing data is not meeting needs		Sound	None	None anticipated
Industry and occupation classifications	Sound	Outdated classifications	Outdated classifications limit the utility of data		Sound	Updated classifications	None
Location-based innovation	Sound	Only national data is generally available	Not generally used as data unavailable		Sound	Steps towards regional data availability	Regional data will be used where available
Entrepreneurship	No consistent definitions or concepts	Data is not comparable across jurisdictions	Existing data is not fully meeting need		Steps towards an agreed framework	Regional comparability issues resolved	Improved utility
Business access to finance	Sound but partial	Limited coverage of sources of investment	Existing data is not fully meeting need		Sound but more complete	Steps towards broader coverage	Steps towards more useful data
Business innovation activities	Sound	Hidden innovation, reference period	International comparability compromised		Sound	Better coverage, comparable reference period	International comparability improved
Collaboration	Sound	Hidden collaboration, reference period (fee-for-service?)	International comparability compromised		Sound	Better coverage, comparable reference period	International comparability improved
Business use of ICT	Sound	Missing new technologies	Existing data is not fully meeting needs		Sound	Basket of new ICT technologies	None
Expenditure on R&D	Sound	None	Frequency, granularity		Sound	None	Annual, more granular R&D data
Business grants	Sound	None	None		Sound	None	None
Patents granted	Sound	None	None		Sound	None	None
Business entries	Sound	None	None		Sound	None	None

Which recommendations should be implemented as soon as possible

Two of the high priority recommendations are time-sensitive, as they leverage existing work by the ABS. These are the measurement of business innovation activities (Rec 2.3) and the measurement of business use of digital technologies (Rec 2.2).

If a decision is made to fund the implementation of the measurement of business innovation activities recommendation by October 2020, it is expected that the ABS will be able to develop a collection to be conducted in relation to the 2019–21 reference year. (The utility of this collection is likely to be maximised by a decision in May rather than in October 2020, given the load on the ABS in the lead-up to the 2021 Census.) This will lead to more relevant innovation data being published by mid-2022. If a decision is made to support this recommendation later than this, more relevant data may not be available until 2024, as this aligns the timing with OECD reporting of innovation indicators.

Business use of digital technologies is collected by the BCS, with the next release of these indicators scheduled for mid-2021. A decision to fund the implementation of the measurement of business use of digital technologies recommendation by May 2020 would provide the opportunity to produce more granular estimates against relevant indicators by mid-2021.

Funding the measurement of business use of digital technologies recommendation will also support the development and release of richer indicators, beyond what is provided in mid-2021, from mid-2023.

Further work

Assessing a wider range of innovation impacts

This Review concentrated on the economic impacts of innovation, as specified in its scope. Over the course of the Review, it was established that innovation is an important tool that is used to address a wider set of objectives. As highlighted in ATSE's literature review (see Table 2 of Appendix E), in addition to economic objectives and benefits, there is demand for relevant innovation indicators relating to the following impacts:

- Environmental – responding to climate change, the need for sustainable use of natural capital, water and energy
- Health and wellbeing – healthy aging and workplace health and safety
- Social – inclusion, addressing inequality and other issues (e.g. problem gambling).

Increasing interest in understanding and assessing a wider range of benefits of innovation warrants multiple approaches to measurement and indicators. However, connecting measures of innovation to economic and social outcomes is often even more challenging than quantifying innovation or its inputs.[127]

The OECD has a substantial program in environmental innovation policy and assessment (see Section 8.3 of Appendix E). The literature review also highlights a number of major projects that have contributed to the body of knowledge relating to environmental innovation. It also acknowledges that the

[127] National Academies of Sciences, Engineering, and Medicine, 'Advancing Concepts and Models for Measuring Innovation: Proceedings of a Workshop'. National Academies Press, Washington, DC, 2017.

development and implementation of a reasonably comprehensive set of indicators for eco-innovation will be demanding.

Despite those areas being beyond the scope of the Review, the Review's consultation process indicated there is demand from stakeholders to better understand the environmental, health and wellbeing, and social impacts of innovation. Further work in this area could usefully be undertaken.

Public sector innovation

Public sector innovation is an important area of innovation research that fell beyond the scope of this Review. In OECD countries, including Australia, the public sector contributes over 20 percent of GDP – too large a sector to ignore in terms of innovation.

There has been extensive debate over the past decade on developing indicators for innovation in the public sector that go beyond measures of R&D, with some now feeling there is adequate conceptual and methodological development to design a robust survey approach for public sector innovation in Australia.[128]

It has been proposed that such a survey should share some elements with the Oslo Manual but differ significantly in others. The OECD is consequently considering developing a measurement manual specifically for the government sector.[129] Experimentation with public sector innovation indicators is ongoing, with large-scale surveys in Norway and Denmark, and the European Co-Val survey initiated in February 2019.

This substantial work in the measurement of public sector innovation has been progressed internationally and could be leveraged to provide Australian indicators.

Innovation data gaps

The Review also noted data gaps that were that were unable to be investigated further or included in the recommendations due to time or resource constraints. Further consideration should be given to these gaps, in particular:

- Measurement of innovation and diversity

There is a need for improved data and statistics in the measurement of innovation related to diversity (e.g. gender, age and ethnicity) to inform policy development and facilitate business utilisation of potentially underutilised resources. The Review has not made specific recommendations on the additional diversity data to be collected but has identified this as an area for future research, and has summarised the feedback obtained from its consultation process in Chapter 2.

- Measures of workforce skills

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128 A Arundel, C Bloch, B Ferguson, 2016. 'Measuring innovation in the public sector.' OECD Blue Sky Forum III, viewed 3 December, 2019.

129 A Arundel, 'Trends in measuring public sector innovation', presentation to Department of Industry, Innovation and Science, Canberra, 2019.

There are problems with using qualifications and experience as proxies for skills (see Chapter 2). Skills classification work is currently being undertaken by the DESSFB. The single entity with national leadership of innovation should ensure this work also meets the innovation ecosystem's need for skills data.

- Management capability

Management capability is a relatively new area of focus for innovation measurement and limited data has been collected and published to measure business management capabilities. Some of this data has proven to be valuable but the relatively high cost associated with the MCM of the BCS has diminished support for administering this particular module again in the same way in the near future. The importance of this data means that other statistical solutions should be considered further.

Appendix A: Scope of the Review

In embarking upon the Review, the co-Chairs established a guiding set of goals and principles along with the scope of the Review, and these were refined and agreed with the international Steering Committee. The goals and principles appear in the Introduction. The scope is given below.

The Review has several broad objectives:

- To undertake a written international literature Review of different approaches to the measurement of innovation to ensure the Review is conceptually well-grounded and at the forefront of international thinking, tapping into new developments from abroad
- To provide a theoretical framework to underpin the design of data collection to measure innovation in Australia, by first producing a discussion paper and seeking feedback on it from an Expert Group and selected international technical advisers
- To examine the measurement of intangible capital and the extent to which changes in intangible capital are captured in innovation metrics
- To look at the data presently available to support the development of innovation metrics and identify the gaps
- To provide recommendations on what to change about current data collection activity aimed at measuring innovation in Australia from an economic perspective, giving a range of options which would more fully address stakeholder needs, and explaining the benefits and costs of each
- To provide recommendations on better options to replace poor quality metrics, or to cease production of metrics whose quality is so poor they are not worth producing
- To develop a set of assessment criteria to determine what constitutes a good metric
- To identify the best metrics presently available
- To identify the best metrics that would be available (including new metrics) based on the data generated if each of the data development options presented was implemented, and in what timeframe
- To consider the composition of an innovation scorecard that will inform policy development, including metrics that
    - measure innovation activity
    - support international comparability
    - increase the transparency of the extent and nature of innovation activity occurring across different industry sectors.

While the framework adopted will be capable of expansion, given the limited budget and timeframe, the Review will focus on addressing the needs identified in this document and the scoping process.

The Review will explore a range of options, including the establishment of a satellite account for innovation, which would measure the contribution of innovation to the economy, and address known data issues, before developing its recommendations. It will make specific recommendations with regard to, but not limited to:

- international comparisons using innovation data
- DIIS' NSRC
- ABS' BCS, the Management Capability Survey (MCS), and surveys of Research and Experimental Development
- DIIS and DET program and transactional data and metrics including the Higher Education Research Data Collection (HERDC)
- the use of non-traditional data sources.

These may include options to redesign or replace current Australian data sources. With regard to more substantive issues that cannot be fully developed in a year, it may propose a road map for further development.

Targeted consultation will be undertaken prior to the preparation of the issues paper to be considered at a workshop on 13–14 March 2019. A public consultation process will be undertaken before the report is finalised.

The Review report will be presented to the Australian Government for its consideration by the end of 2019.

Appendix B: Sectoral studies

Purpose

The Innovation Metrics Review (IMR) undertook four sector-based case studies to provide insight on:

- how innovative activities occur across different sectors of the Australian economy
- how current innovation measures are capturing (or not capturing) those innovation activities
- what is possible and practical in measurement of innovation activities
- how measures might be improved to provide a more comprehensive picture of relative innovation performance in all sectors of the Australian economy, and assist policy makers to make evidence-based decisions?

Background

A key concern highlighted in the project plan for the IMR was that existing metrics and composite indices do not provide comprehensive coverage of innovation performance in all sectors of the Australian economy.

It is widely accepted that innovation is undertaken differently across various sectors of the economy. Innovation activities by their nature are novel and varied. Adding to this, the drivers, innovation ecosystems and regulatory factors that impact on an organisation’s need and ability to innovate differ greatly between sectors.

The extent to which innovation activities are ‘hidden’ from existing innovation metrics is not fully understood. ATSE discusses hidden innovation in its literature review (at Appendix E).

Box B.1: What is hidden innovation?

Until recently, innovation was conceptualised, defined and measured in terms of what was seen as ‘real innovation’– i.e. primarily technology- based innovation for manufacturing, involving R&D investment and patenting, from large companies and their internal labs. This encouraged innovation researchers to develop metrics for measuring innovation through input indicators, such as R&D funding, and number of research personnel, and output indicators based on patents and citations (see Appendix E).

This Review defines ‘hidden innovation’ as innovation activity that is not captured in current innovation indicators.

Nesta has suggested that a focus on sectoral innovation indicators, rather than the development of internationally comparable national indicators, is likely to be more successful in measuring hidden innovation. Nesta emphasised that greater recognition of the significance of ‘low innovation’ sectors (sectors that report low levels of R&D as a percentage of GPD, but which may be significant investors in technology) for value creation and employment, and a greater understanding of the real dynamics of innovation in these sectors, would lead to changes in the scope of innovation policy.[130]

There are a number of industries in Australia where such a focused approach to identifying innovation could better measure innovation activity. In both the agriculture and mining sectors, there are processes of creative accumulation based on continuous improvements, and processes of creative destruction when new technologies, capabilities, and actors emerge. Understanding the dynamics of innovation in both sectors will also require an approach that encompasses the role of knowledge flows and external suppliers.

The literature shows that innovation in services, such as health services and finance and insurance services, is much less likely to involve R&D or result in patents than product innovation. Hence, indicators, such as R&D and patents, are increasingly inadequate and can be misleading. Innovation in services is also more likely to be non- technological in nature and involve organisational and marketing innovations. Trademarks are becoming a more useful indicator than patents. The significance of digital technologies for innovation in services means that businesses' investment in such technologies might be a good indicator of innovation input effort.

As can be seen in the case studies that follow, the IMR found evidence of hidden innovation in Australia, almost exclusively of the non-R&D variety. In Australia, more businesses invest in non-R&D innovation.[131]

The IMR selected mining and agriculture as sectors to examine because of their importance to the Australian economy. These both export goods, so the IMR selected finance and insurance services, and health services, as examples of the service economy.

The four sectors selected for sectoral studies were:

1. Mining
2. Agriculture
3. Health Services
4. Financial and Insurance Services

Mining Sector

Rationale for selection

- Australia's mining sector contributed around $151.59 billion of Gross Value Added (GVA) to Gross Domestic Product (GDP) in 2017–18 at current prices (8.20 percent of GDP).[132] The mining sector had revenue

[130] M Harris & R Halkett, Nesta, 2007. Hidden Innovation- How innovation happens in six 'low innovation' sectors. Nesta, London.

[131] Australian Bureau of Statistics 2019, Characteristics of Australian Business 2017–18, cat. no. 8167.0.

[132] Australian Bureau of Statistics 2019, Australian System of National Accounts 2017–18, Table 5, ABS cat. no. 5204.0.

of $254.55 billion in 2017–18.[133] The mining sector employed about 227,000 persons full-time and 8,000 part-time as at the quarter ending August 2019[134]

- The mining sector is in the middle of a technological transformation, but there is concern that some of the innovation activities are 'hidden' from current measures
- While the number of businesses in the mining sector is small, its economic impact is large. Current business innovation metrics use the business as the unit of analysis without any weighting for size of the business. Therefore, when looking at metrics, such as the percentage of businesses that are innovation active, the contribution of the mining sector to the metric itself is not significant, despite the large overall economic activity of the mining companies supported by their suppliers
- There have been substantial cost reductions in iron ore extraction by large businesses in the sector since 2007,[135] but there may be gaps in reporting these cost savings from new processes, whereas increases in revenue from new goods or services are captured
- Over this same period, Australia's share of international exports in iron ore and coal has grown substantially, despite Australia's high salary cost base[136]
- There is interest in better understanding the impacts of innovation occurring in the mining sector, for example, through cost reductions, productivity gains, revenue increases, or otherwise, and the practicalities that may be involved in measuring them.

Agriculture Sector

Rationale for selection

- Australia's agriculture sector contributed around $47.99 billion of GVA to GDP in 2017–18 at current prices (2.60 percent of GDP).[137] The agriculture sector had revenue of $99.06 billion in 2017–18.[138] The agriculture sector employed about 2390,000 persons full-time and 80,000 part-time as at the quarter ending August 2019[139]

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[133] Australian Bureau of Statistics 2019, Australian Industry, 2017–18, Table 1, cat. no. 8155.0.

[134] Australian Bureau of Statistics 2019, Labour Force, Australia, Detailed, Quarterly, Aug 2019, Data cube EQ06, cat. no. 6291.0.55.003.

[135] Department of Industry, Innovation and Science 2019, 'Department of Industry, Innovation and Science, Resources and Energy Quarterly, September 2019', Department of Industry, Innovation and Science, Canberra, viewed 21 November 2019, <https://www.industry.gov.au/data-and-publications/resources-and-energy-quarterly-all>.

[136] ibid.

[137] Australian Bureau of Statistics 2019, Australian System of National Accounts 2017–18, Table 5, cat. no. 5204.0.

[138] Australian Bureau of Statistics 2019, Australian Industry, 2017–18, Table 1, cat. no. 8155.0.

[139] Australian Bureau of Statistics 2019, Labour Force, Australia, Detailed, Quarterly, Aug 2019, Data cube EQ06, cat. no. 6291.0.55.003.

- Australia is a major agricultural producer and exporter. Demand for agricultural products is set to increase in future as the world population grows
- The agriculture, forestry and fishing sector in Australia saw the largest MFP gains and labour productivity in 2016–17, compared to other sectors, despite facing quite challenging environmental conditions[140]
- Australia does measure innovation in agriculture through the ABS BCS. However, the Oslo Manual did not suggest the inclusion of agriculture, forestry and fishing in innovation surveys until the 4th edition (October 2018), so at present, international comparison data is scarce (Norway, Spain, Serbia, the Netherlands, Canada and New Zealand also publish innovation in agriculture data)[141,142,143]
- Data from 2016 and 2017 indicates that the proportion of agricultural businesses that are innovation active varies considerably (from 19.5 percent for Spain to 34.7 percent for Australia to 65.4 percent for Norway)
- Current Australian innovation measures show that agriculture is characterised by smaller businesses that are less innovative and larger businesses that are highly innovative. Collectively their contribution is of significance to Australia's GDP
- The level of BERD in this sector is not consistent across countries. New Zealand's BERD contribution in agriculture is twice that of Australia; Spain's is one-third; Denmark's is one-sixth. Canada did not publish BERD data for the agriculture sector
- Innovation within the agriculture sector takes place within an ecosystem involving many different actors, including: agricultural research institutions, Rural Research & Development Corporations (RRDCs), domestic and multinational companies, and farmers and managers
- Process innovations in the agriculture sector may be driven by product or process innovations by suppliers in other sectors of the economy. Innovation in the agriculture sector is hard to study in isolation.

Health Services Sector

Rationale for selection

- Australia's health services sector contributed around $127.55 billion of GVA to GDP in 2017–18 at current prices (6.90 percent of GDP).[144] The private sector component of the health services sector had revenue of

[140] Australian Bureau of Statistics 2017, Estimates of Industry Multifactor Productivity, cat. no. 8158.0.55.003.

[141] Australian Bureau of Statistics 2017, Innovation in Australian Business, cat. no. 8158.0.

[142] Statistics Canada database, Table 33-10-0184-01 Innovation activities conducted, by industry and enterprise size, Statistics Canada, occasional updating.

[143] Eurostat, Science Technology and Innovation database, Results of the Community Innovation Survey 2016 (CIS2016), European Commission.

[144] Australian Bureau of Statistics 2018, Australian System of National Accounts, cat. no. 5204.0.

$139.05 billion in 2017–18.[145] The sector employed about 963,000 persons full-time and 778,000 part-time as at the quarter ending August 2019[146]

- Australia is a large investor in health and medical services, and in 2016–17, Australia invested a record high of $180.7 billion on health[147]
- Australia's health system functions at a relatively low cost (as a percentage of GDP) compared to five key comparator countries – the UK, Canada, US, Germany, and Norway – yet outperforms these same countries on the vast majority of health status indicators
- However, the gap between health expenditure growth and GDP growth in the most recent years showing signs of widening and highlights why it is important for Australia to ensure that its innovation policies in the health services sector are appropriate, and to track innovation outcomes[148]
- Measurement of innovation (inputs and outputs) for the health services sector is lacking because the existing metrics do not capture public sector innovation, and health innovation does not contribute to current innovation metrics
- Health services (and healthcare and social assistance more broadly) is not in scope of the 2018 Oslo Manual.[149] It also falls outside the ABS definition of the market sector (as the services are predominantly provided by governments) and therefore does not contribute to the assessment of Australia's overall economic performance and MFP. This omission is increasingly problematic given its growing significance.[150]

Financial and Insurance Services Sector

Rationale for selection

- Australia's finance and insurance services sector contributed around $163.35 billion of GVA to GDP in 2017–18 at current prices (8.84 percent of GDP).[151] The sector employed about 364,000 persons full-time and 78,000 part-time as at the quarter ending August 2019[152]
- By world standards, this sector is sophisticated, competitive and profitable

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[145] Australian Bureau of Statistics 2019, Australian Industry, 2017–18, Table 1, cat. no. 8155.0.

[146] Australian Bureau of Statistics 2019, Labour Force, Australia, Detailed, Quarterly, Aug 2019, Data cube EQ06, Cat No. 6291.0.55.003

[147] Australian Institute of Health and Welfare 2018, Health Expenditure Australia 2016–17, Australian Institute of Health and Welfare, Canberra.

[148] ibid.

[149] OECD/Eurostat, Oslo Manual 2018.

[150] Productivity Commission 2017, Shifting the Dial: 5 year productivity review, Productivity Commission, Canberra.

[151] Australian Bureau of Statistics 2018, Australian System of National Accounts, cat. no. 5204.0.

[152] Australian Bureau of Statistics 2019, Labour Force, Australia, Detailed, Quarterly, Aug 2019, Data cube EQ06, cat. no. 6291.0.55.003.

- Australia's four major banks are among the world's largest banks by market capitalisation, and all rank in the global top 25 safest banks list. They are also some of the most profitable in the world
- Australia has the fourth-largest pool of investment fund assets in the world and the largest in Asia[153]
- Australia has one of the world's best performing financial centres[154]
- The finance and insurance services industry made a significant contribution to BERD (accounting for 19 percent of total BERD in 2015–16)
- Fintech is one of the fastest growing sectors in the global financial services industry and is disrupting the financial services industry.[155] Significant R&D activities are occurring in computer software. The accelerating rate of technological change and increasing penetration of mobile devices, combined with shifting customer preferences, have been rapidly changing how financial services are structured, delivered and consumed. For example, in-branch interactions have now largely been replaced by ATMs, online transactions and mobile services. This trend is evident in Australia and in other countries in the Asia-Pacific region. Future innovation in financial technology is expected to lead to further changes, delivering new services and generating new types of employment.

Methodology

The Review consulted with key representatives from the sectors selected for case studies. To ensure coverage of the sector and consider diversity of perspectives, the Review identified a range of potential stakeholders, including: small, medium and large businesses; peak bodies and industry-owned companies; statutory bodies; and academic institutions.

The consultation process involved interviews that were conducted with individuals or in groups. The minutes of the interviews were cleared by the interviewees. To ensure that interviewees felt able to be entirely frank, the Review gave an assurance that identifiable minutes will not be published. A confidentialised compendium of minutes has been prepared to enable the learnings to be preserved for later use.

In undertaking the interviews, the Review aimed to:

- develop an overview of the sector, including drivers of innovation
- understand how innovation occurs in each sector
- understand how innovation is currently measured in the sector

[153] The Treasury 2016, Backing Australian Fintech, The Treasury, Canberra.

[154] The World Economic Forum 2012, The Financial Development Report, The World Economic Forum, Geneva/New York.

[155] I Pollari, KPMG 2017, 'Fintech and digital innovation: the future of banking', KPMG Sydney, 2017.

- identify the measurement implications, including what is not currently being captured and where there may be opportunity to improve current measures.

The Review asked questions related to:

- the organisation, its functions and processes
- R&D activities
- Non-R&D innovation activities
- implementation of innovation
- transfer of knowledge (i.e. sources of innovation and collaborations).

In addition to the interviews, a range of information sources were consulted to provide further context and supplement the evidence provided by interviewees

More information on how the case studies were conducted – and the range of companies interviewed – is provided at the end of this chapter. This also includes the Australian and New Zealand Standard Industrial Classifications (ANZSIC 2006) covered.

Table B.1: Summary of findings

Finding	Mining	Agriculture	Health Services	Finance and Insurance Services	Measurement implications
INNOVATION ACTIVITY OCCURING					
The IMR found that there is significant innovative activity.	Yes	Yes	Yes	Yes	Significant innovation activity was identified in all sectors. Small businesses in the health services sector have a lack of incentive to be innovative under the present system. The incentives in place encourage a focus on volume rather than innovation.
Non-R&D innovative activity accounts for a significant fraction of total innovation expenditure.	Yes	Yes	Yes	Yes	Measures of innovation that focus on expenditure on R&D do not offer a complete picture of the innovation activity occurring. Sectoral study participants reported spending more on non-R&D innovation than on R&D. A comparison of the non-R&D innovation expenditure reported to the Review with the expenditure reported to the ABS for selected businesses (under ABS return to source arrangements for mining and using businesses' own records for other sectors) suggests that non-R&D innovation expenditure may be significantly under-reported to the ABS in the BCS. The key issue is that non-R&D innovation is not an accounting line item and many businesses do not collect the information necessary to calculate it. Some C suite executives were able to provide lower bound estimates by totalling major non-R&D innovations. These were not in the majority.

Finding	Mining	Agriculture	Health Services	Finance and Insurance Services	Measurement implications
Innovation activity is concentrated in a small number of large businesses.	Yes	No	Yes	Yes	Metrics that report innovation activities based on the number of innovation active businesses do not adequately measure the contribution to innovation as a small number of large businesses are highly innovative and make a significant contribution to the Australian economy.
Public sector innovative activity is occurring.	No	No	Yes	No	Public sector non-R&D innovation is not currently captured in existing non R&D innovation metrics, being out of scope of the BCS.
There is a significant level of investment in intangible assets (e.g. digital innovation).	Yes	Yes, at a lower level	Yes	Yes	Measurement of investment in intangibles is recognised as a data gap (discussed in Chapter 2).
The scale and range of innovation activities taking place in businesses is diverse. Activities range from disruptive, radical large scale changes that represent a significant departure from business-as-usual through to continuous improvements that are more gradual, incremental changes with limited departure from business-as-usual.	Yes – majority of activity is continuous improvements	Yes	Yes	Yes	The way that innovation occurs in businesses is likely to affect how innovation activity is reported. Large scale changes are more likely to be recognised by businesses as innovation, and therefore reported in surveys. Continuous improvements may not be reported, or even be seen, by businesses as innovation. Collectively continuous improvements are likely to have a significant impact. Some businesses, on learning that continuous improvement should be included, indicated they had previously lodged substantial undercounts of non-R&D innovation expenditure. The largest single undercount reported in the sectoral studies was by a business that said including continuous improvement would have raised its non-R&D innovation expenditure by around $100 million.
SOURCES OF INNOVATION					

Finding	Mining	Agriculture	Health Services	Finance and Insurance Services	Measurement implications
R&D is undertaken in-house by staff involved in production (or service) rather than as distinct R&D activity involving R&D personnel.	No	No	Yes	No	When R&D is integrated into ongoing operations, full capture of R&D inputs and outputs might not occur.
Suppliers are a key source of innovation.	Yes	Yes	Yes	No	The scale of this activity is not known as there are no measures in place.
Clients are a key source of innovation.	No	No	No	Yes	The scale of this activity is not known as there are no measures in place.
Significant amount of innovation is sourced from overseas.	Yes	Yes, at a lower level	No	Yes	The scale of this activity is not known as there are no measures in place.
INNOVATION CONCEPTS					
There are misunderstanding of innovation concepts or differences in terminology within the sectors.	Yes	Yes	Yes	Yes	The Oslo Manual definition used by this review and by the ABS is not in general use in the community. Some businesses have their own definitions of innovation. These are in general narrower (meaning that some activities and expenditures recognised as innovation according to the Oslo Manual are not recognised as such and reported by businesses, leading to undercounts). Sometimes these reflect businesses' need to report using the Research and Development Tax Incentive (RDTI) program's definition. Individuals reporting on innovation may report only what they consider to be innovation, as discussed above.
IMPACTS AND BENEFITS					
Businesses tend to evaluate benefits and impacts of innovations introduced over a longer time period (greater than one year).	Yes	Yes	Yes	No	A single-year reference period is not likely to offer meaningful information on the benefits and impacts of innovation implemented for the sectors examined except for finance and insurance services.

Finding	Mining	Agriculture	Health Services	Finance and Insurance Services	Measurement implications
The impacts and benefits of innovation assessed by businesses go beyond economic.	Yes	Yes	Yes	No	Current measures tend to focus on the economic benefits of innovation.
Businesses consider environmental factors when assessing impacts and benefits.	Yes	Yes	No	No	Environmental impacts and benefits of innovation are not currently measured.
Businesses consider safety factors when assessing impacts and benefits.	Yes	Yes	Yes	No	Safety impacts and benefits of innovation are not currently measured.
Businesses consider social factors when assessing impacts and benefits.	No	Yes	Yes	Some	Social impacts and benefits of innovation are not currently measured.
Businesses consider health factors when assessing impacts and benefits.	No	Yes	Yes	No	Health impacts and benefits of innovation are not currently measured.
Businesses have the ability to estimate impacts such as productivity gains and cost reductions.	Yes	No	Yes	Yes	The Review asked whether businesses would be able to provide estimates of the impacts of process innovations, if requested. Sectoral study participants in mining, health services and finance and insurance services believed they could provide estimates of a quality useful to Australian governments. Businesses in agriculture generally did not feel able to provide estimates at all, and those that did thought their estimates may not be within ±20 percent of true values. The Review believes this result occurred as large businesses were better able to estimate the benefits than small businesses.
COLLABORATION					
Collaboration is occurring on a fee-for-service basis.	Yes	Yes	Some	Yes	Fee-for-service arrangements of a collaborative nature are not currently captured, even if IP and risk are being shared through them.
Capture the full extent of collaborative activities.	No	No	No	No	Current measures of collaboration are aligned with the Oslo Manual and do not include fee for service arrangements, as these are explicitly excluded from the definition of collaboration.

Finding	Mining	Agriculture	Health Services	Finance and Insurance Services	Measurement implications
ANALYSING INNOVATION ACTIVITY					
Ability for businesses to estimate total expenditure on innovative activities (including non-R&D).	Yes	No	No	Yes	Mining and finance and insurance services have some ability to estimate total expenditure, but would provide undercounts based on their current accounting practices. For health services, R&D is being conducted by employees not classified as researchers, so there is significant under-reporting.
Internationally comparable data is available.	Yes	No	No	Yes	Benchmarks are useful to gauge relative performance of Australian industries to the rest of the world. The government's ability to collect such data is largely dependent on whether businesses see value in contributing.
Information or data relating to intangibles is being fully captured by businesses.	No	No	No	Yes	More focus is required on measuring intangibles, particularly due to increasing digitalisation. In principle, there is significant granularity possible in mapping the components of innovation that would be served by better collection of intangibles.

Mining

Summary of findings

- The scale and range of innovation activities in the mining sector is diverse across and within businesses
- Step-change, or disruptive innovation, is often what comes to mind when thinking about innovation in the mining sector, but the sectoral study found that most innovation activity occurring in the sector can be considered continuous improvement (including in dollar value terms)
- Measures that focus on new processes will be more useful in understanding mining sector innovation than metrics that focus on new products
- The way that innovation occurs impacts on how businesses report their activity through innovation surveys. As a result, there are continuous improvements that theoretically meet the definition of innovation set out by the Oslo manual, but would be 'hidden' from current measures
- Estimates of innovation activity that use business as a unit of measurement do not account for the economic contribution that innovation in mining businesses may provide, as the innovation of a small number of large businesses is important in this concentrated sector
- Timing needs to be considered when measuring innovative activity. A single reference year is too short a period to use when assessing impacts and benefits of innovation in the mining sector
- Measuring the outcomes from innovation in mining means going beyond economic results to include safety and environmental factors, and needs to be assessed both qualitatively and quantitatively
- The absence of primary mining suppliers in Australia means that a significant amount of innovation and technological capability is brought in from overseas
- Significant collaboration is occurring in the mining sector, however it is performed on a fee-for-service basis, and current measures may not capture the full extent of activities
- Some large mining industry businesses called for the Government to measure imports by type, and in particular, to measure investment in remote operations technologies. They felt that there may be sufficient domestic demand for a business located in Australia providing remote mining technologies to be commercially viable.

Summary of opportunities

- Regular case studies should be conducted on the mining sector to improve our understanding and ability to measure the scale of innovation activity occurring. This would complement existing measures and provide an effective source of qualitative information on key issues, such as 'hidden innovation', to enable greater evaluation of impact over time

- The ABS should explore opportunities to produce alternative estimates of innovative activity that complement existing methods, and present a more complete picture of the scale of innovation in Australian businesses. For example, if business innovation estimates could be produced in a way that take into account business size (for example, measured by employment size or annual revenue), there would be greater understanding of the relative impacts of innovation in Australian businesses
- Innovation surveys should have a reference period greater than one year to improve the quality of data that is collected on the impacts and benefits of new innovation
- There should be improved analysis of collaborative arrangements that are occurring on a fee-for-service basis.

Background and context

The Industry

Australia leads the world in mineral resources, with the largest reserves of iron ore, gold, lead, nickel, uranium and zinc.[156] Although the mining sector is small with respect to the number of businesses operating in Australia, its economic impact is significant.

As at June 2017, there were 7,800 companies in the mining sector, representing 0.35 percent of total operating businesses in Australia (2,238,000).[157] A small number of very large mining businesses dominate the sector. The mining industry contributes $151.59 billion GVA (8.2 percent GVA as a proportion of GDP) to Australia's GDP.[158] The mining sector is growing, and is estimated to contribute a record high $252 billion of exports in 2018–19.[159]

Australia has a revealed comparative advantage in mineral products, which accounts for around 54 percent of the value of total exports in 2016, led by iron ore ($48.2 billion), coal briquettes ($47 billion), gold ($29.1 billion) and

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[156] Geoscience Australia 2017, Australia's Identified Mineral Resources 2017, Geoscience Australia, Canberra.

[157] Australian Bureau of Statistics 2019, Counts of Australian Businesses, including Entries and Exits, cat. no. 8165.0.

[158] Australian Bureau of Statistics 2019, Australian System of National Accounts 2017–18, Table 5, cat. no. 5204.0.

[159] Department of Industry, Innovation and Science 2019, 'Department of Industry, Innovation and Science, Resources and Energy Quarterly, September 2019', Department of Industry, Innovation and Science, Canberra, viewed 21 November 2019, <https://www.industry.gov.au/data-and-publications/resources-and-energy-quarterly-all>.

petroleum gas ($20.3 billion).[160,161] However, Australia's comparative advantage in the mining sector is not purely the by-product of its rich mineral reserve. While global demand for minerals has continued to grow strongly over the last 20 years,[162] Australian mining businesses have faced a number of recent challenges, including:

- fiercely competitive international commodities markets
- declining quality or less accessible recoverable mineral deposits in Australia
- the highest industry wages (full-time ordinary time earnings of over $138,000 per year) driven by a shortage of skilled domestic workers.[163]
- the health and safety of employees has become a high priority for mining companies
- the environmental impacts of mining operations are a key concern for mining companies
- the absence of primary mining suppliers in Australia means that a significant amount of this capability is brought in from overseas.

Innovation

Conditions have presented businesses with a significant productivity challenge, with the industry experiencing falling MFP in the 12 year period between 2000–01 and 2012–13 (Figure B.1).[164] Responding to this challenge, the mining industry has undergone a period of rapid change over the last 10 years to keep the cost of production to a minimum and remain globally competitive. To do this, businesses within Australia's mining sector have invested in innovation activities, such as the implementation of new technology, R&D, continuous improvement processes and collaboration with suppliers and other partners.

The industry has been recording growth in MFP and labour productivity since 2013–14, which is indicative of the significant innovation activities that have been occurring in mining businesses over recent years. However, questions have been raised about the extent to which innovation metrics and data sources have been effectively capturing and measuring these activities and their impacts.

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[160] Department of Industry, Innovation and Science 2018, Industry Insights: Globalising Australia, 2/2018, Office of the Chief Economist, Department of Industry, Innovation and Science, Canberra.

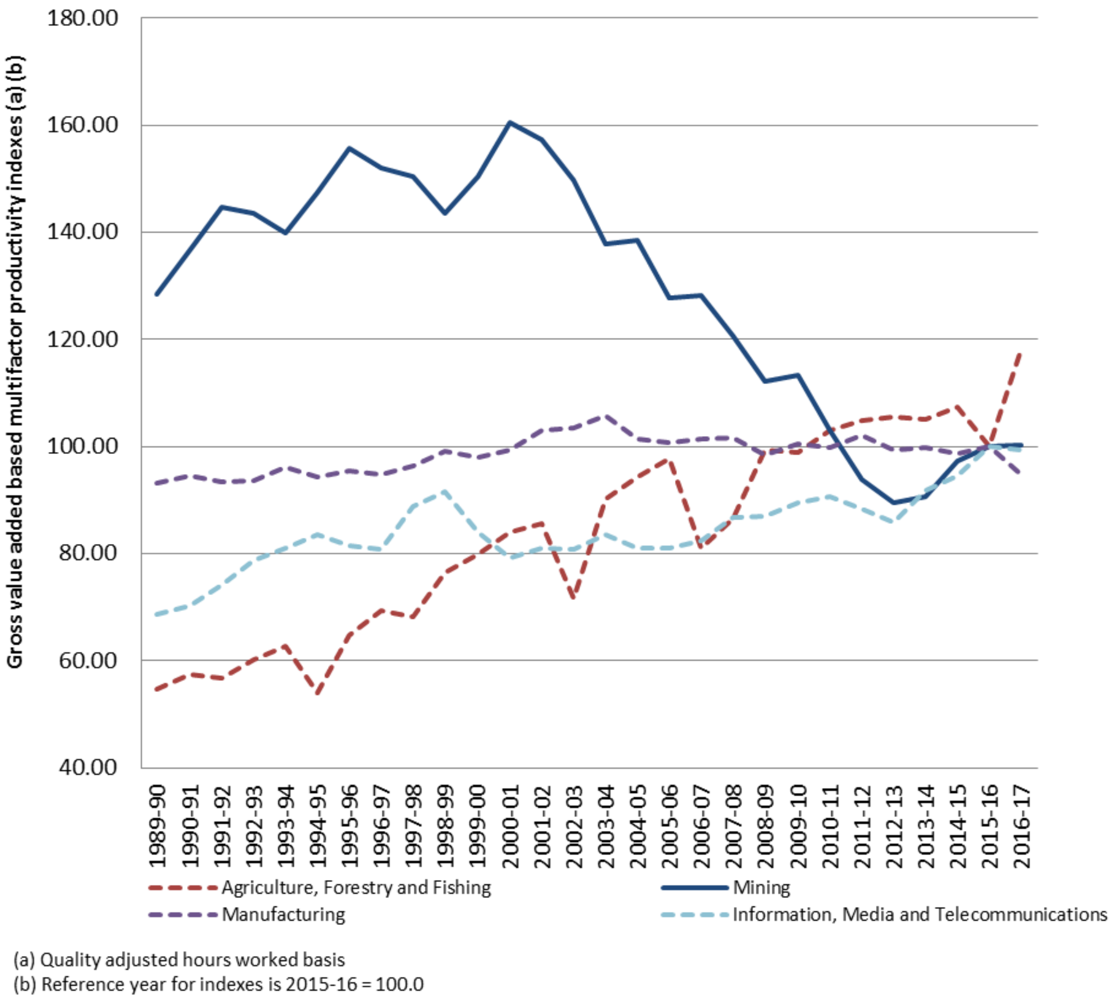
[161] The Observatory of Economic Complexity data visualisation, What does Australia Export? 2017, The Observatory of Economic Complexity.

[162] World Bank Group, 'Commodity Market Outlook: Special Focus – The changing of the guard: Shifts in industrial commodity demand', vol. 1, report no. 131479, 1 October 2018.

[163] Australian Bureau of Statistics 2018, Average Weekly Earnings, Table 10G, cat. no. 6302.0.

[164] Australian Bureau of Statistics 2017, Estimates of Industry Multifactor Productivity, cat. no. 8158.0.55.003.

Figure B.1: Multifactor Productivity, Mining and selected industries, 1989–90 to 2016–17



Source: ABS Cat. No. 5260.0.55.002 – Estimates of Multifactor Productivity, Australia, 2016–17

Scorecard metrics have used measures of expenditure on R&D as a proxy for innovative activity. As shown in Table B.2, in 2015–16, business R&D expenditure varies based on the relative size of businesses in the sector.[165] In comparison to the broader R&D landscape in Australia, in mining, larger companies (with 200 or more employees) account for more of the R&D conducted. Although the contribution of business R&D in the mining sector amounting to over $1.8 billion might seem impressive, it is less than one percent of the total revenue generated by the mining industry. Moreover, this figure has decreased since 2013–14. It is clear that R&D expenditure alone does not provide the full extent of innovation activities occurring in the mining sector.

[165] Australian Bureau of Statistics 2019, Research and Experimental Development, Businesses, Australia, cat. no. 8104.0

While expenditure on R&D has decreased, the mining industry has experienced growth in MFP over the last five years.[166] This growth has come after falls since 2000. The mining investment boom, created by higher commodity prices, required substantial inputs of capital and labour ahead of production. In addition, less productive techniques that were able to be implemented more quickly were preferenced over more innovative methods with longer lead times.[167] Since the mining boom, the industry has been in the midst of a technology-enabled transformation that may be contributing to productivity growth.[168] As discussed earlier at Chapter 6 – Analysis, there are implications that sources of innovation contributing to MFP change are hidden from current metrics.

Table B.2: Expenditure on R&D by size of business in the mining sector

	Mining	Overall
0–4 people (micro)	8.4% ($158 million)	6.4% ($1062 million)
5–19 (small)	10.6% ($198 million)	12.3% ($2054 million)
20–199 (medium)	10.6% ($198 million)	24.1% ($4008 million)
200+ (large)	70.4% ($1322 million)	57.2% ($9535 million)
total	100% ($1876 million)	100% ($16,659 million)

Source: ABS Cat. No. 8104.0 – Research and Experimental Development, Businesses, Australia, 2015–16

How innovation occurs in the mining sector

This section outlines how innovation occurs in the mining sector and highlights some of the measurement implications arising from these activities.

The focus is on process innovation

When it comes to innovation, the focus of businesses in the mining sector is on developing, introducing or improving processes to deliver a minimum viable product, rather than the development of new goods or services. This is not surprising given that the products these businesses sell (for example gold, coal, iron-ore) are, with the exception of purity and configuration, identical to what humans first mined at the dawn of civilisation. They are commodities that are typically used as inputs in the production of other goods and services. There would be little need or conceivable opportunity for new products to be developed by mining businesses.

Measurement implications

- Process innovation is conceptually within the scope of business innovation surveys (i.e. the ABS' BCS), although in practice there is significant undercounting (hidden innovation).

[166] Australian Bureau of Statistics 2017, Estimates of Industry Multifactor Productivity, cat. no. 8158.0.55.003.

[167] Productivity Commission, PC Productivity Bulletin 2019, 4 June 2019.

[168] McKinsey & Company, Behind the mining productivity upswing: Technology-enabled transformation, New York, September 2018.

- Measures that focus on new processes will be more useful in understanding mining sector innovation than metrics that focus on new products.

Process improvements drive innovation

The drivers of innovation in the sector reflect this focus on process innovation. The following broad drivers were common across participating businesses:

- Delivery of minimum viable product at the lowest cost.
- Improve the quality of products.
- Improve productivity.
- Improve safety.
- Improve logistics and supply chain capacity.
- Reduce environmental impacts.
- Enhance existing systems.

Measurement implications

- Drivers of innovation in the mining sector are not purely economic
- When measuring the benefits and impacts of innovation, safety and environmental outcomes should be a consideration.

The types of innovation vary from continuous improvement to disruptive change

The key types of innovation in the mining sector sit at opposite ends of the scale of novelty and significance. These are described in Table B.3 below.

Table B.3: Summary characteristics of types of innovation performed in mining businesses

	'Disruptive' or step-change innovation	Continuous improvement processes
Scale	Radical, large-scale changes	Gradual improvements
Implementation	Implemented over a number of stages From proof-of-concept to full-scale roll-out Can be abandoned	Incremental changes over time
Timing	Long-term	Medium-term
Cost	High capital investment	Modest development costs
Risk	High – the outcome is often uncertain	Moderate to medium
Technology level required	Significant technological advances	Some technological advances
Impact on BaU	Significant departure from business as usual	Limited changes to business as usual
Types of operation	Common in Greenfield or new mine site operations where there is ability to leapfrog to new technology and processes	Common in Brownfield or more established mining operations
Drivers and benefits	▪ Finding solutions to complex problems ▪ Enhanced employee health and safety ▪ Improved environmental outcomes.	▪ Optimising already evolved processes ▪ Delivery of minimum viable product at the lowest cost ▪ Enhanced employee health and safety ▪ Improved environmental outcomes.
Example	▪ Automated subsystems and processes ▪ Automated mining ▪ Fatigue monitoring (SmartCaps) ▪ 3D mapping technologies ▪ Diffraction technology.	▪ One mining company spoke of a relatively minor, but important, improvement in the quality of knuckles used in train carts to increase durability. Increasing the life span of the knuckles could result in significant cost savings for the business ▪ Adoption of in-field mobile devices to provide frontline personal access to critical information and systems, such as equipment status, hazard reports, and maintenance work orders.

Although mining companies engage in the development and introduction of innovation at both ends of the scale, participating representatives indicated that the latter is more common than the former. One mining executive estimated that 80 percent of innovative activities in the company could be considered incremental change or continuous improvement, with the remaining 20 percent considered to be disruptive or radical.

Measurement implications

- Step-change, or disruptive innovation, is often what comes to mind when thinking about innovation in the mining sector, but the sectoral study found the majority of innovation activity falls into the category of continuous improvement
- Step-change, or disruptive innovations, are more likely to be reported by businesses when considering ‘new or significantly improved goods, services, processes, or methods’
- Continuous improvements, on the other hand, may involve a large number of small changes that, when taken in isolation, would not be considered ‘significant improvement’ from existing processes, but collectively would have substantial impact
- While these continuous improvements theoretically meet the definition of innovation set out by the Oslo manual, the way in which this innovation activity occurs (e.g. incrementally, over long time periods, with limited changes to business as usual) may impact on whether this activity is reported in practice. This may be a source of hidden innovation in the mining sector.

Research and development is important, but is not the whole picture

As discussed earlier, expenditure on R&D in the mining sector is less than one percent of total revenue generated by the sector (based on 2015–16 estimates). All of the businesses consulted by the Review indicated that, while R&D is important, more innovation activity occurred outside of the R&D space than within it.

Measurement implications

- R&D activity is well captured through measures of R&D expenditure
- Non-R&D innovation activity is recognised as a gap in current metrics.

Patenting helps to show how and where innovation is happening

Patenting is used by mining businesses, but as with R&D, measures of IP use do not provide the full picture of the innovative activity taking place.

However, IP applications provide interesting insights into the location of inventors holding mining patents. The bulk of patents in the mining sector in Australia are filed by Mining Equipment, Technology and Services (METS) businesses that are primarily staffed by inventors located outside of Australia.[169] This aligns with the findings described below.

Measurement implications

- IP and patenting activity is sufficiently captured through measurement of IP applications

[169] E Francis 2015, The Australian Mining Industry: More than just shovels and being the lucky country, report to IP Australia, Canberra.

- While these measures are not a good proxy for overall innovation activity in the sector, they help build the picture of how innovation is occurring (e.g. through collaboration).

Most innovation is implemented incrementally, over an extended period of time

While some innovations may have clear implementation dates and timeframes (e.g. the introduction of a new durable knuckle used in train carts), the majority occur over an extended period of time, or in phases. For example, Fortescue has spent years expanding its autonomous haul fleet.[170] The technology behind these autonomous vehicles was first introduced in 2013 but it wasn't until 2018 that Fortescue fitted its first truck with this technology. The long-term goal is to move towards a fully autonomous fleet of about 100 vehicles, which will be the first of its kind in the world. This change will occur over an extended period of time and will require simultaneous workforce skill development that Fortescue describes as the "implementation of a staged, sustainable, redeployment process".

Measurement implications

- A single reference year period is considered too short a period to use when assessing impacts and benefits of innovation, which may take longer to manifest in mining
- It may not always be clear at what point in time an innovation is considered to be implemented. It is possible that these innovations are being overlooked because it takes more than a year for them to come into play. This may also impact on the way that innovation is reported.

Innovation quickly becomes business as usual

Technology advances and innovation that once would have been considered significant quickly becomes common practice as it is rolled out across the business. For example, drones and robots are used frequently across mining operations to complete maintenance inspections. Drones are used to inspect the mechanical integrity of confined spaces, and robots are used to complete pipe inspections. Once considered 'disruptive innovation', these activities are now scheduled as routine maintenance.

Similarly, incremental, continuous changes are so common in the mining sector they are also considered routine or business as usual.

Measurement implications

- At what point in the implementation process would an innovation no longer be considered by the business as 'innovative'?

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[170] Fortescue, Latest news: Fortescue expands autonomous haulage at Chichester Hub, media release, Fortescue, East Perth, 11 April 2018.

- Incremental changes that are considered business as usual may not be recognised and reported as innovation. This may be a source of hidden innovation.

Mining businesses and their role in the innovation ecosystem

Mining businesses are large consumers of the technology-intensive goods and services required to support innovation. Considerable adaptation and implementation activity is undertaken in-house for point solutions and continuous improvement. Businesses work closely with suppliers to deliver solutions to identified problems. A significant proportion of innovation comes from new products and services developed by, or in conjunction with, mining suppliers.

For the large businesses interviewed, predominant partnerships are with primary mining suppliers. Businesses identified the following benefits from these partnerships:

- existing suppliers are lower risk
- they understand the mining environment through their exposure in traditional supply
- they have existing market channels through which they can commercialise solutions.

The absence of primary mining suppliers in Australia means that a significant amount of this capability is brought in from overseas. The scale and extent of overseas expenditure associated with innovation adoption is not known.

Measurement implications

- It would be useful to improve our understanding on the extent of the expenditure associated with adoption of innovation that is expended overseas, and on what
- The scale of this activity is not known, making it hard to determine whether policy intervention is required.

Mining businesses are active collaborators

Collaboration is seen as a fundamental enabler of innovation, as it allows the diffusion of knowledge and sharing of risk and capabilities. Mining businesses are active collaborators.

As discussed above, mining businesses collaborate heavily with their suppliers to innovate and deliver solutions to complex problems, which results in mutual benefits for both parties. For example, one mining company worked closely with a truck supplier to optimise payload limits, enabling improved loading outcomes for the mining business and assisting the supplier to maximise delivery loads closer to approved limits.

Of the mining businesses that participated in the sectoral study, collaborations were also noted with universities, external partners, suppliers, research agencies and METS businesses. These arrangements typically occurred on a fee-for-service basis but were part of long-term relationships in which IP and risks are shared. These fee-for-service arrangements are not captured under the current definition for collaboration in the Oslo Manual. For example, in 2018, Fortescue announced a $20 million agreement in collaboration with CSIRO and Brisbane research laboratories to develop and commercialise hydrogen technologies in Australia.[171]

Measurement implications

- Since many collaborations occur on a fee-for-service basis, current measures may not capture the full extent of these activities in the mining sector.

How the impacts or benefits of innovation are measured varies across businesses

There is variety in the approaches used by different mining businesses to measure impacts and benefits of implemented innovation.

The general consensus is that innovation requiring a large capital spend will be well tracked to monitor improvements and outcomes that result from implementation. For smaller scale, less resource-intensive innovation, it is less likely that attempts will be made to quantify or measure impacts. For activities that fall into the continuous improvement space, benefits would be difficult to aggregate and quantify at the business level. For some businesses, the benefits are clear without needing to be measured.

There are attempts being made by some businesses to consolidate and capture innovation expenditure and activity across the business to improve tracking and offer transparency to shareholders. For example, some mining businesses are moving towards the coordination of their innovation initiatives by a central portfolio. This centralisation will provide better visibility of all local innovation occurring in the company. In contrast, other businesses see the inherent difficulty in doing this and acknowledge there would be activities occurring that would not be tracked well or have quantifiable impacts.

In summary, benefits can be qualitative as well as quantitative. For example, some innovation may be measured by increased output, whereas other innovation has less quantifiable impacts such as improved safety, reduced environmental impact, and greater social benefit.

Measurement implications

- Some innovation impacts are easily quantified at the business level and may be measured by increased output of an introduced process
- Not all innovations that occur have obvious, quantifiable impacts. Some benefits are qualitative (e.g. social, environmental and safety)
- Sometimes the impacts are reduced costs or the removal of something inefficient, instead of introducing something novel. This is harder to estimate (e.g. process innovations, cost reductions or productivity gains

[171] Fortescue, Latest news: Fortescue and CSIRO enter into landmark partnership to develop and commercialise hydrogen technology, media release, Fortescue, East Perth, 22 November 2018.

that may be embodied in new technology and processes, such as automation)

- Impacts may be seen and measured at the macro or whole of industry level, but more detail is desirable. However, since the businesses themselves are not able to quantify the full impacts, this would be very difficult to achieve (i.e. measuring the specific outcomes of minor continuous innovation is challenging)
- Although it might be easy to observe each individual change or improvement, it is hard to aggregate all of the innovation that is occurring and assess the cumulative impact of these small projects.

A strong culture of innovation is important for driving organisational capability

The companies interviewed for the case studies highlighted the importance of encouraging and fostering a culture of innovation. Management plays a key role in empowering staff to feel confident in generating new ideas, and a number of initiatives have been implemented to capitalise on the diverse skill sets of staff across different areas of the business. For example, one business promotes a ‘shark tank’ style initiative, where staff have the opportunity to present innovative ideas for the consideration of an expert panel.

Training is seen as a key enabler, and businesses actively support the professional development of staff. One business offers training to develop capability in writing a business case. This ensures that staff have the appropriate skills and tools to feel confident in proposing innovative ideas to improve the business, as well as feeling they have the support of management. These businesses also consider that failure, as well as success, should be embraced as a valuable learning experience. The establishment of positions, such as Head of Innovation, also helps to promote and acknowledge the ongoing importance of innovation within the organisation.

Throughout the interviews, it was apparent that a broad range of activities are working together to develop an innovation culture within these businesses. It is difficult to identify the specific impact of any one factor in driving innovation.

Measurement implications

- Innovation capabilities are difficult to measure, due to their intangible nature.

Agriculture

Summary of findings

- The agriculture sector is heavily intertwined with other sectors. Relative to other sectors, agriculture has a high proportion of small businesses. Based on the conversations held during this Review, the agriculture sector appears to be predominantly an adopter of innovations developed in other sectors, but businesses in the agriculture sector collaborate with these innovators to optimise adoption for local conditions
- The ability of policymakers to implement informed decisions in the agriculture sector has previously been restricted by the lack of data, but there are opportunities to improve the reliability and availability of data (for example, through increased digitalisation)
- The agriculture sector is a good example of where key concepts of innovation may not be adequately understood and captured in the data
- There are significant levels of collaboration in agriculture across all areas.
- There is appetite in the sector for the review of social, health and environmental impacts that are not typically quantified in innovation measurement
- Innovative activities in the agriculture sector also vary with respect to their timeframe for implementation
- There is significant investment in non-R&D and business improvement activities that have the potential to be missed in the assessment of agricultural innovation
- In the digital space, there are new ways of generating knowledge that do not rely on R&D processes, such as hypothesis testing
- There is a lack of internationally comparable data.

Summary of opportunities

- Surveys should have a reference period greater than one year to improve the quality of data that is collected on the impacts and benefits of innovation in the agriculture sector
- Misunderstandings regarding the concepts of innovation could be addressed by including sector-specific explanations and examples in survey instruments
- Measurement of social, health and environmental benefits of innovation that are not typically quantified in innovation measurement should be considered
- There should be collection of data on, and analysis of, collaborative arrangements that are occurring on a fee-for-service basis.

Background and context

The Industry

For the purpose of this sectoral study, businesses from the farming, forestry and aquaculture industries are collectively addressed as the agriculture sector.

Australian farmers are the custodians for over half of Australia's land area.[172] The agriculture sector is comprised of a significant number of companies. In 2016–17, there were 177,251 companies, representing over eight percent of total businesses in Australia.[173] However, the majority of these (~99 percent) are either non-employing (125,160 businesses) or micro agriculture companies (49,891 businesses) employing fewer than five staff. At the end of 2016, there were only 80 large businesses operating in the agriculture sector.

Australia's agriculture sector contributed around $47.99 billion of GVA to GDP in 2017–18 at current prices (2.60 percent of GDP). The agriculture sector, therefore, makes a large contribution to the Australian economy through many small companies. This is in contrast to the mining industry, where large contributions are made by a small number of major businesses.

In addition, business operation in the Australian agriculture sector is the most prone to fluctuations from external forces, such as the costs of inputs and environmental factors.[174] The sector is also one of the least likely to collaborate, with just six percent of businesses reporting they have collaborative arrangements in place.

Innovation

Innovation in the agriculture sector is especially important for business success. In 2016–17, 48.8 percent of innovation-active agricultural businesses reported increased revenue from the previous year, compared to the Australian average of 42.3 percent.[175] Innovation in agriculture is primarily sourced from suppliers and customers, especially when it comes to large businesses.[176] These suppliers and customers may be from outside the agriculture sector, for example, in manufacturing, wholesale and retail trade. In comparison, innovation in the mining sector is mostly sourced in-house.

The agricultural industry has experienced a period of rapid change over the last 10 years to keep the cost of production to a minimum and remain globally competitive. The agriculture industry in Australia had the largest MFP gains and labour productivity gains compared to other industries between 2000–01 and 2012–13 (See Figure B.2).[177]

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[172] Australian Bureau of Statistics 2018, Agricultural commodities, Australia, cat. no. 7121.0 –

[173] Australian Bureau of Statistics 2019, Counts of Australian Businesses, including Entries and Exits, cat. no. 8165.0–17

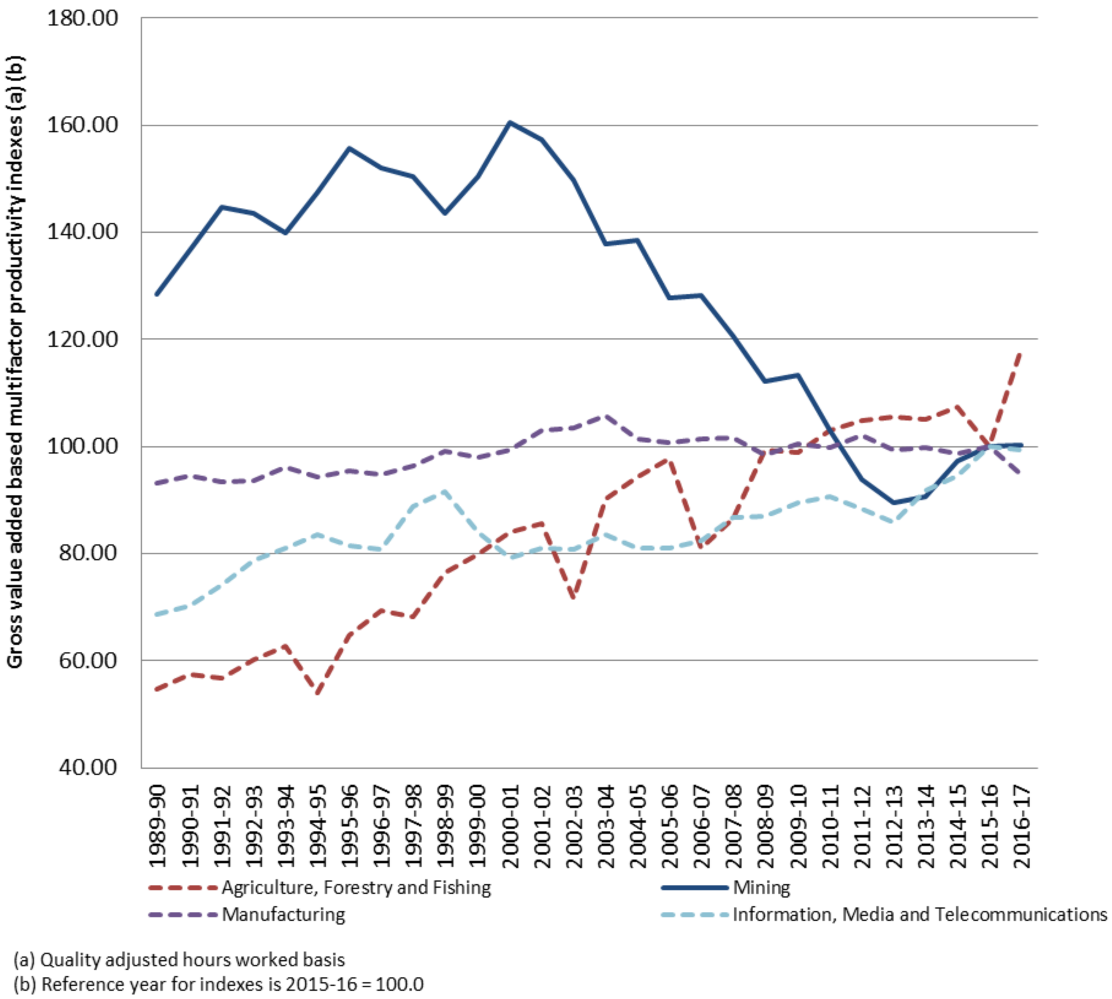
[174] Australian Bureau of Statistics 2019, Characteristics of Australian Business 2017–18, cat. no. 8167.0

[175] ibid

[176] Australian Bureau of Statistics 2017, Innovation in Australian Business, cat. no. 8158.0.

[177] Australian Bureau of Statistics 2017, Estimates of Industry Multifactor Productivity, cat. no. 8158.0.55.003.

Figure B.2: Multifactor Productivity, Mining and selected industries, 1989–90 to 2016–17



Source: ABS Cat. No. 5260.0.55.002 – Estimates of Multifactor Productivity, Australia, 2016–17

However, questions have been raised on the extent to which innovation metrics and data sources have been capturing and measuring these activities and their impacts.

The continued funding of R&D activities is essential for improving agricultural productivity and profitability.[178] In 2014–15, over $3 billion in R&D funding was allocated to rural activities. Of this amount, $1.46 billion was sourced from industry, $0.95 billion from the Australian Government, $0.24 billion from state Governments and $0.35 billion from universities.

Business R&D expenditure varies based on the relative size of businesses in the sector.[179] In comparison to the broader R&D landscape in Australia, R&D

[178] ABARES, Australian rural R&D on the rise, media release, Department of Agriculture, Canberra, 21 September 2017.

[179] Australian Bureau of Statistics 2019, Research and Experimental Development, Businesses, Australia, cat. no. 8104.

is performed less by larger companies (with 200 or more employees) and more by medium-sized companies (20–199 employees) (Table B.4).

Table B.4: Expenditure on R&D by size of business in the agriculture sector

	Agriculture	Overall
0–4 people (micro)	11.3% ($28 million)	6.4% ($1062 million)
5–19 (small)	10.1% ($25 million)	12.3% ($2054 million)
20–199 (medium)	41.1% ($102 million)	24.1% ($4008 million)
200+ (large)	37.5% ($93 million)	57.2% ($9535 million)
total	100% ($248 million)	100% ($16,659 million)

Source: ABS Cat. No. 8104.0 – Research and Experimental Development, Businesses, Australia, 2015–16

The Research and Development Tax Incentive (RDTI) is an initiative by the Australian Government to encourage companies to engage in R&D.[180] The initiative provides a tax offset to Australian companies to claim the cost of eligible activities. In 2017, the agriculture sector reported $466 million in expenditure under the RDTI, which was 3.3 percent of the R&D expenditure reported under the RDTI.

The majority of this research (85 percent) was in the agriculture and veterinary sciences area. This indicates most R&D is performed in crop and animal farming, fisheries, horticulture and farm management. Less than two percent of R&D was conducted in the information management and digital technology research areas. From this breakdown, it appears that the majority of agricultural businesses concentrate their efforts on research specific to their own sectors. They are not investing in R&D that may have spillover benefits for other sectors. For example, businesses in these sectors are not innovating in new technology, such as autonomous vehicles or digital infrastructure, and are most likely getting these innovations from elsewhere via procurement activities.

How innovation occurs in the agriculture sector

This section outlines how innovation occurs in the agriculture sector and highlights some of the measurement implications arising from these activities.

Lack of data has impacted on the ability to respond effectively to challenges

Australia faces unprecedented challenges in the agriculture sector. This uncertainty led the Department of Agriculture to conduct a comprehensive consultation process with stakeholders across the agricultural innovation system in 2019. It found that the sector is becoming increasingly digitalised, however, existing data is highly disaggregated, siloed and inconsistent.[181] To

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[180] Australian Taxation Office 2017, Research and development tax incentive, Australian Taxation Office, Canberra, viewed 21 November 2109, <https://www.ato.gov.au/Business/Research-and-development-tax-incentive/>.

[181] Department of Agriculture 2019, Agricultural Innovation – A National Approach to Grow Australia's Future, report prepared by Ernst and Young (EY), Canberra.

improve on a shared vision for the future, Department of Agriculture recommended that components of the agricultural ecosystem, such as leadership, investment, governance, funding, and culture, needed to adapt.

In 2015, the ABS and the Australian Bureau of Agricultural and Resource Economics Sciences (ABARES) undertook the National Agricultural Statistics Review (NASR) to assess the adequacy of agricultural statistics systems in Australia. The review found a number of deficiencies and concerns, and recommended actions to deliver a modern statistical system based on best practice principles. The NASR indicated that there should be a shift away from surveys to data collected during the course of normal business operations. The NASR also suggested that emerging sources, such as Big Data, satellite imagery and machine learning, be explored for potential use in the statistics system (The statistical applications of satellite imagery are currently being explored).

Measurement implications

- The ability of policymakers to implement informed decisions in the agriculture sector has been restricted by the lack of data, but there are opportunities to improve reliability and availability of data (for example, through increased digitalisation).

Social, health and environmental benefits need to be measured

The measurement of innovation has previously focused on economic indicators. However, the agriculture sector's contribution extends to social and environmental wellbeing. These benefits contribute to:

- future demand (e.g. increasing population and personal incomes)
- current and future environmental conditions (e.g. weather, climate, pests, drought)
- competition for natural resources (e.g. land, water)
- technological opportunities and digital disruption
- customer expectations (e.g. trends, diets, demand for healthier food).

As highlighted in Department of Agriculture's consultations, the agricultural industry is also the sector that will be most affected by environmental and social challenges, such as global food production shortages and climate change.[182] This view was shared by sectoral study participants, who described the challenges of implementing innovation due to environmental factors beyond their control. In addition, the supply chain has broader impacts on health, the environment and social benefits. Department of Agriculture highlighted a bias towards return on investment at institutional levels, and recommended the industry should focus more on social and environmental outcomes to reflect its true value to the economy.

[182] Ibid.

Measurement implications

- Innovation is key to productivity, which leads to improved living standards. Environmental and social impacts are also critical to living standards and therefore need to be measured effectively to improve our understanding of the impacts of innovation. While these are outside the scope of this Review, they are highly significant for agriculture, and could usefully be the subject of further work.

Non-R&D investment and business improvement need to be effectively measured

There is significant investment in non-R&D and business improvement in the agriculture sector, partly as a result of innovation in related sectors, such as manufacturing; and professional, scientific and technical services.

One company estimated the post-launch expenditure on a product intended for use in agriculture is typically 50 percent of the cost of its initial development. For example, if $100 million is invested in the development of crop protection products over a period of five years, there is a further investment of around $50 million over the next five years on post-launch activities. These include extension activities, for example, generating data on the use of products in different environmental conditions, and field trials for regulatory registration requirements.

Nufarm's development and production of omega-3 canola through its subsidiary Nuseed is an example of innovation that feeds into the agriculture sector. The development of this technology has been widely recognised as a world-first, and this is Australia's first wholly created genetically modified crop.[183]

There are other forms of innovation that are also considered important for the success of the business. Previously, Nufarm provided seeds and crop protection solutions to farmers, who then sold their grain to an established market industry. However, the production of long-chain omega-3 fatty acids opened up a new market in the aquaculture industry that required a different business model for the company. Through their subsidiary Nuseed, Nufarm is inventing the seed and maintaining ownership of the grain. It is now involved in all parts of the production process leading to the sale of the final product, something that has never been done before. The implementation of this new model would be classed as innovation as it requires changes to the overall approach of the business.

There is considerable extension of non-R&D agricultural products in the sector

Companies interviewed by the Review indicated that a major focus has been on extension activities. However, they feel there is a gap in the collection of this data. In the past, agriculture and primary industry departments allocated larger amounts of funds for these activities. The criteria have since changed and

[183] S Frazer, OM(e)G(a)! Omega-3 canola gets the green light, media release, CSIROscope, CSIRO, Canberra, 23 February 2018.

extension activities are now either rolled up into R&D projects[184] or progressed by the private sector. As a consequence, agricultural non-R&D innovation data are not adequately collected. Concerns were also raised about the effectiveness of knowledge transfer to feed into metrics of adoption time periods.

Elders undertakes non-R&D innovation and extension to test products that come to market, using a hands-off outsourced model. For example, Elders has partnered with multinational chemical businesses on a fee-for-service basis to undertake trials in Australia on biological products and adjuvants for broad acre crops. Elders' role is to co-ordinate the extension phase of the process. Elders arranges trial sites and expertise (labour) to test products on behalf of the multinational chemical businesses. These products are generally in trials for a period in excess of three years. This provides information on the suitability of new chemicals against current products to support high quality broad acre commodity production. However, the innovation is reported only by the multinational and would not be captured in Australian innovation statistics.

This example highlights the complexity, both of measuring innovation and correctly allocating it.

Measurement implications

- Core R&D by multinational agrochemical companies in the manufacturing sector impacts on business process improvement in the agriculture sector
- The intertwining of sectors is an issue that should be considered in the next ANZSIC review. It is very difficult to consider agriculture in a meaningful way on its own
- The sectoral study found a large proportion of activity occurring in the agriculture sector relates to non-R&D innovation (such as extension activities) and business improvements that are either new-to-business or new-to-sector and have substantial impacts on the economy
- While these continuous improvements meet the definition of innovation set out by the Oslo Manual, there are gaps in the way these activities are recorded that may impact on the quality of data.

A large proportion of core R&D activity is performed overseas

RRDCs are the main way in which the Australian Government and primary producers co-invest in R&D for industry and community benefit. In 2014–15, it was estimated that RRDCs had oversight of $483 million. Of this amount, $277 million was funded by private sector levy payments.[185] All RRDCs consulted with funded research projects through R&D facilities, such as CSIRO. RRDC guidelines are followed for impact assessment, including adoption phases. These processes evaluate the potential for benefits to the industry over an investment period of up to 25 years.

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[184] ABARES 2017, Rural research, development and extension investment in Australia, Research Report 17.11, Department of Agriculture, Canberra.

[185] ibid

However, in the seed and crop protection areas, businesses are less likely to perform this R&D in Australia. Agricultural businesses interviewed for the sectoral study indicated that multinational organisations are key drivers in the R&D of chemical-based advancements. Where they are not developed and released into Australia through these companies, local businesses adapt the formula of these chemicals for domestic conditions.

There is an absence of seed and crop protection companies that perform R&D activities in Australia. This means that businesses are likely to bring in innovation and capability from overseas for adaption to Australian conditions. Innovation is likely to occur in extension, rather than R&D.

Measurement implications

- This further emphasizes the importance of capturing innovation considered as 'extension'.

Key concepts for innovation may not be fully understood by the sector

'Hidden innovation' refers to activity that is not captured by existing innovation indicators, such as expenditure on research and experimental development, patent applications, or through innovation surveys. The sectoral study interviews identified that some participants in the agriculture sector frame their activities in terms of the need to remain profitable, rather than as new. After a discussion of innovation, a number of participants indicated they had under-reported continuous improvement of business processes.

The majority of businesses (>99 percent) in the agriculture sector are small enterprises with fewer than five employees. A common theme amongst all interviewees in the sector was the message that the strict concepts of innovation are not sufficiently understood by these small businesses. Many farmers do not consider their activities as being new. They also do not see their interactions with others as collaboration, and view them in terms of sharing resources.

Measurement implications

- Misunderstanding of the concepts of innovation and collaboration for innovation in the agriculture sector may lead to underreporting of innovative activities in surveys.

The sectoral study found significant levels of collaboration in agriculture across all areas

It is not clear if collaborative efforts in the agriculture sector may be underreported between suppliers and farmers. Results from the BCS collected by the ABS indicate that 94 percent of businesses in the agriculture sector do not have collaborative arrangements in place. This makes the sector one of the most underrepresented in this type of metric. The sectoral study found significant levels of collaboration in the sector. However, it oversampled large businesses, and these would be expected to be more likely to collaborate than small businesses.

In particular, there is evidence of significant levels of fee-for-service activity that is collaborative in nature (in that IP and risk are shared) in the agriculture sector and not currently in the scope of the BCS (as fee-for-service activity is excluded from collaboration under the Oslo Manual definition). Agricultural businesses interviewed for the sectoral study reported that they undertake significant collaborative activities through contracts. One respondent indicated that the R&D is not reported in Australia, as it is conducted by multinationals overseas.

Farmers are also considered a key source of innovation for those supplying the sector. One supplier indicated that the closer it was to growers, the better it understood market needs that enabled it to make more effective products. However, it acknowledged that while contact was important, it was difficult to measure and was an easy target for cost-cutting measures.

Measurement implications

- There is evidence that key concepts of collaboration are not fully appreciated in the agriculture sector. Many relationships are informal, and agreements are verbal and not reflected in contracts at any stage (for example, you test your new product on my land, and if it works and you commercialise your product in future years, you will sell your product to me at a significant discount in future). As a result, current measures of collaboration may not capture the full extent of activities.
- There is a significant level of fee-for-service activity – that is collaborative in nature in all sectors – that is not being captured under the current definition of collaboration.

The time it takes to measure the impact of innovation can vary

The agricultural industry, like many other sectors, is increasingly being influenced by digital technology. This can have a significant impact on the time it takes to implement innovation.

Agricultural businesses with tangible product innovations have much longer lead times for development. Some of the main aspects of their work are not implemented until five to eight years after discovery. The BCS collects innovation data for the previous 12 months. As a result, there are potential implications for international comparability in the measurement of innovation. Having a longer reference period is more appropriate for the agriculture sector, based on the long lead times for innovation.

Measurement implications

- A single reference year period is too short to assess impact in the agriculture sector, as many innovations are not fully implemented within this period.

Digital technology may impact the measurement of innovation

The Yield is a leading start-up in the agricultural technology sector. Working with some the largest corporate growers in the world, it uses its patented technology to produce microclimate weather predictions, even inside tunnels and under netting which powers its apps.[186] The Yield measures 14 variables in real-time that underpin agriculture models to allow growers to know when it is best to plant, irrigate, feed, protect, and harvest. At the corporate level, this information is combined with customer data to solve supply chain problems, such as optimising pricing contracts, inputs, freight, and logistics. It is a leader in data analytics, including machine intelligence and AI.

One of its innovations is its microclimate sensing system, which allows the business installs and supports for customers. It takes care of all support and maintenance, including over-the-air updates in software It remotely monitors performance, including detecting outliers in its sensor fleet, so it can perform maintenance where required.

The Yield is representative of digital technology companies that have applied innovative principles in the agriculture sector. It is considered that current innovation measurement is directed towards tangible outputs (such as the manufacturing sector) and does not adequately capture intangibles, such as digital-based innovation. The Yield platform product allows for the purchase of separate modules, for incorporation into the final products. The company constantly updates and extends these modules which should be considered as innovation, but are not consistently captured in current innovation metrics.

Through its R&D arm, the Thomas Elder Institute, Elders is partnering with various public and private organisations to bridge the gap between research, practical application, and productivity improvements.[187]

One of Elders' most significant recent innovations has been the development and launch of the Smart Farmer application.[188] Elders identified an opportunity to develop a platform application that incorporates multiple service applications into one dashboard. It works with local agriculture technology companies to collect the data in the Smart Farmer application, then provides customers with a range of information to access through the dashboard.

Accompanying the release of this application is a business innovation in the form of flat fee-for-service consulting that is potentially new to the sector. Previously, agribusiness consultants and agronomists are paid through commissions if a customer makes purchases. With the support of this new technology, Elders' customers and consultants have better access to information, and this increased productivity allows Elders' consultants to provide advice more easily when customers need it.

Measurement implications

- There may be alternate transactional data sources, supported by the adoption of technology on farms, which may provide insights that cannot be gained through surveys.

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[186] The Yield 2019, Our company, The Yield story, The Yield Pty Ltd, Sydney, viewed 21 November 2019, < https://www.theyield.com/our-company/the-yield-story>.

[187] Elders, Thomas Elder Institute (Elders), Elders, viewed 21 November 2019, < https://eldersrural.com.au/tech-services/thomas-elder-institute/>.

[188] Elders, Elders Smart Farmer App puts spotlight on digital decision tools, media release, Adelaide, 8 January 2019.

Health Services

Summary of findings

- The health services ecosystem is complex and involves a variety of actors, in both public and private sector organisations
- The public sector accounts for the majority of health expenditure, however, public sector innovation is not captured through ABS surveys
- Innovation in the sector is difficult to measure, both conceptually and statistically, in a way that is useful for government policy and program development
- The timeframe for implementation of innovation is highly variable, and it can take several years before impact can be measured
- Much of the sector is limited to internal sources of innovation, with overseas and domestic competitors rarely considered a source of new ideas
- Engagement metrics, in combination with clinical indicators, are used as proxies for economic outcomes. Inconsistencies in data are problematic for measurement, and there are no benchmarks for gauging the relative performance of health-care providers nationally
- Core R&D is almost always performed in-house, and in many organisations is integrated into ongoing operations, which makes it difficult to capture R&D inputs and outputs fully
- Other types of R&D commonly result in process innovations, including modifications and incremental changes. The impacts and outputs of these innovations are hard to measure
- Non-R&D innovation includes design, marketing and training activities, and accounts for a significant percentage of investment that may not be captured
- Fee-for-service arrangements are used if specialist skills and knowledge are not available within an organisation (e.g. digital health infrastructure)
- The sharing of knowledge is limited, and innovation-relevant data (if collected) is mostly used for internal purposes. This minimises the potential impact across the sector. National data on innovation activity in the sector is lacking
- There are a few exceptional organisations leading innovation in the sector, but the majority are not considered active innovators. The measurement of health-care output, based on volume rather than quality, may act as a disincentive for businesses in the sector to be innovative.

Summary of opportunities

- Innovation in government health services should be measured, as should innovation in government services more generally

- Measurement across the entire sector would enable development of metrics to inform investment in health service innovations, which would be valuable for government policy makers
- Fee-for-service arrangements should be included in measurement of innovation expenditure
- Investment in design, marketing and training represents a major opportunity for innovation measurement that should be pursued
- The government should consider incentivising organisations to keep precise and comprehensive records on their innovation activities and improve current reporting arrangements
- Australia should make better use of existing data through data integration (bringing together data from all states and territories) to monitor the quality of its healthcare system and enable international comparison with other OECD countries.

Background and context

The Industry

In 2016–17, Australia invested a record high of $180.7 billion on health, equating to over $7,400 per person, or 10.3 percent of Australia's GDP (see Figure B.3).[189]

Although a large investor in the sector, Australia's health system functions at a relatively low cost (as a percentage of GDP) compared to the UK, Canada, US, Germany and Norway, yet outperforms those countries in the vast majority of health status indicators.[190] Furthermore, a recent report ranked Australia's healthcare system as the second best in the developed world.[191] This evidence would suggest that Australia's investments in health-care have been well rewarded.

However, real health spending grew by 4.7 percent in 2016–17, 2.6 percent higher than growth in GDP, and the gap between health expenditure and GDP growth in the most recent years is showing signs of widening.[192] This data highlights the importance for the health services sector in Australia not to be complacent, and to prioritise and pursue an innovation agenda.

Two-thirds of the total expenditure (over $120 billion) was spent by Australian governments, with non-government sources (individuals, private health insurance, and other non-government sources) spending the remaining third.

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[189] Australian Institute of Health and Welfare 2018, Health Expenditure Australia 2016–17, Australian Institute of Health and Welfare, Canberra.

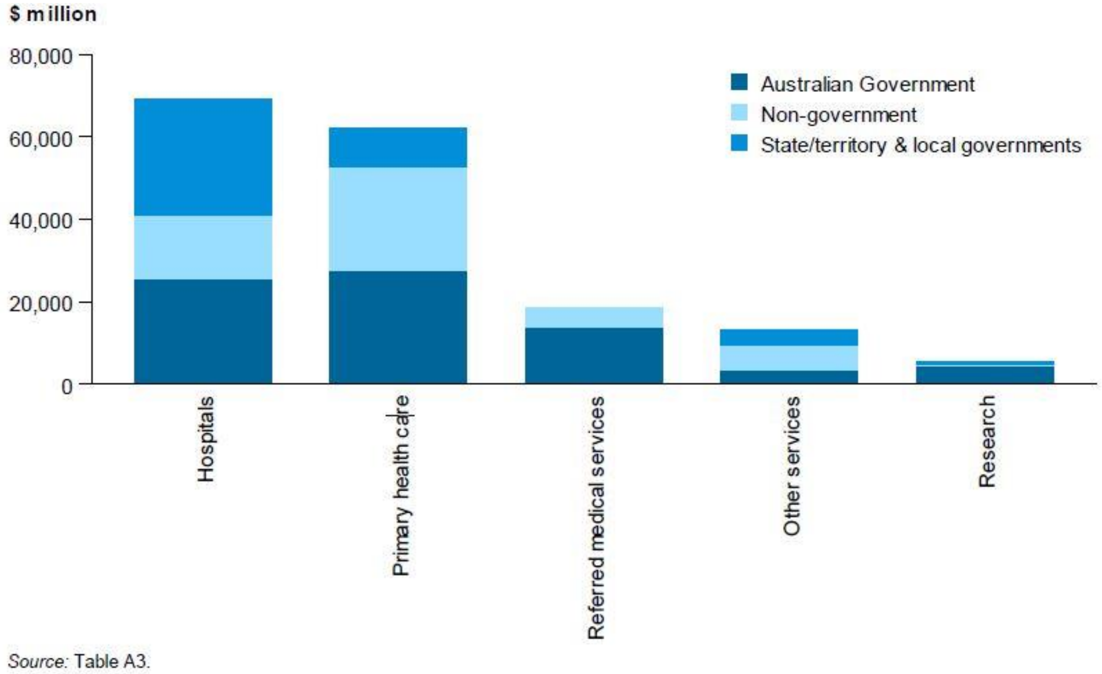
[190] OECD 2017, Health at a Glance 2017: OECD Indicators, OECD Publishing, Paris, viewed 11 November 2019.

[191] The Commonwealth Fund 2017, Mirror, Mirror 2017: International comparison reflects flaws and opportunities for better U.S. Health care, The Commonwealth Fund, New York, viewed 11 November 2019.

[192] Australian Institute of Health and Welfare 2018, Health Expenditure Australia 2016–17, Australian Institute of Health and Welfare, Canberra.

The vast majority of expenditure occurred in hospitals ($70 billion) and primary care (around $65 billion).[193]

Figure B.3: Recurrent health expenditure, current prices, by area of expenditure and source of funds, 2016–17



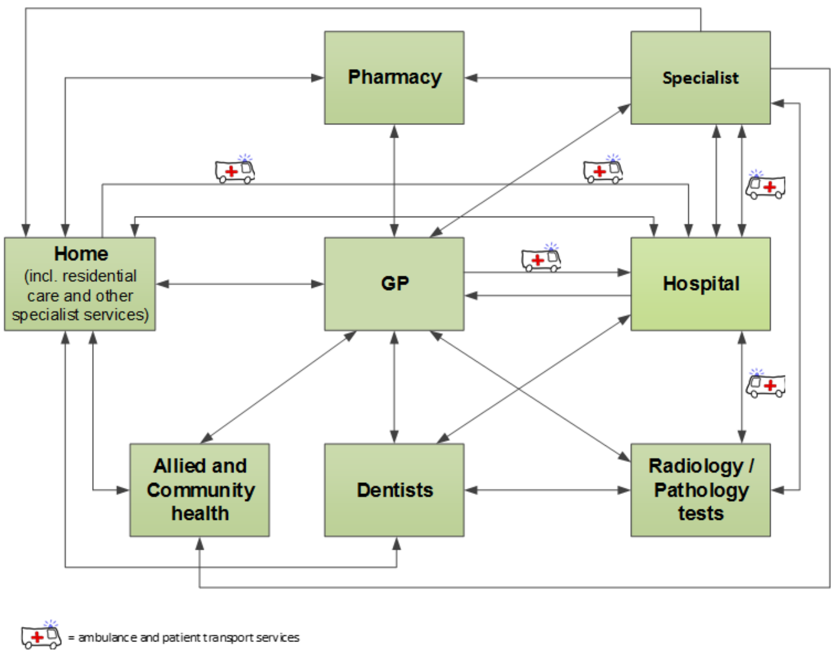
Source: Australian Institute of Health and Welfare, Health expenditure Australia 2016–17

Australia's health services system is large and complex. Health spending occurs in different levels of government, as well as by non-government entities, such as private health insurers and individuals. In many cases, funds pass through several entities before providers (such as hospitals, general practices, and pharmacies) use them to provide health goods and services. In Australia, these services are delivered by a variety of government and non-government providers in a range of service settings that do not have a clearly defined path.[194]

[193] Ibid.

[194] Productivity Commission 2019, Report on Government Services 2019, Part E – Health, Productivity Commission, Canberra

Figure B.4: Client flow within the Australian health-care system



Source: Productivity Commission, Report on Government Services, 2019

Health services are provided by a variety of organisations and individuals, including medical and allied health professionals, hospitals, medical insurers, specialised clinics, and government and non-government agencies. Together, they deliver a wide range of services, from public health and preventative services in the community, to primary health care, emergency health services, hospital-based treatment, mental health and rehabilitation, and palliative care.[195]

These health services are supported by many other agencies. For example, research and statistical bodies provide information for disease prevention, detection, monitoring, diagnosis, treatment, care and associated policy; consumer and advocacy groups contribute to public debate and policy development; and universities and health services (amongst others) contribute to the training of health professionals.[196]

Innovation

Business R&D expenditure varies with the relative size of businesses in the health sector.[197] In the health sector, in contrast to other sectors in Australia, a higher proportion of R&D is performed by medium-sized companies (with

[195] Australian Institute of Health and Welfare, Australia's health 2016, 2.1 How does Australia's health system work, Australia's health series no. 15. cat. no. AUS 199.

[196] Ibid.

[197] Australian Bureau of Statistics 2019, Research and Experimental Development, Businesses, Australia, cat. no. 8104.

20–199 employees) and less by large-sized companies (200+ employees) (Table B.5).

Table B.5: Expenditure on R&D by size of business in the health sector

	Health	Overall
0–4 people (micro)	11.3% ($12 million)	6.4% ($1,062 million)
5–19 (small)	17.9% ($19 million)	12.3% ($2,054 million)
20–199 (medium)	50.0% ($53 million)	24.1% ($4,008 million)
200+ (large)	20.8% ($22 million)	57.2% ($9,535 million)
total	100% ($106 million)	100% ($16,659 million)

Source: ABS Cat. No. 8104.0 – Research and Experimental Development, Businesses, Australia, 2015–16

How innovation occurs in the health services sector

This section outlines how innovation occurs in the health services sector and highlights some of the measurement implications arising from these activities.

The focus is on improving patient outcomes and efficiency

To understand what drives innovation in the health services, we must first understand the primary aims of the sector. These aims are inextricably linked, which are to:

- *Improve client or patient outcomes*. Innovation clearly benefits the individual, but also the community as a whole, because a healthier population means greater workforce participation and national productivity. The service provider also benefits as if patients are satisfied, the organisation will be attractive to new customers
- *Improve efficiency*. Creation of a more effective and efficient health system reduces – or limits increased rates of – health expenditure as a percentage of GDP, allowing resources to be directed to other activities. Furthermore, for businesses, providing equivalent health services at a reduced cost allows costs-savings to be directed to other initiatives to improve customer or patient outcomes.

The drivers, on the other hand, are conditions, resources or components that encourage an organisation to innovate. The drivers of innovation include (but are not limited to):

- increased demand or pressures on health-care resources (e.g. an ageing population)
- digital and technological advancement or disruption (e.g. introduction of new software, such as patient information management systems that lead to changes in processes)
- availability of improved therapeutics, such as new medications and devices

- changes in government policy or legislation (e.g. pricing regimes and My Health Record)
- a shortage of health professionals in rural and remote communities.

There is an incomplete picture of innovation in the sector

Innovation in the health services sector takes place within a complex and dynamic ecosystem that includes hospitals, primary care, allied health and specialist clinics. Services are delivered by government and non-government providers in a variety of settings and involve several actors that each play an important role in the sector, including researchers, clinical staff (e.g. doctors and nurses), support staff (e.g. administrators and cleaners), specialist allied health professionals, medical insurers, and government regulators and funders.

Innovation within the system also relates to the use of many different types of health interventions, including: drug therapies, surgical procedures, devices and tests, health professional training, patient education, and management, financing and service delivery models, and population health interventions. These interventions will often be required to occur simultaneously, and in harmony with each other, if the desired health outcomes are to be achieved.

The Australian Institute of Health and Welfare (AIHW) reports that approximately three percent of total health expenditure is spent on research.[198] However, we have limited understanding of the proportion that is spent on innovation, as there is currently no source of aggregated national data on innovation in health. One reason for this is that government accounts for roughly two-thirds of the total health expenditure, and innovation in the public sector is currently not included in measurement (for example, it is not captured by innovation-related surveys, such as the ABS' BCS).[199] Therefore, to measure total innovation occurring in the health services sector, it is important to account for public sector innovation. It is worth noting in this context that the OECD is considering developing a measurement manual specifically for the government sector. Furthermore, experimentation with public sector innovation indicators is ongoing, with large-scale surveys in Norway and Denmark, and the European Co-Val survey initiated in February 2019.[200]

Measurement implications

- The health services ecosystem is complex and involves a variety of actors in the public sector, non-profit and private sector organisations
- Innovation that occurs within the public sector is not captured by innovation-related surveys, such as the ABS BCS. Some of it is captured in the Higher Education and Government R&D expenditure estimates.

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[198] Australian Institute of Health and Welfare 2018, Australia's health 2018, 2.2 How much does Australia spend on health care, Australia's health series no. 16. cat. no. AUS 221.

[199] Australian Institute of Health and Welfare 2018, Health Expenditure Australia 2016–17, Australian Institute of Health and Welfare, Canberra.

[200] A Arundel, 'Trends in measuring public sector innovation', presentation to Department of Industry, Innovation and Science, Canberra, 2019.

Success is measured differently to other sectors

The primary focus of improving patient outcomes raises the question of whether innovation in health is comparable with other sectors. The measurement of innovation in health has several known challenges:

> *The health-care product is ill-defined, the outcome of care is uncertain, large segments of the industry are dominated by non-profit providers, and payments are made by third parties, such as the government and private insurers. Many of these factors are present in other industries as well, but in no other industry are they all present. It is the interaction of these factors that tends to make health-care unique.*[201]

Many organisations have developed internal dashboards of metrics relevant to their business needs. The purpose of dashboards is two-fold: to improve patient and client outcomes; and to manage the affordability of health-care responsibly (e.g. reduce the cost-base and minimise unnecessary overheads). Dashboards help businesses in tracking their investment in innovation activities and identifying the returns. The capital savings made by the business are then often re-invested in other initiatives that aim to improve client (or patient) satisfaction.

Clinical indicators are commonly used in combination with engagement metrics as proxies for evaluating economic outcomes. These indicators are collected nationally and reported to clinical quality registries (e.g. joint registry, cardiac registry), which enables health service providers to benchmark clinical outcomes against market performance.

Engagement metrics include Net Promoter Scores (NPS) to measure the satisfaction of the client, are also important for measuring staff satisfaction. If collected, they are only used internally by the organisation and are not reported externally. The Productivity Commission's 2107 report 'Shifting the Dial' recommended that development of national benchmarks for gauging the relative performance of health care providers would be valuable in reducing inconsistencies that exist within multiple hospital and other satisfaction and experience surveys.[202]

Measurement implications

- Innovations in the health services sector are difficult to measure, both conceptually and statistically, and in a way that is useful for government policy and program development
- Internal dashboards commonly include engagement metrics in combination with clinical indicators, and are considered proxies for economic outcomes. Inconsistencies exist with multiple satisfaction and experience surveys, and there are currently no benchmarks for gauging the relative performance of health-care providers nationally.

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[201] M Morrisey 2008, 'Health care. The Concise Encyclopedia of Economics', The Library of Economics and Liberty, Carmel, 2008.

[202] Productivity Commission 2017, Shifting the Dial: 5 year productivity review, Productivity Commission, Canberra.

Implementing innovation takes time due to its variability and complexity

Successful innovation in the sector involves, among other things, evaluation and demonstration of the cost-effectiveness of the innovation being introduced.[203] The introduction of health service innovations must also take into account issues, such as: whether a given innovation is worth introducing (the value proposition); who will benefit; and how to minimize unintended consequences.

The processes involved in introducing innovation include adoption, implementation, maintenance, diffusion, dissemination and expansion. These factors overlap in complex ways, which means that health service innovation is almost never straightforward. Increasingly, innovation also involves the development, introduction and mainstreaming of new technologies.[204]

The timeframe for implementation of innovation is highly variable, and depends largely on the scale and length of time for relevant outputs to be known or assessed. Large organisations that have multiple operations or site locations commonly initiate projects as proof of concept or pilot programs, before deciding whether to undertake a large-scale roll out. These larger private companies also commonly have budget allocations set aside for innovation-specific activities, including prototype development and market testing. When innovations are rolled out to multiple sites, it typically takes one to three years before the results and impacts are measurable.

Measurement implications

- The timeframe for implementation of innovation is highly variable, and depends largely on the scale and the length of time for relevant outputs to be known or assessed. It typically takes one to three years before the results and impacts are measurable.

Most innovation activity is conducted within the organisation

Core R&D in the health services sector is almost always performed in-house, and is relatively small in scale compared to other health-related industries such as the pharmaceutical sector.

In organisations that consist largely of medical and allied health professionals, R&D activities are commonly integrated into ongoing operations and undertaken by employees who are also providing services to patients. These organisations also commonly have close links to the research sector, with R&D activities largely occurring in collaboration between the organisation and a university. R&D is not likely to be adequately captured by current metrics because it is often driven by small teams, who are also providing services to patients and conducting R&D 'on the side'. This finding is consistent with innovation in services more broadly, where innovation is largely undertaken by

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[203] E Nolte 2018, How do we ensure that innovation in health service delivery and organization is implemented, sustained and spread?, World Health Organization, Copenhagen.

[204] Ibid.

employees that are not classified as researchers, making it harder to measure innovation inputs.[205]

R&D in the health services sector generally has few regulatory requirements to meet, compared to other medical sectors or the pharmaceutical industry, making R&D innovations relatively simple to trial in health services. However, the key disadvantage of less stringent regulation is that the evidence base may be insufficient to measure the long-term effectiveness and impacts of the innovation.

Measurement implications

- Most R&D is performed in-house. R&D activities may be integrated into ongoing operations and undertaken 'on the side' by employees who are also providing services to patients, making the adequate capture of R&D inputs and outputs more difficult.

Process innovation is hard to measure and often overlooked

A significant amount of innovation within the health services is seen in processes involving incremental changes and modifications. This type of innovation commonly involves either the cessation of activities that were unnecessary, encouraging an increase in procedures that already exist but are not well used, or reorganising existing resources. This type of innovation commonly arises in response to the identification of "pain points" signalled by customers, patients or staff. These changes may also be transformational for the organisation, such as the redesign of workflow and rostering.

These types of innovations are considered fairly straightforward and simple to implement, as they have to meet few, if any, regulatory requirements, but can have significant impacts. Specific examples provided by one company include:

- Introducing an environment cleaning 'bundle' to reduce infections in hospitals. Each hospital received a bundle of recommendations, including information on optimal cleaning agents, cleaning frequency, staff training on environmental cleaning, and a hospital-wide commitment to improved cleaning
    - These changes led to benefits beyond reducing the level of infections in each hospital. The trial resulted in a cultural change in the hospitals, with 66 percent of cleaning staff reporting they felt more valued after the trial, and 70 percent of respondents feeling their own cleaning work had improved. The trial also promoted collaboration within the hospitals (e.g. between cleaning services and infection control staff)
- Improving risk assessments of patients reporting unspecified chest pain when they presented at hospital emergency departments. Some of these patients are at low risk and could be sent home quickly

[205] B Hall & A Jaffe 2012, Measuring Science, Technology, and Innovation: A Review, Report prepared for the Panel on Developing Science, Technology, and Innovation Indicators for the Future, National Academies of Science, Washington DC.

- Through this innovation, unnecessary hospital admissions are avoided, there is less duplication of staff activities, and pressure is reduced for urgent care services
- There are 70,000 presentations to the emergency department at one Queensland hospital each year, with close to one-third related to chest pain
- Improved risk assessments could save over 800,000 staff hours across Queensland each year, and release $29 million in resources.

Measurement implications

- A significant amount of process innovation is evident across the health services sector. The impacts and outputs of these types of innovations are often unmeasured or difficult to measure.

There is a significant amount of non-R&D innovation activity

A significant amount of innovation in the health services involves non-R&D activities, with some organisations estimating an equal split of R&D and non-R&D investment. IT-related, non-R&D innovation common in the sector includes the development of new software, such as electronic discharge summaries and automation of financial services. Other non-R&D activities in the sector include marketing, innovation management and staff development.

Fee-for-service arrangements are generally rare, but are likely to be used when specialist skills and knowledge from outside of the organisation are required (for example, digital health infrastructure and platforms). The companies engaged to perform this type of work are typically small, with fee-for-service the only option available.

Most organisations in the sector focus internally for sources of innovation

Evidence of organisations sharing knowledge in the health services sector is limited. Innovations arising within a particular hospital, for example, are seldom shared outside of the individual institution or regional network. A culture of competitiveness was cited as a reason that contributes to a limited sharing of knowledge. This is concerning, given that such sharing is likely to contribute to improved patient outcomes, which is the primary aim of innovation within the sector. The source of funding was another contributing factor, with projects that received funding from a national body, such as the National Health Research Council, considered more likely to publish results than projects funded by state or local Governments, or by the private sector.

However, there are a few organisations that recognise the value in providing a better service for their clients, and seek to enter collaborations in the form of venture partnership arrangements.

There is also evidence of strong links between the university research sector and specialist providers, as well as with hospitals. The publishing of papers and attendance at conferences are considered an important way to contribute to the sharing of knowledge, especially for medical and allied health professional staff. However, some concerns were raised with the ability of staff to attend forums, such as conferences, due to resourcing limitations.

Much of the sector is limited to internal sources of innovation. The organisations interviewed for the sectoral study advised that there are only a few large organisations sourcing innovation from overseas, and domestic competitors are rarely viewed as a source of new ideas. The measurement of health-care output based on volume, rather than quality, was considered an impediment to innovation for businesses in the health services sector.

Data needs to be used better to maximise its value

The Australian Institute of Health and Welfare (AIHW) is the primary source of national data on the health services sector. Australia's health information and data environment is changing rapidly, and while a large volume of data is already collected, some potentially valuable information is missing. This includes data on innovation metrics.

One of the reasons could be that collection of data is seen as additional to core activities, such as prescribing medications or performing procedures. The Productivity Commission's 2017 report 'Data Availability and Use' cited some key factors that often act as blockages to data exchange in health.[206] This includes limited incentives for health service providers to undertake such exchanges, entrenched models of practice that do not facilitate greater use or exchange of data within their service delivery, and in many cases, providers face an array of governance and other requirements that actively prevent them from exchanging data. These factors were confirmed by companies interviewed for the sectoral study. Private sector organisations, in particular, highlighted the lack of incentives to collect and report data, with the government's ability to collect such data largely dependent on whether businesses see value in participating.

In addition to data not currently being collected, there are also opportunities to improve the use of existing data, including data linkage. Unlike most OECD countries, Australia does not routinely use linked data to monitor the quality of its healthcare system.[207] Linked datasets are valuable, particularly for research and analysis purposes. Although there are linking bodies in all jurisdictions, such as the Population Health Research Network (which brings together data from all states and territories), their use is limited and potential value is yet to be realised.[208]

Measurement implications

- Innovation-relevant data (if collected) is seldom shared outside of an organisation due to a number of factors, including a lack of incentive for

[206] Productivity Commission 2017, Inquiry Report, Data availability and use, Productivity Commission, Canberra.

[207] OECD 2013, Strengthening Health Information Infrastructure for Health Care Quality Governance: Good Practices, New Opportunities and Data Privacy Protection Challenges, OECD Health Policy Studies, OECD Publishing, Paris.

[208] Productivity Commission, Inquiry Report, Data availability and use, Productivity Commission, Canberra.

collection and reporting. National data on innovation activities to inform government investment is lacking

- Australia, unlike most OECD countries, does not routinely use linked data to monitor the quality of its healthcare system. Linked datasets (which brings together data from all states and territories) would provide opportunities to make better use of existing data.

Finance and Insurance Services

Summary of findings

- Misunderstanding key concepts of innovation may lead to underreporting in surveys of the financial sector
- Since many businesses work together in arrangements where one party is engaged on a fee-for-service basis, current measures of collaboration based on the Oslo Manual definition (which excludes fee-for-service contracts) do not capture the full extent of co-operative activities occurring in the financial sector
- The sector operates in a highly competitive market, and a significant proportion of fintech-related innovation and capability is sourced from overseas
- Due to the digitalisation of the sector, in principle there is significant granularity possible in mapping the components of innovation, particularly intangible assets
- Unlike other sectors, measuring innovation over the course of a year is sufficiently long enough for the financial sector as innovation progresses from idea to full implementation very quickly
- There is significant potential for innovation in the sector to spillover into other areas of the economy
- Current measurement does not consider innovation that creates social benefits. Environmental and social changes are key to living standards and therefore need to be measured effectively to improve our understanding of the impacts of innovation.

Summary of opportunities

- Misunderstandings about the concepts of innovation should be addressed by including sector-specific explanations and examples in survey instruments
- Measurement of social and environmental benefits of innovation that are not typically quantified in innovation measurement should be considered
- There should be analysis of collaborative arrangements that are occurring on a fee-for-service basis
- Due to the digitalisation of the sector, opportunities should be investigated to capture data that improves measurement of intangible innovation.

Background and context

The industry

The financial sector is made up of businesses from the banking, financial planning, insurance and superannuation fund areas. For the purposes of this study, they have been collectively addressed as the financial sector.

The finance sector in Australia has some of the largest banks in terms of market capitalisation, and are regarded amongst the safest institutions in the world.[209]

At the end of the 2017–18 financial year, there were 209,621 companies operating in the sector, which represented nine percent of the total number of businesses in Australia.[210] However, the vast majority of these (around 99 percent) are either non-employing businesses (173,723), micro financial sector companies with fewer than five employees (30,241) or small businesses with 5–19 employees (4,415). There was a higher proportion of non-employing businesses in the financial sector (82.9 percent) than for the rest of the Australian economy (61.2 percent).

During this period, there were only 184 large companies in the financial sector. This sector is similar in profile to the agriculture sector in that there are a large number of businesses overall but relatively few large businesses. The sector also comprises a majority of wholly Australian-owned businesses (95.3 percent).

Innovation

Innovation in the financial sector is considered a key element for success. Of innovation active financial businesses, 48.1 percent had increased revenue in the past year.[211] In comparison, only 31.1 percent of non-innovation-active businesses had an increase in revenue. Businesses surveyed by the BCS in the financial sector indicated they are more likely to source innovation internally, and from clients, than the industry average. Universities are seen as a very small source of innovative ideas.[212]

The financial sector made a significant contribution to business expenditure on R&D (19 percent of total BERD in 2015–16).[213] This research intensity is reflected in the Analytical Business Enterprise Research and Development (ANBERD) data in Figure B.5 that shows the Australian financial sector is a leading sector internationally in terms of R&D intensity (ranking third out of 31 countries).

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[209] The Treasury 2016, Backing Australian Fintech, The Treasury, Canberra.

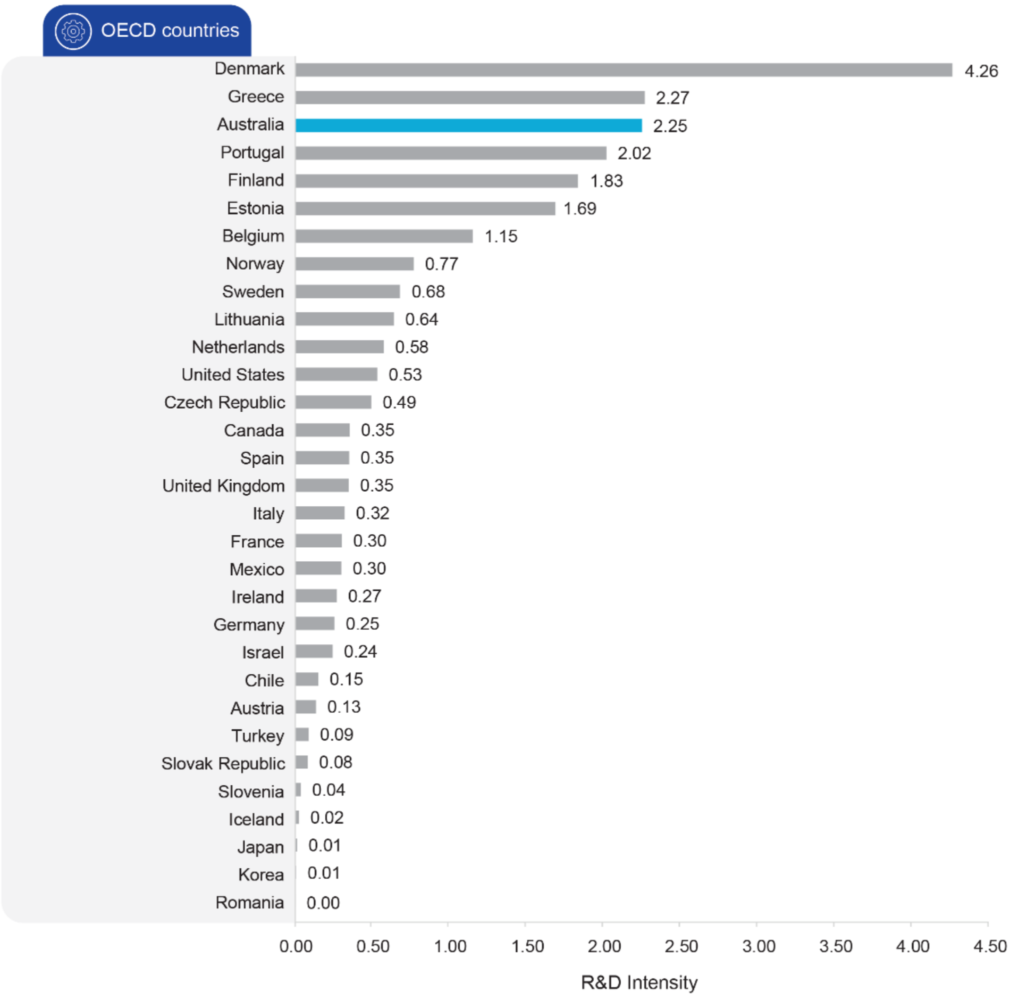
[210] Australian Bureau of Statistics 2019, Counts of Australian Businesses, including Entries and Exits, cat. no. 8165.0.

[211] Australian Bureau of Statistics 2019, Characteristics of Australian Businesses 2016–17, cat. no. 8167.0.

[212] Australian Bureau of Statistics 2017, Innovation in Australian Business, cat. no. 8158.0.

[213] Australian Bureau of Statistics 2019, Research and Experimental Development, Businesses, Australia, cat. no. 8104.0.

Figure B.5: Comparison of R&D intensities in the financial sector in the OECD (2018)



Source: OECD, ANBERD (Analytical Business Enterprise Research and Development) database

In addition, business R&D is overwhelmingly performed by large businesses in the financial sector.[214] They contributed 87.7 percent of R&D expenditure by all financial sector companies in 2015–16.

Table B.6: Expenditure on R&D by size of business in the financial sector

	Finance	Overall
0–4 people (micro)	1.8% ($57 million)	6.4% ($1,062 million)
5–19 (small)	2.3% ($75 million)	12.3% ($2,054 million)
20–199 (medium)	8.2% ($264 million)	24.1% ($4,008 million)
200+ (large)	87.7% ($2,820 million)	57.2% ($9,535 million)
total	100% ($3,215 million)	100% ($16,659 million)

[214] Ibid.

Source: ABS Cat. No. 8104.0 – Research and Experimental Development, Businesses, Australia, 2015–16

The RDTI is an initiative by the Australian Government to encourage companies to engage in R&D.[215] The initiative provides a tax offset to Australian companies to claim the cost of eligible R&D activities. In 2017, $642 million (4.6 percent of the total) was claimed by the financial sector through the RDTI.

The vast majority of this R&D (91.9 percent) was in areas of computer software, information systems and information and computing sciences. From this breakdown, it is apparent there is heavy investment in digital infrastructure R&D that may have spillover benefits in other technology sectors.

How innovation occurs in the financial services sector

This section outlines how innovation occurs in the financial services sector and highlights some of the measurement implications arising from these activities.

Greater clarification is needed on key concepts of innovation

There are various interpretations of what 'significantly different' means from the perspective of a new product and process counting as innovation (as set out in the Oslo Manual). Some respondents set the bar high, identifying only what may be termed radical innovation, while others included minor process improvements (which would also be included in the Oslo classification). While the ABS avoids using the term innovation in its surveys, there was similar disparity in views about what constitutes a 'new' product or process.

Measurement implications

- Misunderstanding may lead to underreporting of innovative activities in surveys of the financial sector.

Collaboration varies in the sector and is based on trust

Collaboration is important as it allows the diffusion of knowledge and sharing of risk and capabilities. In the financial sector, there are various points of view regarding the level of trust in the sector. Trust significantly influences the ways in which businesses collaborate.

Larger businesses advised that they engage in various types of collaboration. Some include true collaborative partnerships with sharing of new IP. Other partnerships are with current and prospective clients through research and feedback on products and services. Some businesses reported significant levels of collaboration through financial transactions, although they indicated it would be difficult to track across the organisation and measure effectively. One company advised that investment in start-ups was viewed as a form of collaboration to bring innovative products and services to market. However,

[215] Australian Taxation Office 2017, Research and development tax incentive, Australian Taxation Office, Canberra, viewed 21 November 2109, <https://www.ato.gov.au/Business/Research-and-development-tax-incentive/>.

most companies advised that the majority of collaboration was conducted through fee-for-service arrangements.

It was noted in interviews that collaboration with overseas companies was often seen as more beneficial than domestic partnerships. Singapore was highlighted as a particularly open country for engagement. One company advised that there was goodwill with other international businesses in the sector, even when there were no financial transactions taking place.

Measurement implications

- Since many businesses work together in arrangements where one party engages on a fee-for-service basis, current measures of collaboration based on the Oslo Manual definition (which excludes fee-for-service contracts), do not capture the full extent of co-operative activities occurring in the financial sector.

The financial services sector is a highly competitive international market

Other countries provide a significant source of innovation for the Australian financial services sector. A number of companies seek to leverage the capability of big businesses and technology businesses based overseas in developing financial technology (fintech) systems. China, in particular, was identified as a major player due to the scale of innovation occurring, and also Singapore, for its receptive regulatory environment. From a digital banking perspective, one company noted that there are strong developments in Europe that could be emulated, but the Australian sector has close comparisons to technology developments in the Americas.

In relation to the recruitment of staff, companies compete in an internationally competitive market for resources. They seek to secure the best resources possible, both domestically and internationally. Recruitment of overseas staff was described by some companies as a key means of increasing capability, especially in the digital technology area. While finance is the key activity of the companies interviewed, all businesses reported the critical need for staff with specialist digital capabilities.

Businesses interviewed for the sectoral study reported that most of the relevant learning took place as on-the-job training, or learning by doing. Formal training was not identified as a significant input.

Digital technology is a significant source of intangible assets

Digital technology is a critical enabler for the financial sector. A large share of innovation comes from the digitalisation of current processes. Other types of innovation involve the creation of new mathematical models for risk and pricing. These activities, along with patenting, provide a significant source of intangible assets.

As an example of digitalisation in the sector, Lendi is an Australian online home loan platform that matches borrowers and loan products. Lendi combines smart technology with more traditional forms of support to make it easier to search, choose and settle a home loan online. Lendi has influenced banks to adopt more digital processes (and become partners with the business) through its work in online identification and verification.[216] Digitising processes has significantly reduced the time it takes to process online home loan applications (e.g. from several months to several weeks). However, there is ongoing work in the fintech sector to reduce this even further. One company advised it is seeking to develop a process that completes mortgage applications in a matter of minutes.

Innovation has helped drive the increasing personalisation of products and services. Businesses such as Netflix and Google, are shaping expectations in other sectors around the quality, speed and tailoring of services. These expectations significantly impact consumer expectations of financial services. From a measurement perspective, this means in principle that significant granularity is possible in mapping the components of innovation in financial services businesses.

Measurement implications

- Due to the digitalisation of the sector, in principle there is significant granularity possible in mapping the components of innovation, including intangibles.

Innovation is going beyond economic outcomes to deliver wider social benefits

The drivers of innovation in the financial sector are closely aligned with economic outcomes. In particular, a number of banks estimated almost 50 percent of expenditure on innovation was driven by the need to respond to regulatory change. This included the costs involved in maintaining IT capabilities and reporting systems. One bank advised that maintaining the integrity of their compliance and regulatory reporting obligations were important factors in their innovative activities.

Evolving customer demand was considered the overwhelmingly agreed upon driver of innovation in the financial sector. All participants in the review indicated that gaining and retaining new and existing customers was of paramount importance to their business. As a result, the financial wellbeing of customers was becoming a significant consideration in driving innovation. The goal is to encourage customers to adjust spending habits and make better choices that will improve their finances over the longer term. For example, Xinja's mission is to build a bank with its customers, designed in their interests that helps them make better money decisions without the angst.[217]

Measurement implications

- There is no quantifiable measure of social benefit (such as improved financial wellbeing) from innovations that restrict undesired behaviours, such as problem gambling and excessive alcohol consumption (for example by limiting ATM withdrawals or credit card payments at particular locations or times at the customer's request).

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[216] S Thompson & A MacDonald, Street Talk, ANZ Bank buys into online mortgage bank Lendi, Financial Review, media release, 14 January 2019.

[217] Xinja, About , Xinja, viewed 21 November 2019, < https://xinja.com.au/about-xinja/>.

Not all innovation is being reported and measured

All businesses interviewed reported undertaking R&D. A significant share of this activity was the adaptation of existing systems and products to the Australian context, which is ineligible to be claimed under the RDTI based on current criteria. As a result, there is a large gap between the R&D activity being conducted and what can be claimed through this program. Many businesses advised that the RDTI did not significantly influence their R&D expenditure. Their R&D activity was conducted mostly, and in many cases exclusively in-house.

Not all innovation is short-term, although short-term innovation appeared to be much more common than long-term innovation this sector. IAG has been conducting R&D to prepare for the implementation of autonomous vehicles for many years.[218] This research could have impacts that go far beyond purely economic, which are very difficult to measure and may take time before outcomes are known.

Due to the financial sector's large digital focus, and mostly short-term focus, feedback on the impacts of innovation occurs much more quickly than in other sectors.

One bank indicated that a lot of digital service offerings are related to financial wellbeing and enhancing the use of its products.

Customer satisfaction is considered a very important measure. It was noted that all businesses interviewed were able to measure this with great accuracy due to the digital nature of the products and services offered. Customer satisfaction is not the same as improved financial wellbeing.

Measurement implications

- Some innovation in the financial sector is long-term in nature, and is conducted to enable an appropriate response to major technological change enabling business survival, rather than increasing revenue or reducing costs in the short to medium-term. This innovation is not hidden, but it is difficult to assess its impact.

Innovation moves quickly from concept to implementation

Innovation in the sector is characterised by short cycles and lends itself well to agile management approaches. The reference period for innovation was generally reported to be less than a year, more commonly six months or less, and sometimes in the order of weeks. For example, Macquarie Bank implemented an agile methodology across its digital operations in 2017.[219] This enables adjustments to be made every two weeks, based on feedback from

[218] Financial Review, Chanticleer – IAG research says automated vehicles decades away, Financial Review, 14 January 2019.

[219] J Brookes 2018, Why Macquarie Bank's digital team only plans three months ahead, Which-50, 6 June 2018.

both staff and early adopting consumers. Macquarie now feels better placed to compete in a digital economy and respond to unexpected competition. In order to realise this shift, Macquarie Bank made a large investment in human capital.

A number of other banks advised they had also implemented agile methodologies across the business to help reduce timeframes and improve digital services for customers. All companies interviewed for the sectoral study considered agile approaches to project management to be a key form of organisational innovation.

Measurement implications

- Unlike other sectors, measuring innovation over a year is generally long enough for the financial sector as innovations go from idea to full implementation very quickly.

There is significant potential for spillover benefits

Several businesses reported significant knowledge spillovers as a result of their innovation. As discussed earlier, Lendi has influenced banks to adopt processes for faster mortgage applications and home loans through its development of online identification processes. It was often noted in interviews that innovation in the sector has great potential to generate benefits in other areas of the economy.

For example, Macquarie Bank has launched an online tool to help support the independent financial adviser industry.[220] Independent financial advisers are able to service clients better using the platforms that Macquarie provides. It allows them to advise clients more efficiently on issues such as self-managed superannuation funds, mortgages, online trading, investments, managed accounts, and improved overall record-keeping. Macquarie does make revenue from the provision of the platform, but it allows others to generate profit from the service.

Measurement implications

- There is significant potential for innovation in the sector to spillover into other areas of the economy.

[220] Macquarie Bank 2019, Solutions, Macquarie Group Limited, Sydney, viewed 21 November 2019, < https://www.macquarie.com/au/advisers/solutions/>.

Appendix C: Updated improving innovation indicators consultation paper 2019, following the public submission process

Australian Government
Department of Industry, Innovation and Science

Australian Academy of Technology and Engineering

Improving Innovation Indicators

Consultation paper 2019

Updated version: includes material published March 2019 and summaries of key points made in submissions received in the public consultation process

Contents

Foreword from the Chief Scientist and the Chief Economist

In almost all respects, life in Australia is better now than it was a generation ago, a positive bequest to hand on to the next generation. Innovation, the human desire to improve things, underpins this. It is what explains rising life expectancy, levels of education and living standards.

An entire generation of Australians has grown up without experiencing a recession. Australia, unlike the rest of the developed world, dodged the Global Financial Crisis a decade ago. In doing so, we broke the global record for years of consecutive economic growth. At the same time, Australia has remained persistently ranked in the bottom half of developed economies, and slipping, across a range of comparative measures such as the Global Innovation Index and the World Competitiveness Index. How is it that both can be right?

Our view is that these measures are not right — they are failing to capture aspects of Australia's economy. Summary measures of Australia's innovation performance seem to get things both wrong and muddled. For example, Australia ranks last, by some margin, among all OECD countries in business-researcher collaboration. There is plainly room for improvement on this measure in Australia, but the international comparisons do not ring true.

For instance, Australia is mid-ranking among OECD countries in patent collaboration between businesses and researchers. It is also easy to demonstrate that the official statistics for Australia undercount the actual extent of collaboration between agencies like the CSIRO and business.

It is well known that in industries like mining and agriculture Australia is a world-leader. These primary industries are seen by some as less important than secondary and tertiary industries, somehow primitive compared to advanced manufacturing. Nothing could be further from the truth. Australian mining and agriculture are highly innovative, indeed pioneering in their application of new technologies. Driverless trucks and trains are already in operation in the Pilbara, remotely controlled from 3000 kilometres away in Perth, supported by a local ecosystem of high-end data analysts. These industries do not typically feature in international measures of innovation performance. That is an oversight.

Australia also seems to be at the forefront of embracing new technologies in the digital economy, as seen in industries such as retail, finance, logistics and hospitality, which raises questions about how much weight should be given to home grown innovation versus being fast followers in embracing innovation from abroad.

We have embarked on this Review because we believe that innovation matters; indeed, hardly anything else matters as much in raising the well-being of Australians over the long run. If we are to continue to raise the well-being of Australians, and if we want to shift the dial on productivity, we need to track our progress on innovation. We need to understand innovation across all of Australia's industries and regions, and make adjustments to policy settings as needed. In a data-rich world, we also need to be sure that we are harnessing new data sources, including from the private sector, to meet our needs better.

Our initial round of stakeholder consultations has yielded a rich variety of perspectives on what is needed to improve innovation indicators in Australia. It is already evident that we will not be able to please everyone, as the different demands are wide-ranging. We invite you to read this first consultation paper, and contribute your views on where you think we should focus our efforts. Combined with the insights of international experts, we are confident that we can offer up a next generation of innovation indicators to meet the needs of policy makers and serve the interests of Australians over the next decade and beyond.

Alan Finkel
Australia's Chief Scientist

Mark Cully
Chief Economist,
Department of Industry,
Innovation and Science

Overview of the Innovation Metrics Review

Innovation is essential to improving Australian productivity and living standards and creating new jobs. Recognising this, it is important innovation is measured as accurately as possible.

The Innovation Metrics Review ('the Review') was recommended in the Innovation and Science Australia (ISA) 2030 Plan, accepted by the Government and included as a measure within the 2018-19 Budget. The Review commenced in May 2018 and is due to be completed on 30 June 2019.

The purpose of this consultation paper is to acquaint innovation system stakeholders with the Review's progress to date, and provide a broader range of stakeholders with the opportunity to provide input.

Goals and principles of the Innovation Metrics Review

In embarking upon the Review, the Chief Scientist and Chief Economist established a guiding set of goals and principles, and these were refined and agreed with the international Steering Committee.

Goals

The Review will deliver a report to the Australian Government recommending:

1. an appropriate data and measurement infrastructure for capturing innovation metrics that:
   - is underpinned by a sound conceptual framework
   - captures data at the most efficient cost
   - sets out a roadmap for change.
2. a suite of robust innovation metrics that:
   - accurately measure and effectively communicate innovation performance and its impacts across all sectors of the Australian economy
   - are presented in a way that is useful for government policy and program development
   - can measure the impact of government policy initiatives on innovation
   - may be useful for international adoption and comparisons.

Principles

The Review recognises the breadth of benefits that innovation delivers to society, but focuses on the economic impacts of innovation (in particular productivity, investment, jobs and exports), as these are where innovation policy can have the greatest impact on living standards.

The Review sets innovation in the context of a modern economy characterised by an increasing dominance of service industries, high levels of investment in intangible capital and deployment of digital technologies.

A key assumption is that Australians want the benefits of innovation from wherever it is sourced — for example, in sectors such as mining and agriculture — which means we must be open to all sources of innovation and uncover hidden innovation.

A mapping exercise based on a conceptual framework will demonstrate which of the existing metrics in use are of sufficient quality and where new metrics need to be developed to fill gaps. A starting position for the framework is in the Australia 2030 Prosperity through Innovation report.

Metrics must be directly relevant to government policy development and program performance. Ultimately high-level metrics will be presented in a scorecard format of a useful number of indicators (around 10 to 15). The full suite of metrics will serve broader purposes in monitoring, evaluation and research on the innovation system and the impact of government policy. Criteria for deciding metrics will be developed to ensure objective metric selection.

Where metrics are also collected and published internationally for advanced economies, these will be favourably considered. The recommended metrics should aspire to be internationally comparable (with zero or minimal correction required).

It is likely that we will recommend some significant changes to the capture of innovation metrics. Where appropriate to do so, these will leverage off existing statistical collections and administrative data sources, but not shy away from using novel sources.

In setting out a roadmap for change, we will aim to ensure the longevity of the changes to the data and measurement infrastructure remain in place to 2030 and beyond.

Underpinning all of the above principles is the principle of pragmatism. The Review's recommendations will be practical, achievable, have due regard for the burden imposed on data providers, and will focus on the most important improvements that could be made.

The approach of the Innovation Metrics Review

The Innovation Metrics Review is being funded by the Department of Industry, Innovation and Science (DIIS). The Review is being undertaken by: a Taskforce of officers from DIIS, the Australian Bureau of Statistics (ABS) and IP Australia; and by the Australian Academy of Technology and Engineering (ATSE). ATSE's role is to provide an independent viewpoint, but ATSE is working in close collaboration with the Taskforce to ensure the Review is robust and conducted in a resource-efficient manner.

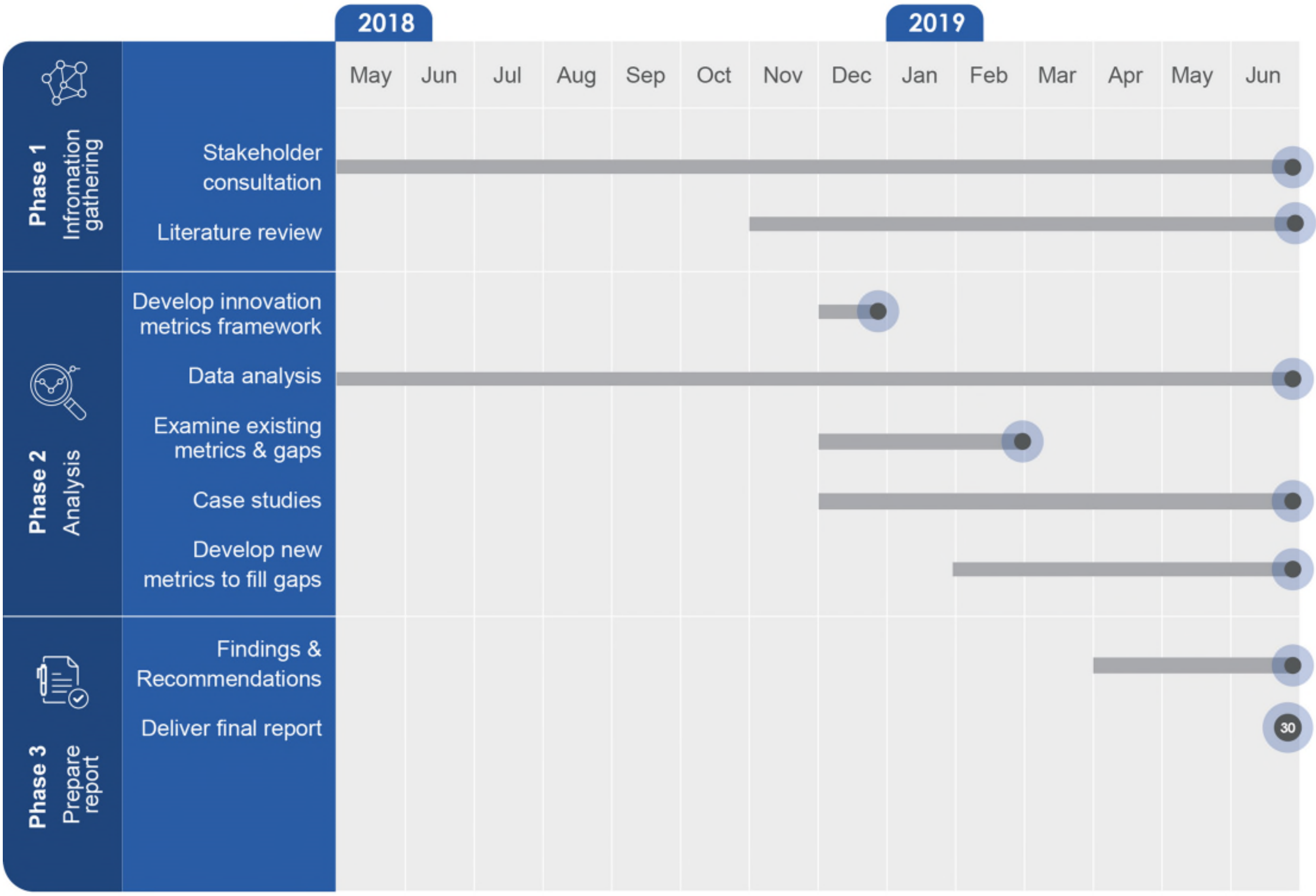
ATSE is being funded to undertake a literature review and advise on a framework; the data currently available – including gaps; and the metrics to be used or developed for future use.

Governance of the Review

The Innovation Metrics Review Taskforce is directed by a Steering Committee, and receives advice from an Expert Working Group. Selected international technical advisers are also providing expert guidance. The composition of these groups is provided in Appendix G.

The main Review activities are shown below.

Figure 1 — Innovation Metrics Review timeline



Consultations

The purpose of the consultation process is to understand stakeholder needs, concerns and priorities to inform the review. Consultations are being undertaken in two phases:

1. Targeted consultations.

About 50 consultations were undertaken with stakeholders from the government sector (international, Commonwealth, state and territory), research sector (independent academics, research organisations and research sector peak bodies) and the private sector (including bibliometric providers) between July and December 2018.

Key messages provided by stakeholders during the targeted consultations are summarised below. Note that these reflect the opinions of and statements made by stakeholders and should not be considered as findings of the Review. Their concerns are being assessed and their needs prioritised as part of the Review.

2. Public consultation

In March 2019, we will undertake public consultation to acquaint innovation system stakeholders with the Review's progress to date and provide a broader range of stakeholders with the opportunity to provide input to the Review. That is the purpose of this document.

In April or May 2019, we will make draft findings and recommendations available for public comment, ahead of the Review's report to the Government at the end of June 2019.

Literature review

The objectives of the literature review, undertaken by ATSE, are to:

1. summarise state-of-the-art thinking about the role of innovation in modern economies, and the drivers of innovation, in the context of rising investment in intangible capital, the growth of the service economy, and the uptake of digital technologies
2. examine conceptual frameworks and approaches used for measuring innovation in key advanced economies, and evaluations and critiques of these
3. highlight novel approaches in metrics and data collection
4. identify any approaches that might help to better measure innovation activity in Australia, including in areas of the economy that are not currently measured.

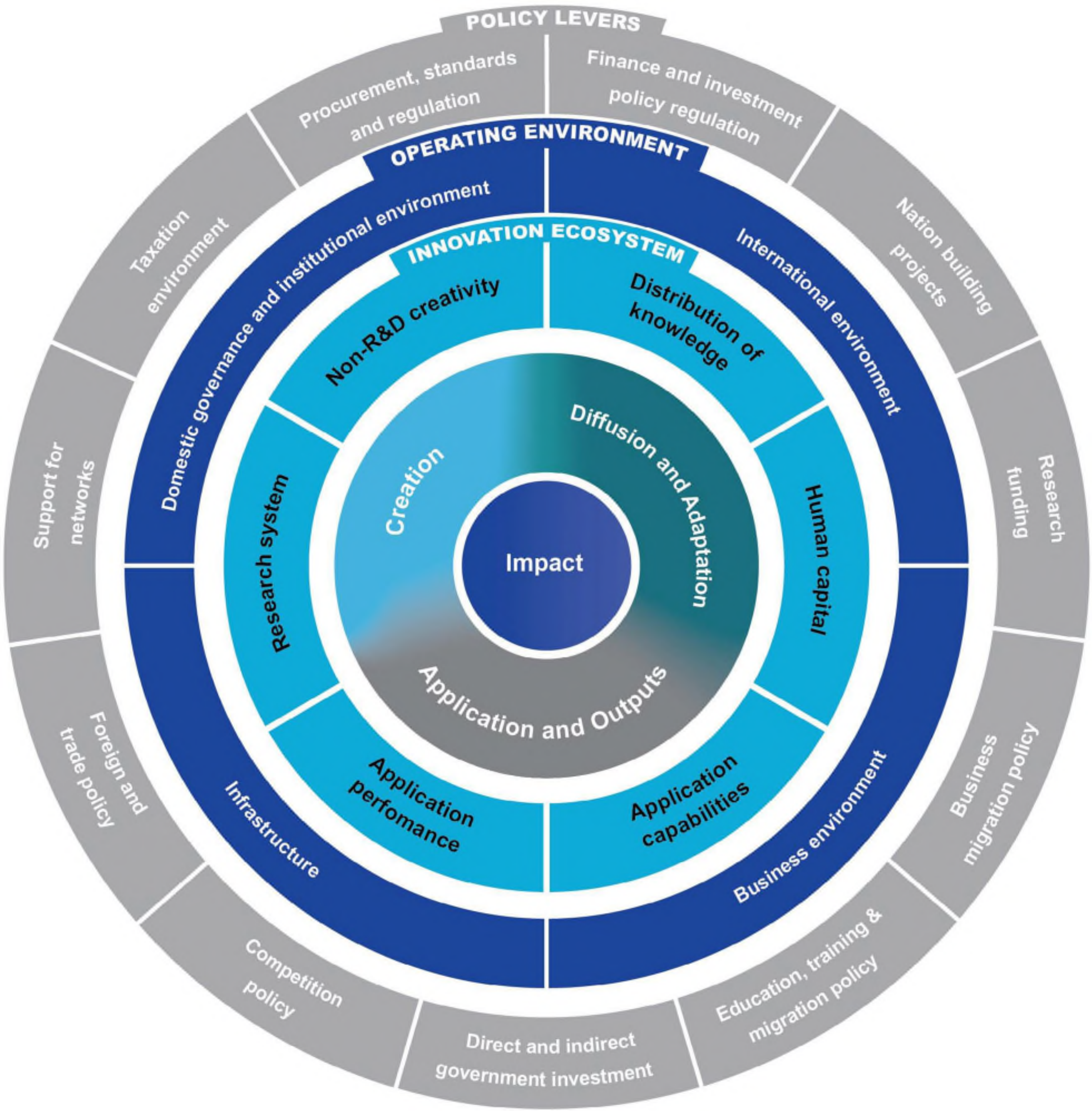
Development of an innovation metrics framework

The Innovation Metrics Framework, developed jointly by the Taskforce and ATSE, is central to the Review's metric collection and categorisation efforts. We acknowledge the many innovation system frameworks currently in existence and that some of these are already used to categorise innovation metrics. Some of the better known frameworks are those used by the Global Innovation Index, the Global Competitiveness Index and the European Innovation Scoreboard.

These other frameworks were developed in order to organise metrics that currently exist.

The Review aims to identify and measure components of the innovation system that are not currently being adequately identified and measured. We developed our own framework to include measures which were not included in existing frameworks. A summary diagram of this framework is shown below.

Figure 2 — Innovation metrics framework



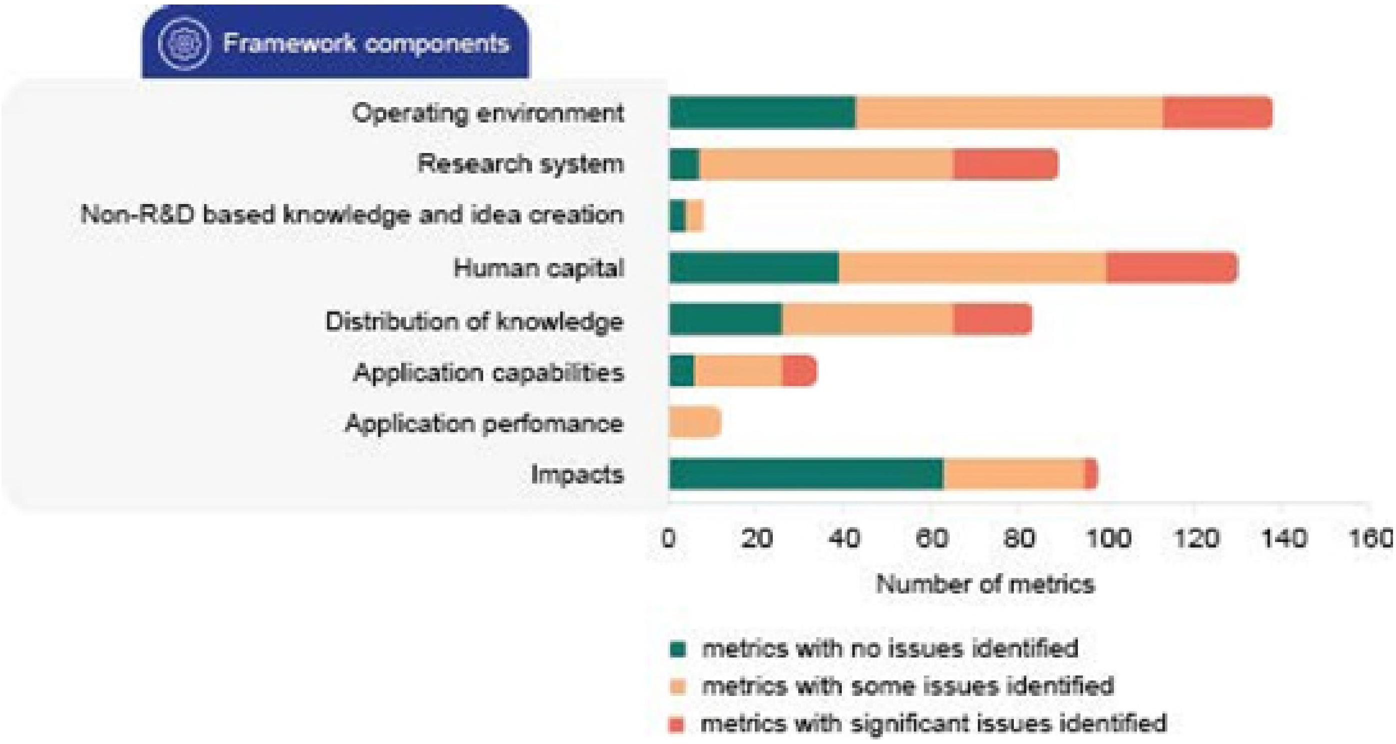
Examination of data

The Review has examined the data presently available for analysis from government administrative and transactional data and surveys and is assessing private sector data which could potentially be made available or collected in order to meet needs that are not currently being met.

Examination of metrics

We examined metrics obtained from a wide range of sources — including Eurostat, the Organisation for Economic Cooperation and Development, the Global Innovation Index, the Global Competitiveness Report, the Innovation and Science Australia scorecards and the Australian Innovation System Report — and assessed them against a range of performance criteria. These are relevance, timeliness, accessibility and clarity, accuracy and validity, reliability and precision, coherence, and comparability. We then mapped metrics against the components of the framework, and identified components of the innovation system for which there are either few or no innovation metrics available and fit for use.

Figure 3 — Number of quality-assessed metrics within each Framework component



Case studies

Case studies are being developed to determine if key industrial and business areas within Australia's economy are generating innovation that is currently not being adequately measured, and the nature of the innovation that is occurring. Focal areas for the case studies include mining, agriculture, health services and financial and insurance services.

Development of new metrics

Where there are gaps in the suite of metrics currently available, we will attempt to develop new metrics to meet stakeholder needs.

International workshop

We are holding an invitation-only workshop during March in Canberra. Participants at the workshop will primarily be innovation system measurement experts based in Australia and overseas. The topics discussed will include entrepreneurship; the international state of play with regard to innovation metrics; hidden innovation in mining; and the measurement of: research and development and innovation; creative inputs into innovation; knowledge diffusion and research commercialisation; intangibles; and capability and absorptive capacity.

Delivery of a report to Government

We will deliver a final report to Government in June 2019. The report will be published and will include a literature review; the findings of the Review, including a roadmap to improve the quality and range of data on innovation performance; the suite of innovation metrics available now and an assessment that shows which of these are most useful; a scorecard comprising a limited number of innovation metrics that best track innovation performance now; and the suite of innovation metrics and scorecard that the Australian Government should aim to produce in future if and when data improvements have been made.

The Government will consider the Review's recommendations and any funding implications as part of its consideration of the 2020-21 Budget.

A preliminary opportunity to comment

To date, the Review Taskforce has met with government, research, and private sector stakeholders. Having conducted initial targeted consultations, we now welcome input from a broader range of stakeholders, including industry groups and businesses.

Given the complexity and breadth of the innovation system and its measurement, these consultations have unsurprisingly revealed great diversity in the ways that different stakeholders use innovation metrics; their concerns with innovation metrics and the underlying data used to produce them; and their views on the opportunities for improving innovation metrics and underlying data.

A summary of the key messages from targeted stakeholder consultations to date is provided below. These represent the opinions of and statements made by stakeholders. We are assessing these stakeholder views and statements and their validity and prioritising the issues raised.

We will not be able to address all stakeholder concerns comprehensively. Some trade-offs will be necessary. We will be prioritising the measurement issues of greatest importance to Australia that can realistically be addressed effectively and which will enable the development of better policies and programs to improve outcomes for Australia.

In developing strategies and prioritising areas for action, we will be guided by the goals and principles discussed on pages 4-5.

We seek stakeholder views on what issues and actions the Review should prioritise and why.

We invite comments on any matters that fall within the parameters of the Review.
Please frame your response by addressing the following questions.

1. Do you agree or disagree with the key messages received from targeted consultations to date? Why?

2. Are there any other issues that fall within the parameters of the Review but which have not been raised in targeted consultations to date?

3. Where do you believe the Review should focus its efforts? Why?

If you would like to provide input to the Review, please do so before **Thursday 28 March 2019**. Input should be sent via email to InnovationMetricsReviewTaskforce@industry.gov.au.

A further opportunity to comment on the Review's draft findings and recommendations will be provided in April or May 2019.

Summary of key messages from targeted consultations

1. What do stakeholders want innovation data and metrics for?

- Stakeholders have indicated that they want consistent and reliable innovation data and metrics to help them determine how to increase innovation activity and measure performance over time. However, innovation is a means to an end. Stakeholders want more innovation because they believe it will lead to:
  - higher living standards
  - higher productivity
  - job growth
  - increased exports
  - social and environmental benefits.
- Stakeholders want innovation data and metrics to provide the evidence base to:
  - compare innovation performance (across countries, states, industries, and participants within an industry)
  - determine where the innovation system in Australia is working well and where improvements can be made
  - help develop cost-effective policies and programs that encourage more innovation
  - determine whether government interventions and procurement activity should be broad-brush or highly targeted
  - measure whether policies and programs are working and should be continued, redesigned, or ceased, by providing comparison data.
- Stakeholders also want to know the relative effectiveness of investing in innovation compared to alternative avenues for government investment.

2. Theory of innovation and implications for innovation measurement

Consultations have yielded some consistent themes relating to the innovation system, the changing nature of innovation, and conceptual implications for how and what should be measured. Key messages from stakeholders include the following:

2.1. Innovation metrics should be approached from a macroeconomic perspective

- Stakeholders highlighted that a key objective of innovation is to increase productivity and thereby living standards. Innovation indicators should be viewed as intermediate indicators.
- Stakeholders highlighted that innovation can be considered in terms of demand and supply.
- Some stakeholders expressed the view that Australia's perceived poor performance on innovation is predominantly due to deficient domestic demand rather than deficient supply. That is, Australia funds scientific research and development (thereby driving innovation supply), but there is a lack of domestic demand (referred to by some as "absorptive capacity") for innovative products and processes once developed.

2.2. Innovation is not just about new-to-world innovation, but is also about innovation adoption and diffusion

- Innovation requires both invention and implementation.
- The rate of development of new-to-world products and processes could drop to zero, and productivity could continue to grow for some time, merely from the adoption of existing innovations and new technologies.
- Being a fast adapter and adopter of innovation and new technologies is important. A considerable number of stakeholders think that adapting and adopting is more important — in terms of getting more firms producing on or near the production possibilities frontier (i.e. efficiently) — than new-to-world innovation, because it has the potential to affect so many more firms.
- There is agreement that many Australian businesses absorb internationally developed innovations and adapt them to Australian circumstances, but considerable disagreement about the relative speed and extent with which this happens.
- Stakeholders note that innovation diffuses geographically as firms expand into new areas or as skilled workers move between firms. They believe that this diffusion happens more quickly across adjoining areas.
- Some see Australia as a fast follower of innovation, whereas others cite Australia's physical isolation as slowing the movement of skilled labour and hence diffusion.
- Some stakeholders believe that there would be value in further exploring where Australia is innovating across the spectrum of simple to complex, and understanding what kinds of innovation Australia adopts.
- There is a need to understand technology diffusion across different types of businesses and business uses of technology, and whether this is world-leading or old technology.
- It is not clear that continuous (incremental) improvement is being counted in measures of innovation.

2.3. Management capability is a key factor in determining the success of innovation in firms

- The development and adoption of innovation and digital technologies, how successfully they are implemented, and whether firms profit from having introduced such innovations, depends on management practices.
- Managerial quality explains some of the differences observed in productivity.
- There is concern about the lack of appropriate risk taking by directors and managers, and their ability to embrace and champion change. Shareholders may be willing to accept risks which may involve firms becoming insolvent, particularly as shares in these firms may account for only part of their portfolios, in the hope of greater gains. However, directors and managers tend not to support risks that may result in job loss.
- Some stakeholders suggest that the Australian mining sector has high managerial quality and should be considered as a case study.

2.4. Measuring the stock of and flows in intangible assets well is important

- Investment in intangible assets may indicate innovation is in progress.
- The proportion of total assets that are intangible has risen steadily in recent years.
- The formation of intangible assets now exceeds the financial investment made in tangible assets for most developed countries.
- The 2008 System of National Accounts does not comprehensively include the measurement of all intangibles in the categories of:
  - database development
  - design and other product development
  - market research and branding
  - business process re-engineering and organisational structure.
- Some expenditure in these areas may represent costs to businesses in the current period, but some represents intangible assets formation.
- The measurement of the stock of and flows in intangible assets is a key issue for many statistical agencies.
- Stakeholders suggest that the Financial and Insurance Services sector should be considered as a case study to help improve understanding of intangible capital in Australia.

3. Stakeholder comments on innovation metrics

3.1. Stakeholders question the data underpinning some collaboration metrics

- Many stakeholders value collaboration metrics, and various metrics have been developed to quantify collaboration in different ways.

  However, stakeholders are concerned about the quality of the data underpinning collaboration metrics.

3.2. Metrics on innovation adaptation and adoption are needed

- We need to improve our understanding on how extension of innovation contributes to adaption and adoption in various sectors of the economy. Much of this activity is considered business as usual, rather than innovation or collaboration.
- Stakeholders have suggested that it would be useful to have a metric to indicate how fast Australia is adopting new technologies, and a metric that quantifies the lag between a new technology becoming available and being adopted.
- Metrics on adaptation and adoption would provide insight into whether Australian firms are fast or slow followers, relative to the rest of the world.
- Stakeholders suggest that the agricultural sector should be considered as a case study to better understand adaption and adoption in Australia.

3.3. Stakeholders value firm-level economic indicators

- Some stakeholders have identified that the most important indicators of innovation to them are standard, firm-level, industrial economic indicators, such as employment numbers and composition, sales growth, employment growth, productivity growth, and profitability.
- However, stakeholders have also indicated that there are problems with the quality of the data that could potentially underpin such metrics — particularly timeliness and extent of coverage —and the accessibility of this data.

3.4. Improved data, metrics and analysis on the scale of innovation spill-overs are needed

- Existing measurement systems do not measure spill-overs of innovation activity.
- Stakeholders have indicated that metrics are needed to quantify the extent of spill-overs between firms, especially with regard to research and experimental development.
- Where possible, stakeholders would like to gauge the extent of spill-overs from innovation activities that affect health and the environment.
- To date, the approach to measuring spill-overs has been via case-studies that provide qualitative data on the wider benefits from innovation activity.
- Hubs of innovation activity occur around research infrastructure. Research infrastructure can help foster industry engagement and collaboration. However, often research infrastructure is taken for granted and should be better measured.
- Several stakeholders need metrics to inform place-based innovation, including the impact of innovation precincts.

3.5. Better metrics on managerial quality are needed

- Many stakeholders indicated managerial quality exerts an important effect on innovation, and therefore indicators of managerial capability are needed.
- There is concern about science, technology, engineering and mathematics (STEM) capability at the managerial level, and a metric on this would be welcomed. However, as innovation may involve creativity rather than science, other metrics are needed as well.
- There is concern over management risk aversion and a metric on this would be welcomed.

3.6. Better metrics on employee quality are needed

- There is a lack of data on the quality of labour. Stakeholders regard metrics on workforce skills as just as important as managerial quality. The behaviour and skills of employees can drive innovation within an organisation.
- Stakeholders want to know whether firms can access the skills they need, and whether the workforce has the required skill sets in the right quantity. That is, stakeholders want to understand whether the supply of skills available matches that in demand.
- Stakeholders are particularly interested with regard to STEM, creative, and certain specific skills.
- Measures of the qualifications of the workforce are not seen as a proxies for the skills of the workforce.
- There is interest in the extent to which the workforce engages in life-long learning. Stakeholders questioned whether the change in qualifications and skills of the workforce is being driven by new workers entering the workforce and older workers retiring, or by people choosing to retrain or upgrade their qualifications and skills mid-career.

3.7. Better metrics on innovation impact are needed

- Stakeholders believe that more effort goes into measuring innovation inputs and activities than innovation impacts.
- Several stakeholders want better data on cost savings, economic benefits and productivity improvements resulting from innovation, and metrics summarising changes in these parameters.

3.8. Better metrics on innovation transfer and networks are needed

- Stakeholders indicated an absence of quality metrics for technology and knowledge transfer, but also that such transfers can be informed by data on talent flow.
- Consultations have indicated that understanding talent flow is of policy relevance because governments are frequently concerned with whether they are attracting talent, and how to attract talent.
- Some stakeholders indicated that they would value metrics on networks between people and how these networks change.

3.9. Better metrics are needed on publication citations

- Stakeholders highlighted that existing scorecard metrics for publication citations are uninformative because they do not take different disciplines into consideration.
- The number of citations considered "usual" differs radically across disciplines, and different disciplines have different citation profiles. For example, in physics, a successful author might be cited 3000 times in five years, whereas in maths, five citations over the same period may be considered a good outcome.
- Some stakeholders believe that without taking discipline into consideration, a single, high-impact publication may change the citation metrics not only for the discipline of the publication, but may distort the overall citation metric.

4. Stakeholder comments on innovation-related data sources

4.1. Better linking of existing data will enable new insights

- Many consultations have emphasised that new insights do not necessarily require different data collection processes but can be enabled by linking existing datasets.
- The Business Longitudinal Analysis Data Environment (BLADE) contains Department of Industry, Innovation and Science program data, as well as tax data and ABS survey data. However, it does not contain data that may be valuable for measuring innovation from other portfolios, such as grants data and trade (customs) data.
- BLADE is considered useful for data-linking.

4.2. Time lags until data are available hinder policy and program evaluation and design

- Australian Taxation Office and Australian Bureau of Statistics data are often not available until significantly after a reference period has concluded, and much of this delay is unavoidable because of how long firms take to respond to official data requests.
- This means the Australian Government is unable to use official data to determine if its policies and programs have been effective or not in a particular reference period until well after that period has ended.
- This is a significant problem. Ineffective policies and programs may continue until there are enough data available to evaluate them and demonstrate that they do not achieve their aims. There may then be a further delay until they can be redesigned or replaced. This delay is costly.
- Having some indicators that are available quickly should be a priority, even at the compromise of some quality.
- The Review should explore the possibility of innovation indicators based on private sector administrative and transactional data which can be made available in real time, to enable the Australian Government to respond more quickly where appropriate.
- Short lag indicators (or, ideally, leading indicators) should be part of a suite of indicators, rather than replacing high quality but significantly lagged indicators. BLADE is only as good as the data that can be linked through it. The time lags involved before key data becomes available limit BLADE’s ability to support timely analysis.
- The access restrictions on data that are potentially available through BLADE limit the analytical work undertaken.

4.3. Data inaccessibility hinders analysis and program and policy design and evaluation

- Consultations emphasised that the barriers to accessing data through BLADE, and to unlinked government administrative datasets, are hindering data analysis, and thus policy and program design and evaluation.
- An enormous amount of existing data is not being analysed because would-be analysts cannot obtain access.
- Data inaccessibility is causing a ‘chicken and egg’ problem. Deeper econometric analyses are needed, but there is a lack of people with the skills to perform them, in part because the data is so difficult to access that academics and graduate students cannot develop the requisite skills to analyse it.

4.4. Australian data are missing from OECD data publications

- Some stakeholders have highlighted concerns with the frequency of collection and missing data in the OECD Science and Technology Indicators (STI) Scoreboard to enable accurate measurement and comparison.

4.5. Data are not capturing 'hidden innovation'

- Some stakeholders consider that innovation metrics focus too heavily on R&D activity as a result of historical interest in the manufacturing sector.
- However innovation occurs in all sectors and needs to be effectively captured to understand the full extent of activity.
- Not all innovation occurs as a result of research and development (R&D). It is important that data on all components of innovation across the spectrum are captured, including in creative industries.
- For example, there is a lack of data on the importance of enabling technologies in businesses, as opposed to specific process technologies. This is important given rapid digitalisation of the economy.
- Stakeholders suggest the health services sector should be considered as a case study to better understand hidden innovation in Australia.

4.6. Collaboration data issues

- Stakeholder consultations highlighted a number of issues with data on collaboration, including problems of accuracy and precision.
- Some stakeholders suggested that having trusted collaboration data should be a high priority.
- Australia's poor international performance on research-industry collaboration may be a statistical artefact. The Oslo Manual, and hence the Business Characteristics Survey (BCS), excludes 'fee-for-service' arrangements from counting as collaboration. This underestimates the number and total value of collaborations reported by the Australian Bureau of Statistics (ABS). This is particularly concerning for Australia, as some stakeholders believe that fee-for-service arrangements are more common in Australia than overseas.
- Even when the fee-for-service definition does not apply, stakeholders highlighted that 'collaboration' is not clearly and consistently defined, and it is interpreted differently by different survey respondents.
- BCS survey data on collaborations is inconsistent with the results obtained from comprehensive administrative data from Australia's public sector research organisations. This is confusing to users and results in distrust of Australian collaboration data.
- Various types of research-industry collaborations occur, which further complicate the reliability of collaboration metrics. For example:
  - some universities hire out R&D infrastructure to businesses, which may not be reflected in collaboration data
  - different universities structure their collaboration efforts differently: some have strategic partnerships involving multiple projects with one or several large companies, others have a large number of small collaborations with many firms. These two different collaborative models result in different numbers of collaborations, yet could result in the same dollar value
  - ideally, data should be collected and published for both the number and value of collaborations.
- A number of stakeholders commented that competition was also important for driving innovation, however it can impede collaboration.

4.7. Inconsistency between R&D data sources

- Stakeholders stated that the various sources of data on R&D expenditure provide inconsistent information. Stakeholders are confused about which data to use under which circumstances. Allowing expenditures that would not be included as research and development according to the Frascati Manual to be claimed under the Research and Development Tax Incentive seems to be exacerbating this.

4.8. Detailed feedback on the Business Characteristics Survey (BCS)

- The BCS is heavily used for both innovation and other purposes by a wide range of users, and there is very strong support for the continuance of the BCS or else other surveys that do the same jobs. However, most users believe the BCS could be improved.
- Users feel the BCS provides good data on the revenue impacts of new products (goods and services) but not on the cost impacts, or productivity impacts, of innovation.
- There is interest in picking up international work on categorising firms by innovation type (strategic, intermittent, adaptive and adoptive), as the scale of their effect on GDP differs.
- There is concern about comparability of the BCS with the Eurostat's Community Innovation Survey.
- There is interest in being able to compare Australia's performance with other resource-based economies to see if Australia is innovating faster or slower than they are.
- Several stakeholders want R&D vs non-R&D breakdown of innovation expenditure within the BCS.

4.9. Make better use of non-traditional data sources

- Many consultations have indicated that non-traditional data sources can provide relevant data in real-time, overcoming the time lag associated with traditional data sources.
- There are limitations with non-traditional data sources relating to representativeness. Coverage is partial and bias in the subpopulation is common. Some stakeholders noted that international benchmarking based on metrics generated from non-traditional data sources may be compromised by different uptake of relevant platforms in different countries.
- Some stakeholders have used re-weighting techniques to address these limitations, and claim some success in obtaining early and meaningful results from their analyses.
- Stakeholder suggestions for the most useful metrics potentially generated from alternate data sources include:
  - connections between businesses and researchers
  - business-to-business collaboration
  - skill supply, demand and transfer
  - entrepreneurship.

4.10. ANZSIC, ANZSRC and ANZSCO classifications are no longer comprehensive enough

- Concerns with the Australian and New Zealand Standard Industrial Classification (ANZSIC) system impact on data quality.
- Some stakeholders have indicated that the economy has moved on since the last iteration of the ANZSIC in 2006, and that it no longer meets their needs, particularly with regard to the green economy, advanced manufacturing and the digital economy.
- Current ANZSIC sectors may not be capturing new and emerging industries. Innovation strategies that are targeting these new industries may encounter measurement issues when mapping against current ANZSIC classifications.
- Specific examples of problems raised by stakeholders include:
  - boundaries between sectors are difficult to discern with the ANZSIC system — for example, where does healthcare end and information technology (IT) begin?
  - it is difficult to determine R&D expenditure in health and medical research, given that such research falls not only under a health classification, but also increasingly under a manufacturing classification. The high degree of aggregation with which ABS data is published further complicates this issue. It is important to track the performance of health and medical research, but currently the data produced is inadequate for this purpose
  - ANZSIC classifications do not align with industry growth sectors, presenting a challenge to policy analysts
  - some vital industries are invisible to ANZSIC classifications. For example, some cybersecurity businesses can be classified as either 'IT businesses', or 'Professional, Scientific and Technical Services'. Likewise, the development of the green and blue economies has largely occurred after 2006. For example, ANZSIC does not facilitate the study of the impact of renewable energy in the Australian economy.
  - Professional, Scientific and Technical Services is a particularly problematic category, which captures many, vastly different types of activity, and has become considerably more complex since 2006
  - firms are not updating their ANZSIC codes when they pick up a second or subsequent line of business, or when they change their line of business
  - errors in reporting are being generated by firms not big enough to be broken up into separate type of activity units (TAUs) having multiple ANZSIC codes apply to their business.

- A review of Australian and New Zealand Standard Research Classification (ANZSRC) codes is currently underway. Some stakeholders consider the ANZSRC a backward-looking approach, which does not aid our understanding of interdisciplinary research and new fields of research.
- The Australian and New Zealand Standard Classification of Occupations (ANZSCO) is similarly outdated, with occupations that have emerged since ANZSCO was last revised in 2013 largely invisible to analysts.

4.11. Stakeholders want better quality data on start-ups and entrepreneurship

- There is lack of an agreed definition of 'startup', as well as other key terms such as scale-up, accelerator and incubator, and this reduces the reliability of relevant data. Consistent definitions are needed for comparability across sectors and jurisdictions.
- More information is needed on the outcomes generated by start-ups, and how innovation performance compares with existing companies.
- More data is needed on entrepreneurial culture.
- LinkedIn was noted as a potential alternative-data source for measuring entrepreneurship.

4.12. Stakeholders want better access to better quality innovation-related ABS data

- Stakeholders view the data gathered by ABS surveys (the annual Business Characteristics Survey, the two-yearly Survey of Research and Experimental Development, and the annual Survey of Venture Capital and Later Stage Private Equity) as incredibly valuable. However, stakeholders feel opportunities are missed due to the high level of aggregation of this data, which does not allow insights on activity and trends in:
  - specific sectors
  - specific geographies
  - fields of research
  - socio-economic objectives.
- Many stakeholders use the ABS R&D survey data and most had suggestions for its improvement. Most of these suggestions concerned higher specificity of data, for example:
  - publication of data with greater geographical resolution (e.g. at the state and territory level and at the Australian Statistical Geography Standard SA3 level), to allow inter-jurisdictional benchmarking
  - publication of data at the 4-digit level for ANZSRC, ANZSIC, and Field of Research
  - administration of surveys annually rather than biennially.
- R&D expenditure provides an input view of innovation activity. Although R&D expenditure is relatively easy to measure compared to other facets of innovation and is directly influenced by government, stakeholders do not have a clear picture of R&D occurring in businesses, and would like to see breakdowns by industry.
- Stakeholders suggested that better quality and more transparent business R&D data would allow universities to better target their research programs to business trends and opportunities.
- They also want the ABS Survey of Research and Experimental Development to be conducted annually.

4.13. Research and Development Tax Incentive (RDTI) data

- Stakeholders would use RDTI data if it were available with sectoral and geographic breakdowns. Without these breakdowns, it is difficult to determine the impact of the program and changes made to it, both generally and within specific sectors.
- There is a demand for RDTI data at the level of different industry sectors.
- Some stakeholders noted they are unable to report a significant proportion of innovation activity under the RDTI as it does not fit the current definition of R&D.
- The alternatives to RDTI data include Australian Stock Exchange data and private, subscription-based data sources, but using these data sources is laborious, expensive or both.

4.14. Stakeholders want access to administrative datasets

- Stakeholders would value better access to industry-related datasets, including those containing program data, such as those held by Innovation Connections, Cooperative Research Centres, Rural R&D Corporations, National Collaborative Research Infrastructure Strategy (NCRIS) supported facilities and industry growth centres.

4.15. Information collected by the NSRC is useful, but of limited value

- Stakeholders indicated that in principle, the data collected through the National Survey of Research Commercialisation (NSRC) is useful, but also noted that improvements are needed.
- Some stakeholders stated that some of the data which the NSRC collects can be generated or approximated using data from other sources.
- Some issues identified include:
  - a need to improve quality controls over the data
  - administrative burden and perceived overlap with other data collections
  - the long and variable time lag between data collection and publication
  - a need to clarify some definitions in the NSRC and address inconsistent interpretation across universities (e.g. 'invention disclosure' and collaboration')
  - a need for greater clarity on how data is used to inform government policy decision making.
- Stakeholders noted some unique and valuable data gathered by the NSRC which is not available from other data sources, such as data about consultancies, licensing and start-up companies. It was suggested there would be value in focusing the NSRC on capturing data which is not currently collected through other mechanisms.
- Some stakeholders indicated that the NSRC would be a good way to capture data on which organisations universities engage with as end-users of research. For example, it could capture data on the proportion of these users that are from government and from the business sector, the size distribution of end-user businesses, and the geographical location of end-users.
- Some stakeholders indicated that it would be useful to capture data on where R&D funding is coming from.

Appendix D: Innovation Metrics Review Workshop Proceedings 13–14 March 2019

Australian Government
Department of Industry, Innovation and Science

APPLIED
Australian Academy of Technology and Engineering

Innovation Metrics Review

Workshop Proceedings

13-14 March 2019

Contents

Executive summary

Using current innovation metrics, Australia generally compares well against OECD countries, and there was general consensus from workshop participants that the Australian innovation system is competitive in enabling innovation. The inputs, outputs and outcomes of the system are being measured to varying degrees of accuracy, particularly with regard to outcomes. Workshop participants were strongly of the view that the quality of information available to support decision-making should be improved.

The following paragraphs summarise the outcomes of the workshop.

Measuring what matters

Consistent with the principles articulated in *Improving Innovation Indicators Consultation Paper March 2019*, workshop members agreed that attention should be directed at those areas of innovation measurement which are:

1. of significant policy interest, as determined through consultations and engagement with policy makers
2. aspects of the innovation system that are known to be associated with improvements in productivity (or a broader measure of living standards).

Issues of policy relevance included the need to be inclusive of small and medium enterprises (SMEs), and not to focus solely on the higher end of the innovation spectrum (e.g. new to the world innovation) but also on the significant gains that can be achieved by diffusing new to the firm innovations through the economy. This was expressed as 'the democratisation of innovation'. The examples provided relate to the adoption of digital technologies by SMEs.

It was emphasised that ensuring the operating environment of the Australian innovation ecosystem facilitates innovation as much as possible is critical. For example, the quality of Australia's transport system has a significant bearing on the quality of Australia's innovation system.

Participants also urged the review to be aspirational and to include in the scorecard measures related to social and environmental impacts. For example, Victoria's Lead Scientist, Amanda Caples, advocated for consideration of the UN Sustainable Development Goals as a basis for identifying relevant innovation objectives and outcomes (and associated metrics).

In a global context, it was noted that users of data have become more demanding, with low tolerance of the trade-offs that are almost always present when comparing characteristics of innovation between countries where country-specific needs conflict with international comparability. This can lead to the misuse of metrics at times. The digitalisation of data globally offers unprecedented opportunities for sourcing science, technology and innovation data but such data requires careful curation.

Opportunities for better measurement and to fill gaps

A fundamental innovation measurement challenge was identified as the lack of consensus on the definition of innovation or the Australian innovation system in the minds of data providers, most of whom have no awareness of the Oslo Manual.

Some information collections, such as that of the Australian Bureau of Statistics (ABS), avoid the term 'innovation' altogether for this reason.

Participants proposed that the scorecard output of the Review should serve both to communicate with policy makers the most significant aspects of innovation and to draw boundaries around the innovation system. The scoreboard will need to mirror the ecosystem and have a cross-section of actors represented.

The mining sector case study highlighted significant gaps in innovation measurement, with some large, innovative projects classified as business as usual or capital expenditure by mining businesses internally and hence not reported to the ABS. It was acknowledged that this was in effect a categorisation problem in the corporate accounts for firms. There may be scope to capture such hidden innovation in future in innovation expenditure totals.

The mining sector case study also noted that it is presently paying for goods and services to be provided by firms overseas, because they are not available locally. The net effect of this is to build capacity internationally, rather than in Australia, in operating mining technology remotely. Mining firm representatives noted that Australia presently does not measure imports than cannot be sourced domestically, which means that the case for developing substitutes locally cannot easily be made. Mining firm representatives felt that there was likely to be enough domestic demand for an Australian Government intervention to establish an Australian capability in remote operations to be successful.

Improved measurement of intangible capital was highlighted as a major opportunity for innovation measurement. Current national accounts measures of intangible capital include research and development (R&D), copyright and software and data but omit brand equity, marketing, design, skills and training. Furthermore, what is included is known to be an undercount. It was noted that the ABS possesses the capability to undertake the work, with sufficient progress having been made globally by key researchers on the methodology that improving measurement of intangible capital is implementable.

One area of intangibles that does require additional research effort to bring it into the ‘measurable’ space is ‘learning by doing’, which is estimated to be responsible for a significant portion of innovative activity. This aspect is not currently being captured and is not easy to capture. However, it affects capability building and where comparative advantages develop over time.

Members urged the Review to be cognisant of not only national level data but also state and local data, in particular that offered by Australian governments through programs.

Various speakers alluded to the importance of making more effective use of governmental administrative data, for example data based on procurements and grants across countries. At present, this data is not available for Australia. Australia would need to introduce a reporting requirement to separate procurements and grants for innovation from those for existing goods and services.

Methods of measurement

Workshop participants stressed the need for experimentation and pilot work. The innovation ecosystem in Australia is changing over time and it is important that a flexible approach is taken to measurement.

Different approaches to measurement were outlined during several sessions that included specific mention of entrepreneurship and start-ups; the creative industries; and the higher education sector.

The predictive analytics approach presented in the ‘start-up cartography’ project offers an alternative way to relating innovation characteristics to outcomes using a probabilistic measure and uses a combination of ‘digital signatures’ to track the development of start-ups. The approach is well-equipped to deal with skewed data (e.g. through predictions of rare outcomes) and may be able to offer a more up-to-date measure.

The need to have a complete understanding of the start-up lifecycle was highlighted in a presentation on university start-ups. It was emphasised that measurement needs to advance beyond measuring start-up formation and follow firms throughout their lifespans using variables such as license provision, obtaining follow-on funding, mergers and acquisitions, initial public offerings and firm deaths. Significant opportunities can be realised through linking university administrative data sets with other administrative and transactional data, through the Business Longitudinal Analysis Data Environment (BLADE) and perhaps longer term through the Longitudinally Linked Employer-Employee Database (LLEED).

In the creative industries, due to its intrinsically subjective nature, metrics that are inherently qualitative may be appropriate. Whilst some existing survey data can be re-purposed and combined (e.g. through fusion of innovation survey questions), hybrid strategies and novel data generation is likely to be required.

Survey instruments

The innovation profiles approach presented by Professor Anthony Arundel was thought to be a useful way of visualising sectoral innovation typologies that could then be used for further policy development. The profiles differentiate between: firms for which innovation is a strategic activity; firms that innovate through modifying their products and processes; and those that are technology adopters. The profiles make use of Community Innovation Survey data and could be modelled using the ABS Business Characteristics Survey or a new innovation-specific survey.

Administrative and transactional data

Further linking of administrative and transactional data was identified as a significant opportunity for the improvement of innovation measurement. Key activities identified included further development of the suite of datasets relevant to innovation that can be linked through BLADE and LLEED. Participants identified the addition of trade (customs) data to BLADE as their highest priority, followed by university administrative data.

Alternative data sources

There was general agreement that private data providers should be considered in innovation measurement (including web data scraping) but challenges exist in ensuring uniform coverage across countries and statistically representative data within countries. A number of OECD countries are equipping their national statistical officers with the means to assess when such sources can be reliably used for official statistics.

Mr Fernando Galindo-Rueda from the OECD encouraged Australian authorities to become more proactive in expanding data collection opportunities through surveys, administrative and commercial sources. He suggested Australian authorities consider how they can provide relevant incentives for firms to keep and report on the types of records that they wish to use as a basis for policy development, program evaluation and statistical measurement. He stressed the importance of being fully cognisant of the synergies and trade-offs between different uses of data about innovation.

Workshop participants indicated that a hybrid data strategy is required, supported by a suitable governance system.

Introduction

The purpose of the Innovation Metrics Review, scheduled to report later in 2019, is to improve the measurement of Australia's innovation system, in order to support better decision-making which will drive improved economic outcomes for Australia.

The purpose of the Innovation Metrics Review Workshop held on 13 and 14 March 2019 in Canberra was to inform the Innovation Metrics Review about international developments and share the thinking of international and domestic experts on how innovation measurement may be improved.

The audience for the workshop consisted of selected innovation metrics experts and innovation system stakeholders, and members of the Review's governance and advisory bodies.

Context

The *Innovation and Science Australia 2030 Plan*[1] includes recommendation 30:

'Support the development of a suite of innovation metrics and methodologies to fully capture innovation and link it to economic, social and environmental benefits. In particular:

- request the Australian Bureau of Statistics (ABS) and the Department of Industry, Innovation and Science (DIIS) to review business and research and development data collections to ensure they are fit for purpose and take full advantage of all available data sources
- commission an independent body, such as the Australian Academy of Technology and Engineering, in consultation with the ABS and DIIS, to review existing innovation metrics and report on a set of recommended metrics within 18 months, including new innovation metrics to track other areas of our innovation economy with a view to promoting these for use by the broader international community.'

The Government's response to this recommendation was 'The Government supports this recommendation.

The Government supports ongoing improvements to innovation metrics and methodologies. This creates a robust evidence base that provides us with a clear picture of our performance on innovation and will help pin-point issues in the system that may be limiting our capacity to innovate. This enables the Government to design cost-effective and robust policies to best address such issues.

The Government commits to a review of innovation metrics. The adequacy of the current innovation data collections and methodologies will be reviewed with a view to refining existing methods and developing new ways of measuring innovation performance.

The Department of Industry, Innovation and Science will absorb the cost of the Innovation Metrics Review. The ABS and the Australian Academy of Technology and Engineering (ATSE) will also be involved in the Review. It is envisaged that the Review will produce a co-branded report that will be launched in December 2019.'

Two teams have been working on the Review, one led from within DIIS, that includes departmental and ABS staff (the Taskforce), and one led by the Academy. The intent of involving the Academy was to add an independent voice to ensure the Review considered long term Australian priorities for innovation metrics rather than just government needs. Both teams have worked in close co-operation to avoid duplication or gaps in work.

Workshop participants were introduced to the conceptual framework that had been developed by the Taskforce and the Academy to map the Australian innovation ecosystem. The framework is centered on impact and captures innovation activities, the innovation ecosystem, the innovation environment, the broader operating environment, and policy levers that can influence innovation. Preparing this framework provided a useful reference to ensure that metrics selected by the Review provide suitable coverage of all the aspects of innovation.

Participants were also given an overview of the findings and key points of the literature review, which was prepared by the Academy and aimed to cover current, state-of-the-art and novel approaches to considering and measuring innovation. The literature review highlighted a number of indicator gaps and priorities for policy in Australia, along with several opportunities for measuring different aspects of innovation more comprehensively.

[1] Innovation and Science Australia 2017, Australia 2030: Prosperity through Innovation. Australian Government, Canberra. p. 4.

Prior to attending, workshop participants were provided with:

- a workshop pack containing an agenda, abstracts of speeches and speaker biographies
- the Improving Innovation Indicators: Consultation Paper March 2019 that summarized the consultations with stakeholders
- a draft Compendium of Innovation Metrics that assessed the suitability of existing metrics for the purposes of the Innovation Metrics Review
- a draft literature review prepared by the Academy.

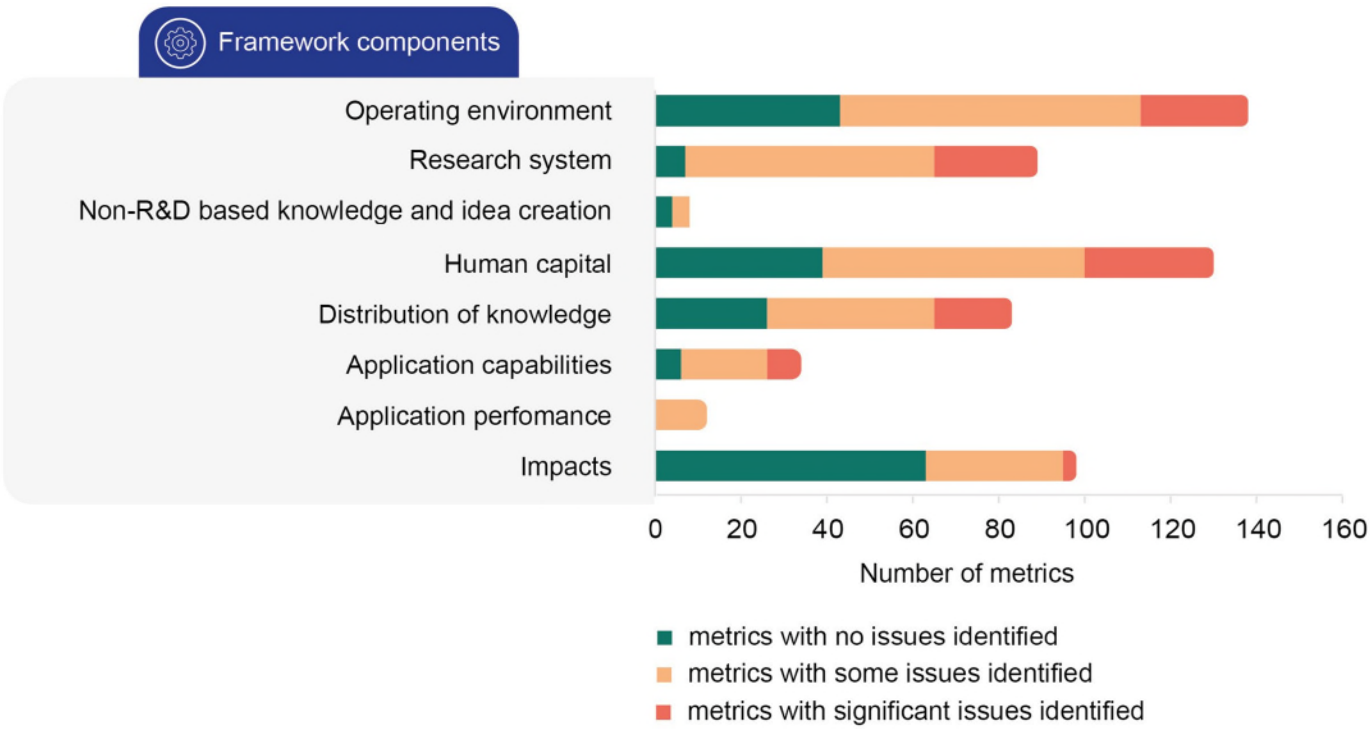
After mapping existing metrics to the innovation framework developed, the metrics were assessed as green (broadly fit for use), orange (still useful, with caveats) or red (significant data quality issues), according to the following criteria:

- relevance
- timeliness
- accessibility and clarity
- accuracy and validity
- reliability and precision
- coherence
- comparability.

Three key gaps were identified by the Taskforce, as shown in Figure 1 below:

- non-R&D based knowledge and idea creation
- application capabilities
- application performance.

Figure 1 – Number of quality-assessed metrics within each Framework component



Workshop participants noted the focus on R&D and advanced manufacturing by much of the rest of the world. This focus was considered inappropriate for many countries, including Australia, given the different structure of the Australian economy and the importance of non-R&D based knowledge and idea creation.

Some preliminary views were shared regarding how to improve the data underpinning innovation metrics, and what this could mean for ABS and other collections.

These included making better use of administrative and transactional data available from Australian government agencies and private sector sources, and also integrating more data, for example through the Business Longitudinal Analysis Data Environment (BLADE) or the Longitudinal Linked Employer Employee Database.

Some preliminary views on analytical gaps were also shared.

Workshop sessions day 1

Session 1: Entrepreneurship

The Start-up Cartography Project: A New Agenda for Measurement, Policy and Action

PRESENTER: PROF SCOTT STERN

Abstract

A central challenge for innovation policy is developing real-time and granular metrics of entrepreneurship. This presentation introduces a novel approach that combines comprehensive business registration records with predictive analytics to develop a new class of statistics characterizing not only the quantity but also the quality (growth potential) of new companies. The Start-up Cartography Project offers insight into the evolution and dynamics of regional entrepreneurial ecosystems (to an arbitrary degree of granularity), allows for the assessment of particular policies and initiatives, and provides insight into the role of institutions such as research universities and venture capital. The general principles can be applied to regions around the world, and provide comparative insight into the similarities and differences in innovation-driven entrepreneurial ecosystems around the globe.

Session summary

A central concern for policymakers is the state of business dynamism – the net birth rate of firms that have the potential to serve as sources of future employment and productivity growth in the economy. However, despite its importance, there is a sharp disconnect between alternative measures of entrepreneurial ecosystems. For example, in the United States, the Longitudinal Business Database (LBD) that tracks the total quantity of newly established enterprises has seen a secular decline in business dynamism over the past twenty-five years, while more selective measures such as the funding by venture capital investors has seen a sharp upswing over the past decade.

Not simply a measurement question, real-time and granular metrics that account for both the quantity and growth potential of entrepreneurship are necessary for policy analysis, including the assessment of policy initiatives aimed at spurring entrepreneurship and the commercialization of new technology. To overcome this impasse, the Startup Cartography Project (SCP), led by researchers at Massachusetts Institute of Technology (MIT), Columbia and Boston University, aims to provide such data by combining comprehensive business registration records with a predictive analytics approach.

The SCP combines three interrelated insights. First, as the challenges to reach a growth outcome as a sole proprietorship are formidable, a practical requirement for any entrepreneur to achieve growth is business registration (as a corporation, partnership, or limited liability company). This practical requirement allows us to form a population sample of entrepreneurs ‘at risk’ of growth at a similar (and foundational) stage of the entrepreneurial process. Second, we are able to potentially distinguish among business registrants through the measurement of characteristics related to entrepreneurial quality observable at or close to the time of registration. For example, we can measure start-up characteristics (which result from the initial entrepreneurial choices in our model) such as whether the founders name the firm after themselves (eponymy), whether the firm is organized in order to facilitate equity financing (e.g. registering as a corporation or in Delaware), or whether the firm seeks intellectual property protection (e.g. a patent or trademark). Third, we leverage the fact that, though rare, we observe meaningful growth outcomes for some firms (e.g. those that achieve an initial product offering (IPO) or high-value acquisition within six years of founding). Combining these insights, we measure entrepreneurial quality by building a predictive model on the relationship between observed growth outcomes and start-up characteristics using the population of at-risk firms.

This approach is implemented on a large dataset comprising all business registrations for 34 US states, accounting for 83% of the US GDP, from 1988 to 2014. The dataset contains 29,961,838 firms. The predictive analytics results (though not causal) are striking: at the time of founding, a startup registered in Delaware that files for a patent is close to 200 times *more* likely to realize a significant growth outcome than one that is not. Firms named after their founders or entering into local businesses, on the other hand, are anywhere from 29 – 73% *less* likely to achieve a growth outcome. Importantly, however, startup characteristics correlate with growth outcomes, but do not cause them.

The SCP then maps the predictions that result from the model to estimate the level of entrepreneurial quality of each firm. In out-of-sample tests of predictive power, 69% of realized growth events fall within the top 5% of the models' estimated entrepreneurial quality distribution, and more than 50% of the realized growth outcomes fall in the in the top 1%.

We can use these estimates to assess not simply the quantity but the quality-adjusted quantity of entrepreneurship in a given entrepreneurial ecosystem. Once one accounts for quality, there is a striking divergence relative to the traditional quantity metric: relative to the secular decline in entrepreneurship observed in the LBD, the SCP documents a cyclical pattern, and a strong pattern of recovery commencing after the 2009 financial crisis.

As emphasized in the MIT Regional Entrepreneurship Acceleration Program, this type of measurement tool can catalyze shared understanding and strategic action across the various stakeholders within innovation-driven entrepreneurial ecosystems. The combination of a real-time measurement tool and a user-focused design approach that allows various stakeholders to examine the data at a granular level allows for both assessment of particular policy initiatives as well as insight into challenges facing particular regions.

Finally, the core elements of this type of data, and the general applicability of our approach, have potential not only in the United States but also in Australia. Professor Char-lee Moyle at Queensland University of Technology is already heading up an ambitious effort to do so using Australian data.

From Little Things Big Things Grow:
How Digital Connectivity is Helping Australian Small Businesses Thrive

PRESENTER: DR ANDREW CHARLTON

Abstract

The Review should consider the drivers of innovation in Australia. Many Australian businesses are innovating by taking up cloud-based process applications (apps). This is a silent productivity driver in Australia. The report 'From little things big things grow' examines how changes in digital connectivity affect Australian small and medium-sized enterprises (SMEs). The paper examines the effect of faster high-speed broadband on SMEs to understand the impact at the macro level. To understand it at the micro level, the paper analyses the take-up and impact of cloud-based apps on individual businesses.

Session summary

When many small firms implement innovations this adds up to large national productivity changes. We should be measuring this. But how? They may be collecting their own data, using platforms such as Xero. If we look at how businesses are adopting and adapting new ICT-based productivity software, we can also see how this may be impacting upon their productivity.

Cloud computing is saving businesses' money, data and time. It is helping them reduce infrastructure costs, refresh aging infrastructure, support new business opportunities, enhance business continuity, increase collaboration and improve capacity and scalability.

Different types of businesses have different 'pain points' that lead them to use different types of apps.

For example, the hospitality sector has a large casual workforce with variable hours to roster and pay. Rostering must comply with regulations, and there is a high volume of customer transactions to process. By contrast, the trade and construction sector has a mobile workforce that needs remote coordination and supervision. It has a high volume of client jobs to schedule, perform and invoice. It also has quality, safety and compliance assurance needs.

These different types of needs are now being met by different types of apps. Many of these apps are able to be integrated with Xero. Xero is a New Zealand-based public software company that offers a cloud-based accounting software platform for small and medium-sized businesses. The company also has offices in Australia, the United Kingdom, the United States, Canada, Asia and South Africa. Its products are based on the software as a service (SaaS) model and sold by subscription, based on the type and number of company entities managed by the subscriber.

Bigger businesses are more likely to use apps than smaller businesses, and SMEs that have higher revenue growth use more apps. Different industries have different adoption rates for different types of apps. There are apps in areas such as clerical and accounting, business intelligence, job scheduling and invoicing, rostering, and point of sale.

Discussion

A recent paper by Jacquelyn Pless (Oxford, MIT) was highlighted which provides a summary of the issues regarding the complexity of interactions between different forms of government subsidies for R&D. There are ongoing questions about R&D subsidies vs tax credits. Discontinuous changes of eligibility make it possible to study the effectiveness of tax credits. There are many challenges in studying them, but they appear to be one of the few robust measures.

There is a much broader range of literature, including OECD work, which looks at the impact of R&D tax incentives.

The need for reliable measurement of entrepreneurship was noted and the possibility of adopting the approach of Scott Stern for use in Australia. Data coverage is in particular a challenge in the entrepreneurship and start-up space, although it was noted that ultimately a firm that grows will have to register. In spite of this, apparently about a third of firms that are registered with the company Xero are unincorporated.

Key findings for the purposes of the Review

- The predictive analytics approach presented in the 'Start-up Cartography' project offers an alternative way to relating innovation characteristics to outcomes using a probabilistic measure. The approach is well equipped to dealing with skewed data (e.g. in making predictions of rare outcomes) and may be able to offer a more up-to-date measure. This approach may also be useful for application to what the review terms 'alternative data'.
- Innovation measurement and policy needs to ensure that SMEs are not left out. This is both good policy and good politics. Whilst it is tempting to focus on the more radical innovations, significant, economy-wide gains will require the adoption of innovation by the SME population (the 'long tail' of the distribution argument). One area that offers clear benefits is the adoption of digital practices by SMEs. Any measurement of the innovation system should be cognizant of this.

Session 2: Innovation Metrics – state of play: a WIPO GII perspective

Lessons from 10 Years of Innovation and Intellectual Property (IP) Metric Work – Global Innovation Index and WIPO

PRESENTER: DR SACHA WUNSCH-VINCENT

Abstract

The objective of the presentation is two-fold. First, we will report on our experience on what makes for effective and policy-relevant innovation metrics at the national and international level. Some of these insights can possibly inform the aim and the resulting outputs of the Australian Innovation Metrics Review. Second, we will report on the main weaknesses in available innovation metrics, to flag where action is most and least needed, and, finally, what WIPO is doing about IP and intangible asset indicators in particular.

Session summary

A well-designed scorecard, underpinned by an innovation system framework is essential for:

- stimulating dialogue with the public and with policy makers about innovation and advancing policy development
- aiding in the development of new metrics, which should seek to reflect the quality and not exclusively the quantity of innovation.

The Global Innovation Index can offer the Innovation Metrics Review insight into designing, maintaining, and using an innovation system framework and scorecard of metrics to understand the structure and performance of the innovation system. These products of the GII are powerful tools for benchmarking and analysing the performance of countries' innovation systems. They can serve as a focal point for uniting different ministries in a dialogue about the innovation system. They can contribute to incentivising data collection. They can also serve as a foundation for experimentation with new data and metrics.

It is absolutely necessary to have an innovation scorecard or dashboard. A scorecard must mirror the innovation system, and there must be a cross-section of innovation system actors who develop goals and monitor progress. Scorecards can also serve as a foundation for experimentation with new data and metrics.

A key requirement of a scorecard is that it is relevant to advancing innovation policy.

Several areas in which innovation metrics are most urgently needed include metrics that capture:

- innovation that is currently hidden from existing data and associated metrics. Innovation is hidden most notably in the services and resources sectors; when it does not involve technology; and when it occurs informally
- innovation clusters and networks, and innovation collaboration and linkages
- innovation outputs and impacts that go beyond describing innovation outcomes and impacts simply in terms of returns to the firm
- innovation quality, rather than simply quantity. We rely overwhelmingly on measuring the quantity of innovation by looking at the amounts invested in R&D, and numbers of citations, patents and start-ups. We should seek to develop metrics that reflect the quality of these activities.

Given the limitations of many existing metrics, and the need for new ones, it is important to innovate and experiment with innovation concepts and metrics themselves. Developing new metrics takes time, but ultimately it is important to develop new ones that overcome some of the major issues with existing metrics.

Lessons for Australia from 10 Years of Innovation and Intellectual Property Metrics Work

PRESENTER: DR AMANDA CAPLES

The presentation by Dr Caples outlined two problems:

1. there is a lack of understanding of what constitutes an innovation system
2. the government narrative revolves around several factors, which do not resonate with the business sector or the general public, including
   a. inputs and outputs (publications and patents)
   b. government's role
   c. high-tech products (which are the exception rather than the norm).

The Victorian Government's innovation framework is an organising framework that starts from the position of a user (small or medium enterprise, start-up or large corporation) rather than from government's role in supporting the system. It seeks to clarify the three primary drivers of innovation in a business and illustrate how a business draws upon elements of the system for its needs as required. It is intended to be used to:

1. map cross-portfolio initiatives to identify gaps and opportunities to scale-up successful programs
2. align and connect initiatives to enhance their impact
3. provide a common basis for discussion, mitigating the risk of miscommunication and improving relevance to the broader community.

Discussion

This session promoted a discussion about the boundaries of the innovation system, the definition of which will have implications for the metrics which aim to describe it.

A rhetorical question raised through this discussion is as follows: if innovation ultimately drives productivity, how can the Review avoid simply stating that measurement of innovation is the equivalent of measuring productivity? It was noted that the focus - both political and policy – is increasingly on the employment element.

There was a brief discussion about risk-appetite. Risk taking is an important element of innovation. There is variation across firms with respect to risk appetite, as there is for individuals – both of which have implications for innovative entrepreneurship. More work is needed on measuring 'risk appetite'. One key factor noted was access to information as this is a principal factor in de-risking. A low risk but high gain strategy is to facilitate the adoption of existing innovations and technologies by firms.

Key findings for the purposes of the Review

- An innovation scoreboard is required both to communicate those metrics that are of policy importance, and to help to draw boundaries around the innovation system. The scoreboard accordingly needs to mirror the ecosystem and include a cross-section of actors. The scoreboard also needs to allow for international or yearly benchmarking over time.
- Risk appetite is hard to measure but is a key determinant of innovative activity and it is therefore worth investing effort to measure this.
- Absorptive capacity is also a key determinant and needs to be included in any discussion of innovation system and measurement.
- Employment is a key policy focus and needs to be incorporated into the measurement framework.

Closing day 1

Speech by Dr Alan Finkel

Dr Finkel gave an introductory address at the Innovation Metrics Review International Workshop on 13 March 2019 in Canberra.

I acknowledge the Ngunnawal people who are the traditional custodians of the land on which we meet and pay my respects to their Elders past and present. I extend this respect to all Aboriginal and Torres Strait Islander peoples in attendance today.

You all know the old joke about a police officer who sees a drunk searching for something under a streetlight and asks what the man has lost. He says he lost his keys and they both look under the streetlight together. After a few minutes the officer asks the drunk if he is sure he lost them here, and the man replies, no, he lost them in the park. The officer asks why he is searching here, and the man replies, "the light is much better here".

The moral: we look where it's easy, not necessarily where it's useful.

And that's where the story ends.

But I say it's where the real story begins.

Because the police officer could shake her head and walk away in frustration…

…or she could persuade the man to get a torch and go to the park…

… or even better: she could persuade the local council to move the streetlight.

How do we, the police officers, achieve the right result?

To start, we need to focus on the outcome.

In our case, it's simple: what we all want is increased productivity and higher living standards.

Innovation is the key that unlocks them – and metrics are the light with which we find the key.

So that's why Chief Economist, Mark Cully, and I teamed up – as Good Cop, and Bad Cop, I'll let Mark decide which is which – to help this country to move to the park and find the damn keys.

My own journey into the police force began several years ago.

Like most people in my field, I'd always accepted that innovation was hard to define and even harder to measure, but the measures we had were no doubt the best we'd got.

I began to suspect that something wasn't right when I was President of the Australian Academy of Technology and Engineering, and somehow was made to feel guilty for Australia coming up in last place on the measurement of collaboration between universities and innovation intensive companies.

As Chief Scientist, colleagues expected me to travel around the country berating our research institutions about our woeful record.

But it was also my job to travel around the country launching business-university collaborations.

And I discovered at the first university I visited that they had lots of collaborations with industry. So I asked the Vice-Chancellor how he explained the discrepancy – and he told me that the problem must lie in all the other universities.

Funny, at the next university I visited, I made the same observation, asked the same question and got the same answer!

Something wasn't right. I discussed the problem extensively with Mark Cully. Eventually, I called some colleagues at two of our leading universities and each of them had nearly as many collaborations as we reported to the OECD for the whole country. So Australia was coming up as infeasibly low, dead last in the list, at about 3% of innovation-active companies. It didn't seem plausible.

And I must say that at a gut level I am equally surprised that the leading countries on this particular metric, at the other end of the spectrum, have apparently achieved a collaboration rate of nearly 70%.

This dead-last collaboration statistic for Australia was driving a frenzy of negative commentary. All the while, our economy is outperforming most of the OECD…

…we have had 27 years of recession free growth – not achieved by any other country since GDP records began…

…we have a world-class health-care system, and we're a world-class exporter of minerals, agricultural products and educational services…

… and still, we were convinced that we were somehow devoid of innovation.

None of the policy measures we adopted seemed to make a measurable difference.

As Chief Scientist, I felt that the discrepancy between what the data were saying and what the Australian innovation system was actually achieving could no longer be ignored.

We were stubbing our toe on the streetlight that was supposed to be helping us find something useful.

Worse, we were starting to believe that the keys didn't actually exist.

It all came to a head for me in my role as Deputy Chair of Innovation and Science Australia.

We were asked by the Prime Minister for a comprehensive review of the Australian innovation system.

This request was for the obvious reason that in order for governments to implement innovation policy they need to be able to measure innovation, to decide where to intervene, and to determine whether their interventions have been successful.

Inherent in the purpose of the review is that our audience is government rather than business, because published indicators are generally too broad for management purposes.

It is obviously important to have meaningful measures of performance – a scorecard of useful metrics. Not too many and not too few.

Instead, we were constantly frustrated by measures that were incomplete, likely to be affected by erroneous or non-comparative data, or wrongly adapted to our economy.

My pet peeve is the Australian mining industry. Every industry insider, here and globally, will tell you that this country is a world leader in mining innovation, with remotely controlled underground drilling machines, possibly the largest autonomous vehicle fleet in the world, algorithmically determined process quality control and remote control rooms to optimise the overall operations.

And now they are adopting artificial intelligence approaches to make their operations even more efficient.

And yet, in most innovation metrics, the mining industry is basically invisible. Why? Because a lot of their innovation is in-house, and even more comes from the R&D buried in supply contracts.

Even worse, on minor metrics such as the percentage of high tech exports, since the mining industry's actual exported product hasn't changed in ten million years and is regarded by many as 'dirt', our mining exports do not contribute to the top 'high-tech' line in the ratio. However, they do contribute to the bottom 'total exports' line of the ratio, which means that every time our mining industry innovates and captures a greater share of the world market this particular measure of innovation gets worse, not better.

I started to use the phrase 'hidden innovation' to refer to important innovation that is fundamentally invisible to the existing innovation metrics.

I've already mentioned mining, but what about education? International education is reported as bringing in $30 billion of revenue to Australia. The industry was developed by innovative vice-chancellors, but I can't see where its growth shows up in any of the innovation metrics.

The problem is probably because, in part, the existing innovation metrics focus on the linear process of research and development leading to new products. That works well for countries with strong manufacturing and high tech industries, but in Australia only 7% of our workforce is employed in manufacturing.

Another problem we encountered is that the methodology used for business surveys is so different between countries. Some are compulsory, while others are voluntary. The surveys are administered at different intervals and they use different reference periods. These differences contribute to statistical noise that sometimes dwarfs the signal.

So, in one of its recommendations, Innovation and Science Australia called for a review of the existing innovation metrics for accuracy and adequacy.

And I became a cop.

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There are several goals for this Review.

First, in the short term, to improve data sources and metrics that are not quite fit for purpose, or are in some way inaccurate, or do not allow direct country comparisons.

Second, to identify and fill measurement gaps, so that innovation is measured in the hitherto invisible, or perhaps difficult to see, sectors of our economy such as mining, education and hundreds of thousands of small businesses.

Third, to build a short list of metrics – what I call a scorecard – that will be of policy relevance to government.

It is a task for Australia, but at the same time we aim for this to be a project for the world: our measures have to be comprehensible, credible and comparable to our global partners.

To start, we have to think about what, in a nutshell, is innovation.

You all know the formal definition, but my simplest definition is doing things differently and doing them better. I am attracted to this simple definition for a few reasons.

First, it is not locked into the linear definition of research being the starting place of all innovation. Instead, in addition to evolving from research, innovation arises from an idea in the middle of the night or the creative outputs from a brainstorming meeting.

Second, this definition eliminates consideration of the trivial.

Third, my definition is short enough that it is easy to remember!

This definition of innovation arguably applies to this international workshop and the Innovation Metrics Review. If we are going to be innovative, we need to do innovation measurement differently and we need to do it better.

Dare I say it? – we need to be innovative in our approach to innovation measurement.

A lot of attention internationally is focused on advanced manufacturing and high tech.

And so it should be, because these are important.

But there is so much more to our economy.

If we get it right, we will make visible the innovation in traditional industries such as mining, health, education, banking and agriculture. These sectors have a major impact on people’s lives, and they are critical to the economy.

I want to stress that this is not an exercise in making Australia look better than it is.

It is an exercise in giving us useful information.

That includes the problems we’re not seeing.

I also want to stress that we are not blind to the limitations of data when it comes to capturing a complex phenomenon like innovation in policy-relevant terms.

That is why, for example, in Australia we have started a process to try to understand the research relationship between universities and end users such as industry and government departments.

A few years ago, work began on a fair and credible metric for university impact – first through a pilot program led by the Australian Academy of Technology and Engineering, called Research Engagement for Australia; and then through our national research funding body, the Australian Research Council.

The new ARC Engagement and Impact metric is now a compulsory data gathering exercise for all Australian universities, collected last year, with results expected soon.

One thing to note is that after a lot of design work the ARC decided that data alone would not be enough and that a series of short impact statements would be required. These will be evaluated by expert panels. This will be difficult and expensive but the conclusion was that impact statements will provide insights that would otherwise not be available.

Perhaps there is a role for impact statements, evaluated by expert panels, in innovation measurement. This would be hard work and fraught with risks, but if that is the only way to measure innovation in some sectors we should be open minded about the possibility.

It could be another important step to moving the streetlight – and finding the keys.

The Innovation Metrics Review Taskforce, my co-chair Mark Cully, the Academy of Technology and Engineering, the Steering Committee and the Expert Reference Panel have done a lot of excellent work to get us to this point.

But we don’t have a solution in hand yet.

The purpose of this workshop is to bring into the open innovative thinking about innovation measurement.

We need to come to meaningful conclusions so that we can finish our report by the end of June.

I urge you not to be incremental. Our goal must be to go beyond tweaking.

We must avoid doing things differently for the sake of it, but be prepared to recommend new ways to do it better.

Above all, whatever we recommend must go beyond the academic and be useful for policy formulation.

I thank every one of you for what you have contributed so far and I thank you in advance for what you will contribute to the remainder of this workshop.

And, for the sake of all of us, may the Force be with you.

Thank you.

Workshop sessions day 2

Session 3: Hidden innovation in mining

Hidden Innovation in Mining

PRESENTERS: DR ALAN BYE AND MR MARK THOMAS

Abstract

For the purpose of this review, we have defined innovation as 'the execution of new ideas to create value'. The innovations considered span continuous improvement, step change and transformational innovation. Creation of value in a mining organization manifests in improved performance in safety, productivity, culture and contribution to society.

To address the question 'is there hidden innovation in mining?' a review of activities driving company performance improvements was compared with information reported in the ABS Business Characteristics and Research & Experimental Development (R&D) surveys.

Results indicate that there is hidden innovation in mining. This innovation can be categorised into broad activities including:

- efforts on improving the safety of mining operations
- continuous improvement initiatives including process improvement
- efforts applied to the adaptation, modification and implementation of technology and solutions
- step change efficiency achieved through vendor contracted programs such as automation and large scale operating model innovation
- greenfield capital expansions or developments
- partnerships with broad ecosystem stakeholders focused on driving social and cultural benefits.

Case studies from each of the categories identified were developed to gain insight and provide recommendations on potential metrics to reflect the innovation activity in the mining sector in Australia better.

Session summary

The mining sector has experienced declining multifactor and labour productivity relative to other sectors, as the quality of remaining deposits is declining and they are generally less accessible. However, the mining industry is targeting productivity improvements.

Relative to other sectors, the mining sector has a low R&D intensity – about 0.4% of revenue. The adoption of technology as measured by process improvements can be slow, taking up to 20 years for 50% adoption in the industry. This does not however cover broader measures of innovation where adoption is faster.

In mining centres, the definition of innovation is where new value is added to businesses. Much of the innovation in mining is through adoption and adaptation. Outcomes include improved safety and capability and training improvements. Safety is improved by automation that takes people out of dangerous areas.

Recent examples of innovation in mining at BHP that have not been captured in innovation measurement, due to it not being reported as innovation, include:

- halving of iron ore operating costs over five years due to pressure from the collapse of ore prices
- drilling automation, where one person can now operate five drilling rigs from a safe location
- ship-loader automation
- integrated remote operations
- digital mines in setting up greenfield capital expansion.

A lot of these expenses are measured as business as usual costs or as capital expenditure.

In the future, the focus will shift from operation to services. Currently a large portion of the capability and skills needed have to be sourced from overseas due to domestic shortages.

Australian mining firms are presently paying for automated remote operations technology-related goods and services to be provided by firms overseas, because they are not available locally. It is in effect building capacity internationally rather than in Australia in operating mining technology remotely. Australia presently does not measure imports than cannot be sourced domestically, which means that the case for developing substitutes locally cannot easily be made.

There is a significant opportunity to create new jobs in Australia that will support the expected increase in automation of the mining, petroleum and agricultural industries.

Discussion

The challenges around evaluating the impacts of research were raised. In mining, it can take a long time before R&D results in innovations being implemented and impacting commercial operations. The Co-operative Research Centre (CRC) Mining R&D work funded in the 1990s showed impact in 2005.

One needs to be careful about overly focusing on productivity as safety and environmental outcomes do not contribute to it (or contribute negatively). One of the reasons why productivity is low is certain outcomes, such as improved safety and reduced environmental impact, are not fully captured in productivity measures.

A significant part of the innovation in this sector is through learning by doing. This is not being captured and is not easy to capture. However, it affects capability building and where comparative advantages develop over time.

Key findings for the purposes of the Review

- There is evidence of systematic underreporting of innovative activity – 'hidden innovation' – in the mining sector based on the case studies presented.
- The underreporting is a result of innovation expenditure being categorised as other types of expenditure such as business as usual or as capital expenditure.
- There may be scope to work with key stakeholders in the sector to capture innovation-related expenses better. This would improve at a sectoral level the estimates of innovation activity. It may also offer insights to generalise this approach to cover other sectors.

Session 4: Measurement of R&D and innovation policies

The Measurement of R&D and Innovation Policies

PRESENTERS: DR FERNANDO GALINDO-RUEDA AND PROF THOMAS SPURLING

Abstract

Understanding the effects of innovation policies on the overall innovation system is a major priority for policy makers and one, if not the main, rationale for investing in innovation measurement. However, and somewhat paradoxically, there are not as many reliable indicators about innovation policies and their key attributes as one would wish for to serve basic accountability objectives, allow comparisons of policy use and design, let alone support ex-ante and ex-post policy evaluation.

This presentation will explore the reasons why innovation policies are challenging objects of measurement. The design and delivery of innovation policies and practices can be complex and differ from the explicit intentions of the enabling legislation and budgetary decisions, as different administration layers and jurisdictions interact. Access to administrative data may be jealously guarded for reasons that have to do as much with confidentiality as with concern about how data might be used for decision making, impacting on the careers of their policy managers. Those directly responsible may not see information as a basis for data that can be useful for others nor a need to compile it, while suitable aggregated data can help compare countries or regions over time. Building an understanding of innovation policies across different jurisdictions requires additional efforts to use common language and taxonomies, or at least to be able to transpose local realities onto them.

This presentation will focus on what can be done to address this gap in a national and international context, arguing that coordination between these two levels is essential to make the most of efforts in this area. A number of examples (capturing specific policy instruments, thematic policy interests and modes of data collection and analysis) will be provided to highlight recent and ongoing OECD initiatives that exhibit varying degrees of success and promise, with a view to promoting a dialogue about what types of innovation policy 'metrics' are feasible and desirable in the Australian context.

Session summary

According to OECD data, Australia is an innovative country. Australia is seen as a leader in terms of progressing dialogue surrounding non-R&D innovation and its measurement.

The changing nature of the demand and use of innovation metrics

Sometimes trade-offs are necessary when it comes to the metrics required by individual countries and metrics that allow international comparisons. Data users are

becoming more demanding and have low tolerance for trade-offs. This can lead to irresponsible use of metrics.

As innovation gains a place in management and public debate, more areas of the innovation system will understand the value of reporting on their activities, and will encourage others to do so. Government policy has a role in influencing this behaviour.

Innovation measurement and data in policy

The Government can and should do more to incentivise businesses to build precise and comprehensive records about their innovation activities and report in the appropriate manner. The Government's ability to collect such data depends on whether businesses collect it and value it. Businesses can report with some accuracy on their activities if this information is valuable to them, and this is evident from the fact that they do so for many activities, including for compliance, grant applications, and claiming tax subsidies.

The OECD uses data about policies for analysis of national and global innovation systems. Data about policies are often qualitative and inaccessible. Data about policies can be valuable when aggregated, and can aid in comparing policies across countries and over time. OECD comparative policy analysis is progressively evolving from descriptive to impact-focused. This work is most advanced with R&D tax incentives as a policy instrument, but work is underway to consider procurement policy and other tools that place more emphasis on the demand side of innovation.

The OECD needs countries to provide data to make this analysis possible.

Innovation policy must be data-aware. Policy analysts need to take responsibility in co-developing data collection. Policy makers must be data literate, and understand the data life-cycle.

Data analysis and policy should have a reflexive relationship – understanding which data are of policy relevance is aided by development and analysis of data.

Data collection and use

The OECD Blue Sky Agenda is promoting the empowerment of national statistical offices to access and use data from a broader range of sources.

A hybrid strategy is required to enable comparison of official and private data.

State and local governments also hold relevant datasets. For example, the City of Knox Business Visits program has data relevant to firms' networking behaviour.

Innovation procurements and grants are not separable from other procurements and grants using current data.

There are opportunities for digitisation – and barriers are often more social than technological.

Discussion

Around 95 percent of the budgets of state governments are allocated to service delivery, with the remainder allocated to discretionary items, of which innovation is but one. It is therefore important for the Review to consider metrics for innovation in government service delivery. This fact also means that governments need metrics that inform about whether and how to invest in innovation.

The lack of data available for China was highlighted as a major gap in international comparability for innovation activities and performance. It was noted however that the OECD has a long-standing program of engagement with China on R&D and innovation statistics which has already resolved many gaps, and that more will be addressed when China has finished implementing the latest edition of the 2018 Oslo Manual.

Key findings for the purposes of the Review

- Governments should work on incentives for private sector participants to improve data coverage and quality.
- A hybrid strategy is likely to be required, linking data from public and private providers.
- Users of innovation statistics need to appreciate the trade-offs involved when balancing country needs against international comparability, as well as other trade-offs such as timeliness versus handling data revisions.
- The digitization of data globally offers unprecedented opportunities for data integration, which have not yet been fully realized.
- Data analysis has shifted from being descriptive to impact-focused, but needs the latter as a starting point. The best example demonstrating this is the R&D Tax Incentive. On-going work in procurement illustrates the same point. At present, more information is required on this from OECD member countries.

Recommended background reading

OECD R&D Tax Incentives Database. http://oe.cd/rdtax

OECD/Eurostat (2018), *Measuring external factors influencing innovation in firms*, in Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition, OECD Publishing, Paris/ Eurostat, Luxembourg. DOI: https://doi.org/10.1787/9789264304604-10-en.

S. Appelt and F. Galindo-Rueda (2016), *Measuring the link between public procurement and innovation*, OECD Science, Technology and Industry Working Papers, No. 2016/03, OECD Publishing, Paris, https://doi.org/10.1787/5jlvc7sl1w7h-en.

OECD STIP Compass Database. https://stip.oecd.org/.

Session 5: Creative inputs into innovation

The Creative Industries and Innovation: Drivers, Definitions and Data

PRESENTER: MR JUAN MATEOS-GARCIA

Abstract

The creative industries are defined by the UK Department of Culture, Media and Sport as 'those industries which have their origin in individual creativity, skill and talent and which have a potential for wealth and job creation through the generation and exploitation of intellectual property.'

This collection of sectors, which ranges from creative services such as Advertising and Design to digital sectors such as Software or Video Games and cultural activities like Publishing and Music are increasingly recognized as a locus of innovation that does not always take the form of traditional scientific R&D, instead relying on 'soft' (aesthetic) forms of novelty and on innovation in business models, and new combinations of technical and artistic inputs via design. There is also growing evidence that the creative industries can act as a driver of innovation elsewhere in the economy through the supply of relevant inputs for innovation (including talent, services and spaces for innovation) as well as the generation of knowledge spillovers.

The presentation summarises the state of play in the definition and measurement of the sector highlighting the challenges raised by fluidity in sector definitions and structural change, and the importance of freelance talent for the sector. It also identifies opportunities to use novel data sources such as social media and text to capture creative activities, networks and clusters.

Session summary

The presentation highlighted that creativity is across all industries, not only what are generally termed the 'creative industries' associated with the arts.

One differentiating feature of economic value associated with creative industries and inputs is that the notion of value is highly subjective – in the eye of the beholder. The illustrative example presented was the humble coffee cup, where the purely functional ceramic mug without any branding cost a few dollars, compared to the high end, highly branded, digitally enabled coffee mug that sold for about $40.

Components of value are therefore beyond the functional and include aesthetic and cultural elements. Four components of economic value in the creative industries were identified and explored – (1) fusion; (2) non-technological innovation; (3) decentralization; and (4) concentration.

1. Fusion refers to the combination of elements from the arts, technology and business. The example in the presentation was the level of innovation activity in companies with different levels of arts-tech fusion.
2. Three elements of non-technological innovation were presented – diffusion, soft innovation (e.g. innovation in aesthetic terms), and new business models. The key point was that value often does not come from advancing the technological frontier. These aspects can be probed through the use of various technologies. Evidence was presented using data on UK games companies by platform and year based on creative platform data.
3. The decentralized characteristics of creative innovation were illustrated through the distribution of networks and knowledge exchange using the connections between creative communities in different parts of the UK based on social media data.
4. The concentration of the creative industries and the premium that can exist on co-location and spatial proximity was highlighted using the dashboard of located creative activity in the UK.

The high level conclusion was the need for a hybrid strategy in measuring the creative industries that makes use of both existing and novel data. Approaches to capturing this information may include existing innovation surveys, sector specific web data analytics, and interactive formats that enable exploration (open source).

The Dynamic Essence of Innovation – A Challenge for Innovation Metrics

PRESENTER: PROF RON JOHNSTON

Abstract

As innovation can be taken to be essentially the 'doing and producing of new or better things'. It is inherently constantly in flux. What was recognised as an innovation yesterday will not be an innovation tomorrow – it will be an imitation.

Some of the new forms and embodiments of innovation are essentially variations on an established model or practice. Others are systematic and structural transformations, often referred to as disruptions. Furthermore
'just as innovation is increasingly seen as relevant to a wide range of policy objectives, so policy in a wide range of areas is increasingly seen as relevant to innovation' (Australian Academy of Technology and Engineering *Innovation Metrics Literature Review*, 2019).

Traditional metrics highly prize characteristics of stability over time, universality to allow comparability with other performers and quantitative reliability.

The fluid, dynamic characteristics of innovation, together with its intention of difference to achieve competitive advantage, suggest contemporary innovation metrics should emphasize:

- identification of new types of innovation and their characteristics
- recognition that durable time series may be not relevant
- qualitative measures may be more revealing than strictly quantitative ones.

Session summary

The presentation by Juan Mateos-Garcia from NESTA provided a clear exposition of the characteristics of the 'creative industries' viz: fusion between the arts, technology and business; value that mostly does not arise from advancing the technological frontier; a premium on flexibility and open innovation; and, perhaps paradoxically, spatial proximity.

The creative industries are considered to include music and performing arts, film, television and radio, advertising and marketing, software and interactive content, writing, publishing and print media, design and visual arts, and architecture.

Its significance in the Australian economy is officially recognised. The industry value added in Australia was estimated at $33 million in 2011-12 with a labour force of 4.4% of the total.[2] The achievements of this industry are also widely covered in general and specialist media.

As is widely acknowledged, models and metrics of innovation have been largely shaped by the manufacturing sector, with distinct processes of R&D (usually preceded by some form of customer input), manufacture, distribution and maintenance. Innovation was largely confined to R&D activity to generate new products, processes and services.

As exemplified by the characteristics of the creative industries, and many other drivers of change in the nature and impact of innovation, these assumptions no longer mirror experienced reality.

The key differentiator between the creative industries and others is the inherent emphasis of the subjectivity of value; and multidisciplinarity (e.g. STEAMs). This creates economic dynamism in itself.

From a measurement perspective, four elements were identified that could be considered in measuring subjective value:

1. a fusion of existing metrics
2. employing a variety of technologies to explore the 'creative frontier' (e.g. the share of UK games companies by technology platform)
3. taking into account decentralisation and networks, (e.g. connections between creative communities)
4. measuring concentration effects due to spatial proximity and co-location (e.g. clustering of local businesses).

[2] 'Valuing Australia's Creative Industries', Creative Industries Innovation Centre, 2013

[3] https://www.globalinnovationindex.org/gii-2018-report#

Discussion

It was proposed that a strong candidate for inclusion in the final scorecard was a metric that reflects 'creative industry' innovation. Its particular advantages are that it is a form of innovation that is widely recognised and indeed celebrated by the public and hence presumably also policy-makers. Just think of the attention that the 'Oscars' attract; likewise the opening of new films or drama, the launch of new games, the plethora of 'apps' that enter the marketplace every day, the design of public space and new buildings.

The most recent Global Innovation Index[3], based on a range of indicators, shows Australia's creative outputs rank the country as 22nd in the world, well ahead of its knowledge and technology outputs, and in line with the overall score on all factors.

Key findings for the purposes of the Review

- Due to the intrinsically subjective nature of the creative industries, metrics that are inherently qualitative may be appropriate.
- Whilst some existing survey data can be re-purposed and combined (e.g. through the fusion of innovation survey questions), hybrid strategies and novel data generation is likely to be required.

Session 6: Knowledge diffusion and research commercialization

Metrics to capture innovation more fully

PRESENTER: PROF MARYANN FELDMAN

Abstract

This presentation makes four suggestions to support development of a suite of innovative metrics and methodologies to capture innovation, and link science investments back to economic, social, and environmental benefits.

First, it encourages you to track beyond start-up formation, recording firm survival and progress towards commercialization. These data are within reach, as technology licensing offices require reporting for licensing agreements, which typically have provisions for milestone payments that can be used to track progress towards commercialization. These data could be incorporated into the BLADE platform, and be a resource for academics and policymakers. This would permit evaluation that extends beyond the original start-up phase, enabling consideration of: how companies grow and mature, and what conditions promote survival and commercialisation.

Second, using licensing agreements it is possible to collect annual data from a larger set of firms to build a time series of progress towards introducing new products or generating revenue from university inventions. The idea of better harnessing licensing data would allow further consideration of how knowledge diffuses.

Third, strategies are presented to capture important sectors of the Australian economy that do not conduct R&D.

Finally it recommends considering some efforts that are currently underway that have successfully broadened the discussion about impact. These efforts build on the idea that all people, including policymakers and politicians, like stories. Rather than simply telling stories, we now have the ability to weave narratives with numbers, and data with descriptions to add life to the metrics on which we rely.

Session summary

Four suggestions for improving innovation measurement related to research commercialisation and knowledge diffusion were put forward:

1. **Better measurement of University start-ups**
   There needs to be better tracking of the development of new firms. Typically data collection stops at license and launch, however it is possible to follow firms forward, especially if they take a license.

   What is important is not just the number of start-up firms created, but also: are they successful; how long do they last for; what happens with their technology?

Then it would be useful to track such things as:

- follow-on funding
- fommercialization progress
- exits; mergers & acquisitions; initial product offerings; and deaths
- what happens to their ideas and people.

2. **Outcomes from university licenses**
   We are interested in general, rather than just specific outcomes. These outcomes might include follow-on research projects and progress towards commercialisation. Outcomes may be reflected in royalty payments from licensing agreements. Making better use of administrative records could assist with tracking such outcomes. The ‘dirty little secret of university technology transfer’ is that it does not usually generate much – if any – revenue for universities when considered in the aggregate.

3. **Innovation activities that are not based upon R&D**
   For example, agricultural innovation is difficult to capture but this is an important economic sector in Australia. There is declining government investment in extension services, education and training and research funding. Consequently it is particularly important to understand how these changes are affecting agricultural innovation. Environmental services are another area where non-R&D innovation needs to be better captured. For example, remediation can lead to cost savings, and there are examples of need based and user innovation that could be explored.

4. **Broadening the discussion – policy makers need stories as well as metrics**
   The AUTM Better World report demonstrates the importance of stories, as does the Association of Public and Land-grant Universities (APLU) and its Commission on Economic and Community Engagement (CECE), which established the Innovation and Economic Prosperity (IEP) Universities Program.

Heading a mission-based approach to measuring research translation

PRESENTER: PROF BETH WEBSTER

Abstract

The desire for effective research translation is desired not for its own sake, but rather as a means for achieving societal goals. Before we decide the how much, where and when of translation, we need to be clear about 'for what'?

Rather than opting for a mashup aggregated measure of 'innovation' or 'research translation', the presentation recommends we consider metrics within the context of missions. It gives examples of two missions – low carbon energy and digital transformation – and discusses the metrics we can use to track (a) the attainment of the goals and (b) the success of strategies in place to achieve these goals.

Session summary

Innovation is not just about material goods and services. Climate change, childhood cancers, chronic disease in the young, mental health conditions, intractable disadvantage and global poverty are also issues where innovation is important.

But material and immaterial well-being are related (they enable each other). Strategies to enable improvements in such areas include direct intervention and market forces. These represent two polar opposite views on how to approach such problems. Measures should apply to both strategies (and everything in-between).

Research translation should not be treated as a goal in itself. Rather, it is undertaken to achieve societal goals. Before we decide how much, where, when, we need to be clear about 'for what'? There is doubt that mashup measures of 'innovation' or 'research translation' are useful. They may be useful for media headlines (e.g. as part of a 'shock and awe' strategy) but are not good guides for public policy.

Governments increasingly use mission-oriented approaches (e.g. National Science & Research Priorities, Growth Centres and Precincts). The presentation is going to give an example of how I believe we should measure innovation using two common missions as examples: (1) low carbon energy and (2) digital technologies/ 'industry 4.0'.

Government sets goals (e.g. for 2030) and metrics should clearly separate annual progress towards the attainment of goals from implementation of strategies (e.g. direct, market or a mix).

1. Low-carbon energy

Goals might be:

- carbon emissions (-28% of 2005 levels by 2030)
- energy storage capacity (x GW by 2030)
- carbon sequestration (x tonnes CO2 per year by 2030)

Strategies might include:

- the Clean Energy Finance Corporation
- the Clean Energy Innovation Fund
- the Emissions Reduction Fund
- the Carbon Tax
- collaboration programs: Cooperative Research Centres; Rural R&D Corporations; Australian Research Council (ARC) and National Health and Medical Research Council (NHMRC) programs.

The appropriate metric for these strategies would be carbon reduction per dollar spent.

2. Digital technologies/ 'industry 4.0'

Goals might be:

- number of firms using robots
- number of firms with integrated information and communication systems
- number of firms with other automated systems
- number of firms entering global value chains.

Strategies might include:

- managerial change (e.g. through the Entrepreneurs' Program),
- development and use of new digital technologies.

Appropriate metrics for these strategies include:

- number of new technologies (with or without patent applications)
- number of new PhD student interns and graduates placed in industry
- activities to engage the finance sector with new technologies
- number of (first and third) party firms commercialising/exporting new technologies.

Other potentially significant gains may be had through the development of LEED and the linking of trade (customs) data to BLADE.

Discussion

Universities' engagement in the form of consultancies was identified as comprising a significant, largely unmeasured, form of interaction with industry. Technology transfer is a much smaller component of industry-university engagement. The Better World report was highlighted as a source of data on the activity of faculty and consulting. It was also raised that ultimately, the greatest spillover between academia and industry occurs on graduation day.

The power of a narrative and of case studies were discussed, with both pro and contra positions advocated for. It was agreed that both numbers and stories are required to capture the complexity of the interaction. Stories help to communicate the events on the ground and the accompanying quantitative analysis lends it the broader context to show how representative the case studies are.

To properly understand the collaboration phenomenon, more is required than simply expenditures on the input side. Managerial capability is an important aspect but is somewhat of a 'chicken and egg' issue. Until we measure it, we don't know what the important aspects are that need to be measured.

It was noted that the National Survey of Research Commercialisation (NSRC) collects data on contracts, fee for service and collaboration. It may be worth investigating the feasibility of linking university data to BLADE.

Key findings for the purposes of the Review

- When measuring entrepreneurship, the focus needs to expand from counting the number of new firms created to tracking the development of firms, as well as other commercialisation pathways. Useful variables include licensing and consultancies.
- In the university context, this could include variables such as follow-on funding and exits – mergers and acquisitions, initial product offerings and deaths.
- The linking of university administrative data with BLADE would afford a more complete picture of the interaction between universities and industry.
- Other key data sets that could be linked to BLADE include trade (customs) data.
- Accelerating the development of the LLEED would be a significant step in furthering the understanding of human capital in innovation.

Session 7: Intangibles

Intangibles

Presenters: Stian Westlake, Dr Ben Mitra-Kahn

Abstract

Since the mid-1990s, businesses in the world's more innovative economies have invested more in ideas than in bricks and mortar. Investment in R&D, branding, skills, design, software and content has outpaced investment in plant and machinery in the US, the UK, and several other developed countries, while intangible investment growth has been more robust to the global financial crisis than investment in tangible capital. Intangibles are different, as outlined by Jonathan Haskel and Stian Westlake in *Capitalism without Capital*, both in terms of how they can be measured, and the effect they have on the wider economy.

The shift to a more intangible economy has had a noticeable effect on productivity growth, industry structure and competition, as data across the world, and in Australia shows. Several exercises are being carried out to estimate intangible investment better across the OECD, and increasingly there are consistent ways of measuring and accounting for intangibles in the national accounts, and outside them. Applying these exercises to Australia is wholly possible – but would require some additional data collection, and a broader consideration of what intangible investment should be part of the national accounts, and how it can be included.

Session summary

In relation to the measurement of innovation, a good system is identified as one that reflects how innovation really happens (i.e. it goes beyond traditional manufacturing indicators), has a common unit of measurement that ties into national accounts, and can be developed from existing data and methodologies.

Investment and capital assets are changing. There is a move away from tangible investment (e.g. in buildings, computers, plant and machinery) to intangible investment (e.g. R&D, training, design, organisational development, brands and marketing, artistic originals, software and data). However, this change is hidden. Measures of GDP do not include most intangibles and neither do company accounts.

Intangibles have the characteristics of investment: they are made by a producer, costly to obtain and provide a benefit over time. Four key economic properties of intangibles are identified in the figure below.

As far as measurement in the Australian context goes, it is acknowledged that not all intangible investment is captured in the System of National Accounts, 2008 (SNA08), and what is captured is thought to be undervalued (see Table 1).

Table 1: Types of intangible investment and coverage in National Accounts

Type of investment	Captured in SNA08
Research & Development	Yes
Minerals exploration	Yes
Brands & Marketing	No
Design	No
Copyright	Yes
Software & Data	Yes
Organisational Development / Training	Partially
Skills & Training	No

Since it is estimated that 20% of productivity growth in Australia occurs from investment in intangibles, there is growing interest in developing methods to measure intangibles.[4]

Possible approaches to measurement include development of a satellite account or developing methods for inclusion of intangibles in the System of National Accounts. However, it is acknowledged with any approach there are significant measurement challenges that need to be resolved.

[4] Paula Barnes and Andrew McClure (2009), Investments in Intangible Assets and Australia's Productivity Growth, Productivity Commission Staff Working Paper, Canberra

Internationally, the SPINTAN project has completed a significant amount of research work in the space of intangibles and setting out measurement, as has the Office of National Statistics in the UK and the Bureau of Economic Analysis in the USA. In Australia there is already a trail of work dating back to Paula Barnes' work with the Productivity Commission in 2009.[5][6][7][8][9][10] It is recognised that further work is required. International cooperation and coordination of efforts should be the starting point so that research and Australia data collection is not conducted in isolation, and when completed these can be compared with research and estimates already made elsewhere.

Discussion

A feature of intangibles highlighted was that such goods are not able to be mortgaged but are heterogeneous and embodied in labour. A significant component is 'learning by doing'. No reliable methods currently exist to measure this aspect.

The rise of the services sector has significantly contributed to the rise of intangibles.

The measurement of intangibles in corporate accounts is currently imperfect. One question was 'if companies could not measure intangibles, how could it be measured in the System of National Accounts?' At the economy level, errors cancel, affording a reliable economy-wide estimate.

Key findings for the purposes of the Review

- Improved measurement of intangible capital represents a major opportunity for innovation measurement which could and should be pursued. There is currently a significant undercount.
- Learning by doing represents a large source of intangible capital but requires additional research to establish a method of measuring it.
- As a general principle, there has to be an identifiable relationship between any metric proposed and productivity.

[5] 'Beth Webster (2000), 'The growth of intangible enterprise investment in Australia', Information Economics and Policy, vol. 12, pp. 1–25.

[6] G de Rassenfosse (2012), "Intangible assets and productivity growth." Report for the Australian Government Department of Industry, Science, Research and Tertiary Education - Rassenfosse extends PC estimates for the Department of Industry, Innovation and Science

[7] Elnasri & Fox (2014), The Contribution of Research and Innovation to Productivity and Economic Growth, UNSW. http://research.economics.unsw.edu.au/RePEc/papers/2014-08.pdf .

[8] S Bucifal and F Bulic (2016), Updating investment estimates for Australia's organizational capital, Commonwealth of Australia. https://www.industry.gov.au/sites/g/files/net3906/f/May%202018/document/pdf/updating_investment_estimates_for_australias_organisational_capital.pdf.

[9] Paula Barnes and Andrew McClure (2010), Investments in Intangible Assets and Australia's Productivity Growth: Sectoral Estimates (July, 2010). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1802854 ,

[10] Paula Barnes and Andrew McClure (2009), Investments in Intangible Assets and Australia's Productivity Growth (March, 2009). Productivity Commission Staff Working Paper. https://www.pc.gov.au/research/supporting/intangible-investment/intangible-investment.pdf.

Session 8: Capability and Absorptive Capacity

Innovative Capabilities and Profiles: Examples Using European Innovation Survey Data

PRESENTER: PROF ANTHONY ARUNDEL

Abstract

The concept of an innovation profile refers to assigning innovative firms to unique categories based on the innovation capabilities of the firm, the novelty of innovation outputs, or on other characteristics such as sales of innovative products in non-domestic markets. Profiles are of policy interest because they disaggregate innovative firms into distinct groups. Several studies during the 2000s produced profiles using European Community Innovation Survey data. Currently there is renewed interest in profiles, in part due to the inclusion of profiles as a measurement goal in the 2018 fourth edition of the OECD/Eurostat Oslo Manual. Eurostat is currently funding research on the design of profiles, with the results tested using CIS data in several European countries. Profiles have been constructed at a high level of disaggregation, with one experiment including 24 discrete categories. These can be re-aggregated to produce smaller numbers of profile categories. The main variables used to construct the profiles for product innovators include the presence of in-house innovation capabilities, the characteristics of market innovations, and R&D status. Different variables are used for process innovation. The results are validated against other variables (change in turnover or profits etc.) to ensure that the profiles provide relevant results for policy.

Summary session

In considering the definition of innovation, the Oslo Manual focuses on the economic benefits of innovation on businesses that innovate. Does the definition for innovation set the bar too low? Should there be a requirement for a substantial technological step or creation of new knowledge? It was argued that several game-changing innovations did not require new knowledge or major technological steps. These included the Multiplex cinemas that staved off the oncoming introduction of home movie rentals. The introduction of the shipping container allowed mass transport of goods internationally and allowed China to play a significant role in the manufacture of goods.

Policy makers have long been dissatisfied with the key indicators such as the percentage of firms that innovate. The capabilities of innovators varies. On the lower innovation capability side of the equation, there are firms without any process innovations or ones that can still produce process innovation. On the high innovation capability end of the equation, there are firms with high-end R&D expenditures and also those that do not perform any R&D.

In response to this dissatisfaction of policy makers, work from the early 2000s was cited in classifying the 'innovation modes' of firms using the Community Innovation Survey 3 data (1998-2000) into the classifications of: 'Strategic', 'Intermittent', 'Modifier' and 'Adopter' using the two main criteria of:

- the level of novelty in the firms innovations
- the creative effort that the firms expend on in-house innovation activities.

Work is currently underway with Eurostat to create 'innovation profiles' with voluntary European participants of both small and large economies (11 in total). There is support for this type of classification in the fourth edition of the Oslo Manual (section 3.6.2.). The classification system can be substantially applied to existing innovation type survey questions based on the Oslo Manual. All firms are assigned one profile to get a distribution of innovation activities across all industries in an economy. There was also a suggestion that weighting by employment can be used to reduce differences in markets such as a comparison between Germany (an established, advanced economy) and Romania (whose economy is developing).

This type of classification allows for the success of policy intervention to be determined over the breadth of a country's activities if there are shifts in firms from being Adopters to Modifiers; from Modifiers to Intermittent innovators; and from Intermittent to Strategic innovators. This work should be undertaken at the Industry level in countries as a means to assess industry based policy intervention.

Discussion

Workshop participants discussed the extent to which the use of Big Data could replace expensive survey data that can take up to two years to be made available. The group expressed reservations about the use of Big Data, with issues noted including:

- self-selection of information by business that the business wishes to make public
- incompleteness of the information set available through Big Data that is of interest to stakeholders
- potential lack of representativeness in the data due to exclusion of members of the population that were less 'visible' than others.

New thinking about capabilities: Innovation and technologies and behavioral science

PRESENTER: PROF MARK DODGSON

Abstract

Scientists are using new tools and techniques to provide novel and often surprising insights into innovation capability. New innovation technologies not only intensify innovation, but through machine learning can create it: they are the capital goods of the modern economy. In a post-artificial intelligence (AI), service-based economy, innovation is increasingly a behavioural phenomenon. Behavioural science can explain, predict and change innovation capability at an individual and population level. Combining these new technologies and behavioural insights enhances our ability to improve and measure innovation.

Summary session

It was suggested that new thinking is required on capabilities in light of advances in innovation technologies and behavioral sciences. Scientists are using new tools and techniques to provide novel and often surprising insights into innovation capability. In a particular example by Armand Leroi, analysis of 17,000 Billboard Hot 100 songs was conducted using signal processing and text-mining to analyse musical properties, chord changes and tone. Evolutionary methodology was applied using digital analysis to determine the three revolutions of music (60's Rock, 80's synthesisers and 90's hip hop).

In a post-AI, service-based economy, innovation is increasingly a behavioral phenomenon. Various companies including PwC suggest that behavior matters more when innovation occurs at the point of consumption. Behavioral science can explain, predict and change innovation capability at an individual and population level.

There are increasing numbers of data sources and data technologies including analytical and predictive tools. Combining these new technologies and behavioral insights enhances our ability to improve and measure innovation.

Discussion

The UN Sustainable Development Goals were raised as worthy of using as a basis for impact measurement by Amanda Caples, and would serve to address social and environment issues. Although outside of the scope of the Review, it was thought that the Review could note these impacts and suggest the use of the UN goals as a basis for future work.

Text mining on the objects of innovation was raised as a possible way of further understanding innovation at the firm and product or service level. Any such attempt would require further validation.

Key findings for the purposes of the Review

- Innovation profiles offer a novel approach for identifying and communicating the diversity of innovation characteristics of firms at a sectoral level and across countries.
- The profiles are based on the Community Innovation Survey and are compatible with the Business Characteristics Survey, thereby allowing for international comparison.
- The UN Sustainability and Development Goals were identified as a useful basis for incorporating social and environmental impacts into the Roadmap of the Review.

Workshop wrap-up

Members were asked to identify breakthrough ideas and expectations from the workshop that could be pursued by the Taskforce and the Academy. The following is a summary of the key themes that emerged.

Policy and strategy

- New metrics considered should either:
  - contribute to the measurement of currently 'hidden' innovation, or
  - be policy relevant and have a straightforward conceptual basis.
- A clear link needs to be established in the Review's work between productivity, the conceptual framework and innovation.
- The Review should consider what the key drivers of productivity growth are; what metrics are available that are directly related to these components of productivity growth; and what policy levers affect them. If the above can be established, the Review should set out an evaluation schedule to assess the implementation of the Review recommendations.
- The innovation metrics roadmap component needs to consider up to a 10-year time horizon and differentiate between short and long-term goals.
- The long time to impact is concerning from a measurement and policy perspective. Any impact assessment should include short term policy interventions and be followed up.
- The Review recommendations should be outcome-centric rather than focussing on 'how to get there'.
- The Review needs to achieve a balance between pragmatism and ambition. There needs to be room for experimentation and citizen engagement.
- The use of advanced analytics is a priority area of government. Its implementation for innovation measurement should be trialled and should complement existing metrics.
- The Review needs to be inclusive of the full business population and not forget about SMEs.
- The act of the collection of metrics itself results in behavioural change from respondents. Requiring those receiving public funding to provide better data on how they are contributing to innovation would improve measurement.

Measurement opportunities and gaps

- More analysis of non-publicly available data is required. This would require better communication about the value of this data and its use to data providers.
- A coordinated approach to standardising centres or research institutes to focus on aspects of innovation including entrepreneurship would be helpful.
- The Review roadmap should be future-focused and consider behavioural innovation.
- The innovation profiles approach at the sectoral level should be pursued and could be expanded to incorporate longer term challenges including environmental issues.
- There is a need to track emerging technologies.
- Government needs to foster experimentation in relation to innovation measurement to realise the benefits of advances in innovation measurement theory.

Measurement approaches

- Use text data and mining techniques to turn data into a richer picture of innovation.
- Focus on short term metrics that are output-oriented and are internationally comparable.
- Expand the way we are measuring innovation by using qualitative and quantitative methods.
- Task growth centres to develop state of the sector reports including international comparisons. They would have qualitative components including case studies.
- Aim for intensity measures that can be measured at the firm level and aggregated to the sector and national level.

Appendix A – Workshop agenda

WEDNESDAY 13 MARCH 2019

Start time	Event	Speaker	Location	Duration
11.00 am	Pre-Workshop presentation: *Measuring Innovation: What have we learnt, and what does this mean for Australia?* All welcome (own transport required)	F Galindo-Rueda / A Arundel	ABS House Ground Floor, Knibbs Auditorium	1hr
12.45 pm	LUNCH	------	QT Bar/Grill	1hr
1.45 pm	WORKSHOP REGISTRATION	------	Ballroom Foyer	15min
2.00 pm	**MC opens workshop**	**M Cully**	**QT Ballroom 3**	**15min**
2.15 pm	Innovation Metrics Review context setting	C Williams / M Wenham	QT Ballroom 3	30min
2.45 pm	Session 1: *Entrepreneurship* [VIDEO CONFERENCE]	S Stern / A Charlton	QT Ballroom 3	45min
3.30 pm	AFTERNOON TEA	------	Ballroom Foyer	30min
4.00 pm	Session 2: *Innovation Metrics – state of play – a WIPO GII perspective* [VIDEO CONFERENCE]	S Wunch-Vincent / A Caples	QT Ballroom 3	45min
4.45 pm	**MC closes workshop (for Day 1)**	**M Cully**	**QT Ballroom 3**	**15min**
5.30 pm	DRINKS	------	QT Lounge	45min
6.15 pm	**Introductory address**	**A Finkel**	**QT Lounge**	**15min**
6.30 pm	OFFICIAL DINNER	------	QT Lounge	2hr

THURSDAY 14 MARCH 2019

Start time	Event	Speaker	Location	Duration
8.30 am	ARRIVAL/COFFEE	------	Ballroom Foyer	30min
9.00 am	**MC opens workshop (for Day 2)**	**M Cully**	**QT Ballroom 3**	**15min**
9.15 am	Session 3: *Hidden innovation in mining*	A Bye / M Thomas	QT Ballroom 3	45min
10.00 am	Session 4: *Measurement of R&D and innovation policies*	F Galindo-Rueda / T Spurling	QT Ballroom 3	45min
10.45 am	MORNING TEA	------	Ballroom Foyer	30min
11.15 am	Session 5: *Creative inputs into innovation* | *New data for R&D policy*	J Mateos-Garcia / R Johnston	QT Ballroom 3	45min
12.00 pm	Session 6: *Knowledge diffusion and research commercialisation*	M Feldman / B Webster	QT Ballroom 3	45min
12.45 pm	LUNCH	------	QT Bar/Grill	1h15min
2.00 pm	Session 7: *Intangibles*	S Westlake / B Mitra-Kahn	QT Ballroom 3	45min
2.45 pm	Session 8: *Capability and absorptive capacity*	A Arundel / M Dodgson	QT Ballroom 3	45min
3.30 pm	AFTERNOON TEA	------	Ballroom Foyer	30min
4.00 pm	Key issues identified and closing	Chief Economist	QT Ballroom 3	45min
4.45 pm	**Workshop Close**	**------**	**QT Ballroom 3**	

Overview

Purpose

The purpose of the Innovation Metrics Review is to improve measurement of Australia's innovation system, to support better decision-making which will drive improved economic outcomes for Australia.

The purpose of the workshop is to inform the Innovation Metrics Review about international developments and share the thinking of international and domestic experts on how innovation measurement may be improved.

Structure

The workshop will open with context setting and then be followed by eight sessions. The workshop sessions will be presented by pairs of speakers. The first speaker will give a 20 minute presentation and the second speaker will give a 10 minute presentation on the same topic focussing on the Australian context. This will be followed by a 15 minute question and answer session involving the audience.

Audience

The members of the audience for the workshop are innovation metrics experts and innovation system stakeholders, and include most of the members of the Review's governance and advisory bodies.

Venue and Timings

The venue for the workshop event will be QT Hotel, 1 London Circuit, Canberra. The venue is located a 15 minute walk or a 5 minute drive from Industry House, or a 12 minute drive from ABS House (refer Attachment A).

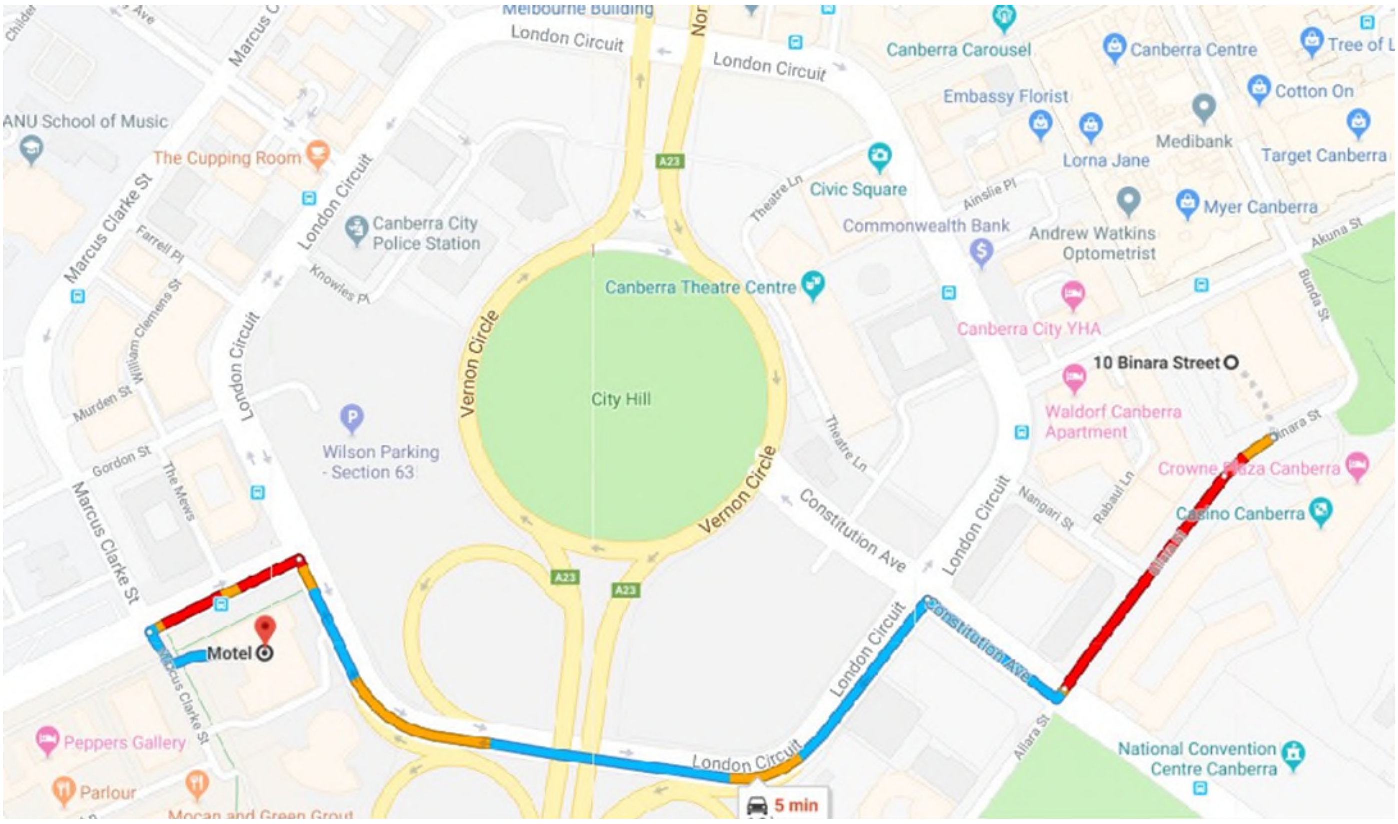
Within this venue, there are four locations where events will take place:

- **QT Capitol Bar and Grill**, which is located on the ground floor of the hotel. Seating for workshop participants will be provided in two long rows. While other hotel guests may be using this restaurant at the same time, the workshop participants are expected to account for the majority of patrons at that time
- **QT Lounge**, which is located on the top floor of the hotel and provides views of the city and lake. The QT Lounge will be the location for the workshop dinner and pre-dinner drinks
- **Ballroom 3**, which is located on the first floor of the hotel and accessible by steps from the lobby
- **Ballroom foyer**, which is the area immediately outside of the ballroom, for workshop registration, welcome tea and coffee, and morning and afternoon tea.

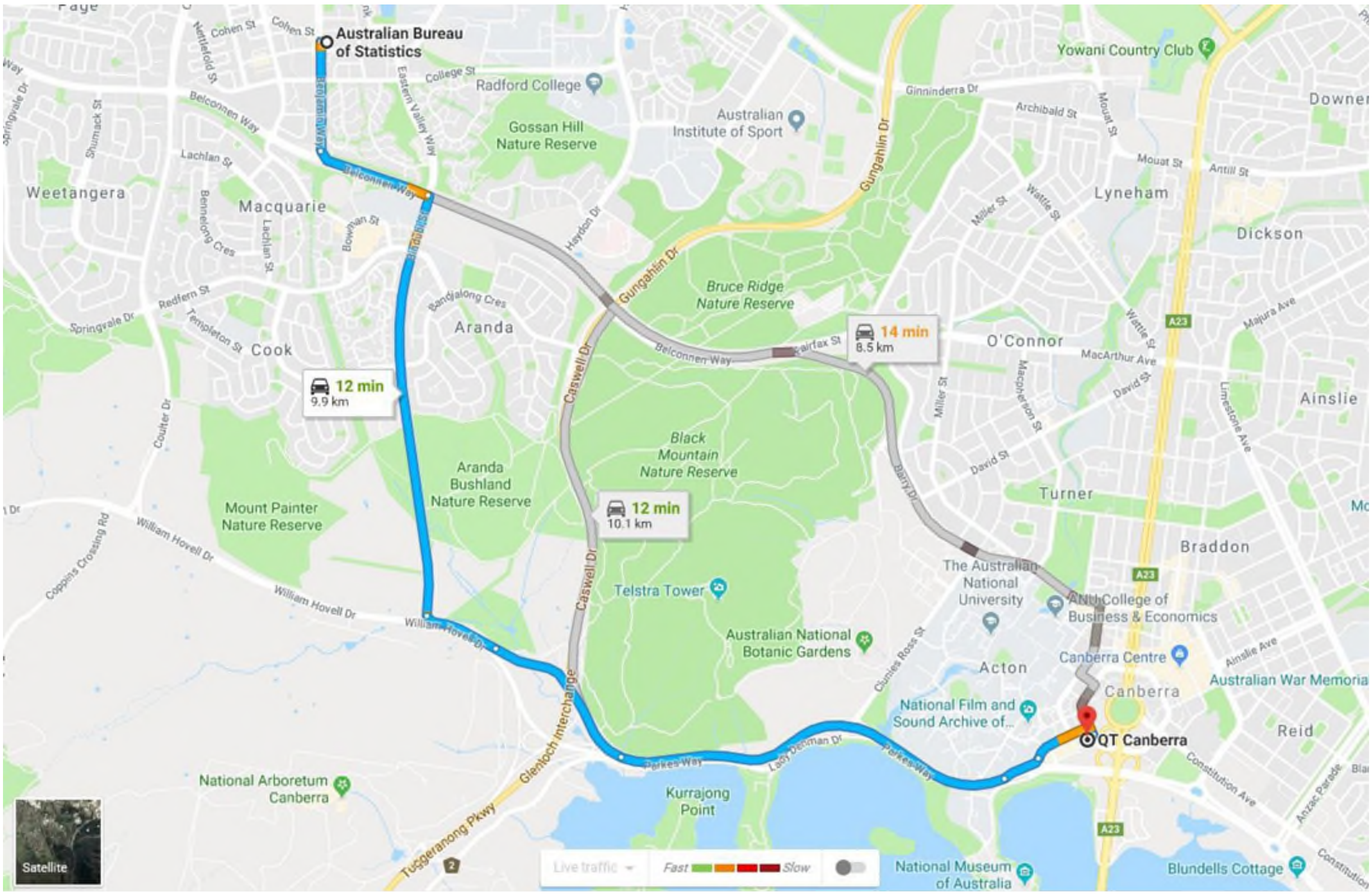
Outcomes and next steps

Detailed minutes of the presentations and discussions that take place at the workshop will be kept. These documents will also form part of the review's suite of final documents. A draft version of the report (including proposed findings and recommendations) will be made available for public comment after the Workshop and prior to June 2019.

Attachment 1
Directions to meeting locations



a 12 minute drive



Attachment 2
Biographies of Speakers

Mark Cully, Chief Economist, Australian Department of Industry, Innovation and Science

Mark Cully was appointed Chief Economist for the Department of Industry, Innovation and Science in 2012. In that role he oversees economic advice, analysis and forecasting published by the Office of the Chief Economist, as well as the department's evaluation activity, data governance and Bizlab, the department's policy innovation and design lab.

Mark has a first-class Honours degree in Economics from the University of Adelaide. From 1992-95 he was a British Council Commonwealth Scholar at the University of Warwick obtaining a Master of Arts, while working at the Warwick Business School.

In 1995 he was appointed head of research on employment relations for the UK Government, where he ran what was the world's largest survey of working life. He returned to Australia in 1999 as Deputy Director of the National Institute of Labour Studies, and was then General Manager at the National Centre for Vocational Education Research for six years, running its statistical then research operations. In 2009 he was appointed inaugural Chief Economist at the Department of Immigration and Citizenship and in that role chaired the OECD's Working Party on Migration. In 2017 he was a Special Guest of the Brookings Institution. He is a member of the Committee for the Economic Development of Australia's Council on Economic Policy.

Dr Alan Finkel, Australia's Chief Scientist

Dr Finkel commenced as Australia's Chief Scientist on 25 January 2016. He is Australia's eighth Chief Scientist. Prior to his appointment, he served as President of the Australian Academy of Technology and Engineering (ATSE), and for eight years as Chancellor of Monash University.

As Chief Scientist, Dr Finkel has led a number of national reviews, delivering the 2016 National Research Infrastructure Roadmap, the 2017 Review into the National Electricity Market ("Finkel Review") and the 2018 STEM Industry Partnership Forum report. He serves as the Deputy Chair of Innovation and Science Australia.

Dr Finkel has an extensive science background as an entrepreneur, engineer, neuroscientist and educator. He was awarded his PhD in electrical engineering from Monash University and worked as a postdoctoral research fellow in neuroscience at the Australian National University.

In 1983 he founded Axon Instruments, a California-based, ASX-listed company that made precision scientific instruments. After Axon was sold in 2004, Dr Finkel became a director of the acquiring company.

In 2006, he focused his career in Australia and undertook a wide range of activities including co-founding Cosmos Magazine. During his time at ATSE, he led the development and implementation of the STELR program for secondary school science.

Dr Matt Wenham, Executive Director, Policy at the Australian Academy of Technology and Engineering

Dr Matt Wenham is the Executive Director, Policy at the Australian Academy of Technology and Engineering, Australia's national academy for applied science and technology. Matt leads the Academy's policy team, which provides independent, evidence-based advice to government and industry based on the expertise of over 800 Fellows of the Academy.

Prior to joining the Academy in 2014, Matt was a Senior Policy Associate at the Mitchell Institute for Health and Education Policy, an independent think tank based in Melbourne, Australia. Prior to returning to Australia in 2013, Matt was Associate Director with the Institute on Science for Global Policy, a non-profit organization based in Washington, DC that aims to help improve and expand the dialogue between scientists and policy makers on key public policy issues impacted by science and technology. As Associate Director of the Institute, Matt was responsible for programs on emerging infectious diseases and biosecurity, food safety and security, and emerging technologies, and managed a team of staff and fellows located throughout the US and overseas. Before joining the ISGP, Matt was a postdoctoral research fellow in the National Institute for Diabetes and Digestive and Kidney Diseases at the US National Institutes of Health in Bethesda, Maryland.

Matt received his Bachelor of Science and Honours degrees in biochemistry from the University of Adelaide. In 2005, Matt was selected as a Rhodes Scholar for Australia-at-Large and moved to the University of Oxford to undertake his DPhil (PhD) in cell biology and immunology at the Sir William Dunn School of Pathology. Matt has served in the Australian Army Reserve and completed the reserve officer commissioning course at the Royal Military Academy Sandhurst, UK. In 2003, he was awarded the Australian Centenary Medal, for services to the community as chair of the South Australian Government's ministerial advisory council on youth affairs.

Christine Williams, General Manager, Innovation Metrics Review at the Australian Department of Industry, Innovation and Science

Ms Christine Williams is an Australian Bureau of Statistics (ABS) officer who is currently outposted to the Department of Industry, Innovation and Science, leading the Taskforce. Christine has worked in the private sector, academia, and the state and federal public sectors. Her previous roles relevant to the Review include: five years leading the Economic and Policy Research Branch of the Tasmanian Department of Primary Industries, Parks Water and Environment; and four years at the ABS in the roles of Assistant Statistician (branch head), Indigenous, Education and Cultural Statistics Branch, and Assistant Statistician, Education and Data Integration Branch, where she founded the ABS Centre for Data Integration.

Christine has over 20 years of experience as a non-executive director, is a Fellow of the Australian Institute of Company Directors (AICD), and has been an ACT AICD Division Councilor for the past four years.

Christine has a Bachelor of Economics with Honours, a Master of Business Administration, an Advanced Diploma in Financial Services (Financial Planning), and has completed the AICD Company Directors' Course (with Order of Merit), Mastering the Boardroom, and the International Company Directors' courses.

Session 1: Entrepreneurship

Prof Scott Stern, the David Sarnoff Professor of Management, MIT Sloan School of Management

Prof Scott Stern is the David Sarnoff Professor of Management at the MIT Sloan School of Management.

Scott explores how innovation and entrepreneurship differ from more traditional economic activities, and the consequences of these differences for strategy and policy. His research in the economics of innovation and entrepreneurship focuses on entrepreneurial strategy, innovation-driven entrepreneurial ecosystems, and innovation policy and management. Recent studies include the impact of clusters on entrepreneurship, the role of institutions in shaping the accumulation of scientific and technical knowledge, and the drivers and consequences of entrepreneurial strategy.

Scott has worked widely with practitioners in bridging the gap between academic research and the practice of innovation and entrepreneurship. This includes advising start-ups and other growth firms in the area of entrepreneurial strategy, as well as working with governments and other stakeholders on policy issues related to competitiveness and regional performance. In recent years, Scott has developed a popular new MIT Sloan elective, Entrepreneurial Strategy, co-founded the MIT Regional Entrepreneurship Acceleration Program, advised the development of the Social Progress Index, and served as the lead MIT investigator on the US Cluster Mapping Project.

Dr Andrew Charlton, Director, AlphaBeta Advisors

Dr Andrew Charlton has senior experience in business, government and international institutions. After commencing his career with the Boston Consulting Group (BCG), he received a Doctorate and Masters in Economics from the University of Oxford, where he studied as a Rhodes Scholar. From 2008-2010, through the period of the global financial crisis, he served as senior economic advisor to the Prime Minister of Australia and Australia's senior government official to the G20 economic summits. He was the prime minister's representative to conferences of the United Nations Framework Convention on Climate Change (UNFCCC) and the Major Economies Forum on Energy and Climate (MEF). From 2010-2014 he worked for Australian conglomerate Wesfarmers, including two years in corporate strategy (M&A and major group projects) and two years in operational roles (divisional Chief Financial Officer and General Manager). His academic research covering international economics, trade and development has been published in leading international journals including the American Economic Review, World Trade Review and World Economy. He is the author of two books, Ozonomics (2007) and Fair Trade for All (2005), co-written with Nobel laureate Joseph Stiglitz. In 2011 he was named a Young Global Leader by the World Economic Forum.

Session 2: Innovation Metrics – state of play – a WIPO GII perspective

Dr Sacha Wunsch-Vincent, Co-Editor Global Innovation Index & Head, Section, Economics and Statistics Division, World Intellectual Property Organization

Dr Sacha Wunsch-Vincent is Head of Section in the Economics and Statistics Division at the World Intellectual Property Organization (WIPO) and Co-Editor of the Global Innovation Index. He joined WIPO in 2010 to help set up WIPO's economics work under the Chief Economist. At WIPO, he is one of the main authors of the World Intellectual Property Report and the Global Innovation Index. His primary research foci and current area of work are concerned with the interaction of innovation, intellectual property, and economic development.

Before joining WIPO, he was an economist at the OECD Directorate for Science, Technology, and Industry for seven years. Earlier he was the Swiss National Science Fellow at the Berkeley Center for Law and Technology (University of California, Berkeley) and the Peterson Institute for International Economics (Washington, D.C.). He has served as advisor to organizations such as the World Bank and the World Economic Forum, and has testified before governments and parliaments. His recent WIPO-CUP book on "Innovation in the Informal Economy of Developing Counties – Hidden Engine of Innovation?" will be published by Cambridge University Press in September 2016.

Sacha holds a Master of International Economics from the University of Maastricht with a Masters Thesis at MERIT and a PhD in Economics from the University of St. Gallen, Switzerland. He teaches International Economics at Sciences Po Paris, and the World Trade Institute in Bern.

Dr Amanda Caples, Victoria's Lead Scientist

Dr Amanda Caples joined the Victorian public service in 2002 as the inaugural Director of Biotechnology and was appointed to the role of Victoria's Lead Scientist in mid-2016. Amanda brings broad experience in technology commercialisation, public policy development and governance of public and private entities. As Deputy Secretary, Sector Development and Programs, Amanda was responsible for the development of Future Industries strategic sector growth plans and for support of the Victorian science, innovation and entrepreneurial ecosystem.

After graduating from the University of Melbourne with a PhD in pharmacology, Amanda began her pharmaceutical industry career with Servier Laboratories Australia where she was responsible for local product development and the registration of new medicines for the treatment of diabetes and high blood pressure. Amanda progressed to business development roles first with AMRAD where she secured licensing deals and strategic alliances for the R&D portfolio before joining the Walter and Eliza Hall Institute to establish the Technology Transfer Office.

Session 3: Hidden innovation in mining

Dr Alan Bye, Vice President Technology at BHP Billiton

Dr Alan Bye is Vice President Technology at BHP Billiton. Alan and his global team are accountable for defining the Technology strategy and execution of innovation programs across the company covering both digital and extractive technologies. This includes responsibility for strategic partnerships, emerging technology, innovation labs, enterprise architecture and intellectual property management.

Prior to this Alan led the establishment and was CEO at the Cooperative Research Centre for Optimising Resource Extraction. A $100m venture involving 34 partners with the purpose of 'Transforming Mining into an Advanced Manufacturing Industry'. He was previously, Professor and Director of the Bryan Research Centre at the University of Queensland.

Alan has a mining operational background, spending 10 years with Anglo American where he held mining operational roles both in underground and open pit operations. Over his career Alan has worked in 15 counties covering 9 commodities. Alan was recently elected a 2018 Fellow of the Australian Academy of Technology and Engineering.

Mark Thomas, Group Manager Procurement and Information Services at Fortescue Metals Group.

Mark Thomas was appointed Group Manager, Procurement & Information Services at Fortescue Metals Group Limited in July 2017. He has previously held senior positions at Fortescue including: Group Manager, Infrastructure Services; Company Secretary, Group Manager Finance; and Head of Finance & IT. Prior to Fortescue Mark held senior finance and accounting positions with the Goldfields Australia Group and with a number of professional service providers.

With more than 20 years' experience in the mining and professional services industries, Mark has gained comprehensive experience in finance and accounting, governance and risk, information technology and business administration. He has a Bachelor of Commerce from the University of Western Australia, Graduate Diploma in Applied Corporate Governance, a Masters of Business Administration and is a Certified Practising Accountant and a Fellow of the Governance Institute of Australia. Mark is a Non-Executive Director and Chair of Risk Committee at ChemCentre.

Session 4: Measurement of R&D and innovation policies

Dr Fernando Galindo-Rueda, Senior Economist at the OECD Directorate for Science, Technology and Innovation

Fernando Galindo-Rueda is a Senior Economist in the Economic Analysis and Statistics Division of the OECD Directorate for Science, Technology and Innovation (STI). He leads the directorate's S&T and Innovation indicators and analysis unit and coordinates the work of the OECD Working Party of National Experts on Science and Technology Indicators (NESTI). He is responsible for the development of OECD statistical standards for the measurement of R&D and innovation (including the recent update of the Frascati and Oslo Manuals), the delivery of targeted analysis of science and innovation data and the dissemination of key OECD statistics, including the Main Science and Technology Indicators, the R&D Statistics and R&D Tax Incentives databases. He is also in charge of implementing the measurement agenda arising from the OECD Blue Sky Forum, which he co-organised in 2016.

Prior to joining the OECD in 2010, he was Deputy Director in charge of Business Economics at the UK Government's Department for Business, Innovation and Skills, where he was responsible for economic advice on and the evaluation of UK industrial policies, with particular focus on technology-advanced sectors and the impact of energy and climate change policies. He has also led the Economic Methodology branch at the UK Office for National Statistics and has been a research economist at the London School of Economics' Centre for Economic Performance and Centre for the Economics of Education. He has a PhD in Economics and an MSc in Environmental and Natural Resource Economics from University College London.

Prof Thomas Spurling, Professor, Innovation Studies at the Centre for Transformative Innovation, Swinburne University of Technology

Prof Tom Spurling is Professor of Innovation Studies at the Centre for Transformative Innovation, Swinburne University of Technology.

Tom is a scientist with experience in managing the process of translating research into commercial products. His current research interests include the use of social network analysis in understanding how best to commercialise public sector research, the use of economic analysis to understand why some firms invest in innovation, and the use of case studies to tell the story of Australian innovation.

Session 5: Creative inputs into innovation | New data for R&D policy

Juan Mateos-Garcia, Director of Innovation Mapping at Nesta

Juan Mateos-Garcia is Director of Innovation Mapping at Nesta.

Prior to joining Nesta, Juan worked as a researcher at SPRU (Science Policy Research Unit) at the University of Sussex, and CENTRIM at the University of Brighton.

Juan has a degree in Economics (with distinction) for Universidad de Salamanca (Spain), and an MSc (with distinction) in Science and Technology Policy from SPRU, University of Sussex.

Prof Ron Johnston FTSE, Executive Director, Australian Centre for Innovation at the University of Sydney (recently retired)

Professor Ron Johnston has recently retired after 26 years as Executive Director of the Australian Centre for Innovation (ACIIC) and is an Emeritus Professor in the Faculty of Engineering & IT at the University of Sydney.

Educated initially as a scientist in Australia, the UK and the US, he has devoted most of his career to develop a better understanding and application of the ways that science and technology contribute to economic and social development, of the possibilities for managing research and technology more effectively, and of insights into the processes and culture of innovation.

Session 6: Knowledge Diffusion and Research Commercialisation

Prof Maryann Feldman, Heninger Distinguished Professor, Department of Public Policy, University of North Carolina

Prof Maryann P. Feldman is the Heninger Distinguished Professor in the Department of Public Policy at the University of North Carolina, an Adjunct Professor of Finance at Kenan-Flagler Business School and a Research Director at UNC Kenan Institute of Private Enterprise.

Her research and teaching interests focus on the areas of innovation, the commercialization of academic research and the factors that promote technological change and economic growth. Maryann is an editor of the journal, Research Policy, and chairs an interagency working group on Science Policy. From 2014-2017, Maryann held a joint appointment at the National Science Foundation as the Science of Science and Innovation Policy (SciSIP) Program Director.

Maryann was the winner of the 2013 *Global Award for Entrepreneurship Research* for her contributions to the study of the geography of innovation and the role of entrepreneurial activity in the formation of regional industry clusters

Maryann has written extensively on the process and mechanics of the commercialization of academic research. Her most recent work explores emerging industries, entrepreneurship and the process of regional transformation. Currently, Maryann is actively engaged in researching the industrial genesis of the Research Triangle region. The project follows the development of the regional economy over a 50 year time period using a unique database of 3200 entrepreneurial ventures and attempts to understand the institutional dynamics that created a vibrant regional economy.

Prof Beth Webster, Pro Vice-Chancellor (Research Policy and Impact), Swinburne University of Technology

Professor Beth Webster is the Director of the Centre for Transformative Innovation at Swinburne University of Technology. She is also Pro Vice-Chancellor for Research Impact and Policy.

She holds a B. Economics and M. Economics (Monash University) and a PhD in economics (University of Cambridge). She has authored over 100 articles on the economics of innovation and firm performance and has been published in RAND Journal of Economics, Review of Economics and Statistics, Oxford Economic Papers, Journal of Law & Economics, Cambridge Journal of Economics and Research Policy. She has been appointed to a number of committees including the Bracks' review of the automotive industry; Lomax-Smith Base funding Review; CEDA Advisory Council; the Advisory Council for Intellectual Property; President, European Policy for Intellectual Property Association; and General Secretary, Asia Pacific Innovation Network.

Her research interests include: economics; innovation; R&D policy; firm performance; productivity; intellectual property policy; industry dynamics; knowledge spillovers; markets for technology.

Session 7: Intangibles

Stian Westlake, Executive Director of Policy and Research

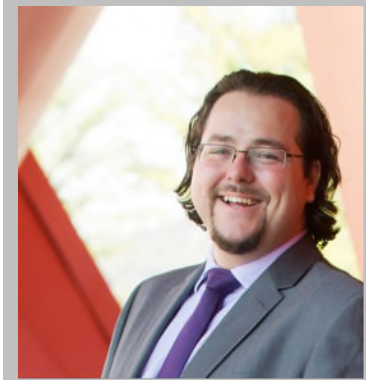
Stian Westlake is a consultant on innovation and technology policy. He has worked as the adviser to three UK science ministers. Prior to that, he spent eight years as an Executive Director of Nesta, the UK's national foundation for innovation, where he led the organisation's think tank. Before that, he worked in social investment at The Young Foundation, as a consultant at McKinsey & Company in Silicon Valley and London (where his work focused on healthcare, private equity and infrastructure), and as a policy adviser in HM Treasury. He also founded Healthy Incentives, a healthcare social enterprise.

He is co-author of Capitalism Without Capital: the rise of the intangible economy (Princeton, 2017). He is a governor of the National Institute for Economic and Social Research, a senior fellow of Nesta, and a visiting researcher at Imperial College London.

His research interests include the measurement of innovation and its effects on productivity, the role of high-growth businesses in the economy, financial innovation, and how government policy should respond to technological change.

Stian was educated at the University of Oxford, Harvard University and London Business School.

Dr Ben Mitra-Kahn, Chief Economist, IP Australia



Dr. Mitra-Kahn has been the Chief Economist at IP Australia since November 2012, previous to which he was the senior economist at the UK Intellectual Property Office. In 2017 he was a joint winner of the Indigo Prize with Diane Coyle for work on re-imagining GDP.

His academic work has focused on the history of national accounting, CGE models, development, innovation and Intellectual property, and he has worked on intangible asset measurement as well as IP policy issues.

His background includes time as an academic, consultant and company director in the UK, US and Australia, and he is currently based in Sydney.

Session 8: Capability and Absorptive Capacity

Prof Anthony Arundel, Professorial Fellow at UNU Maastricht Economic and Social Research and Training Centre on Innovation and Technology

Prof Anthony Arundel is a Professor of Innovation at the University of Tasmania in Hobart, Australia and concurrently a Professorial Fellow at UNU Maastricht Economic and Social Research and Training Centre on Innovation and Technology (UNU-MERIT). He was previously a Senior Researcher at UNU-MERIT since 1992. Anthony specialises in the design, implementation, and analysis of innovation surveys. His research interests include questionnaire design and methodology, technology assessment, environmental issues, intellectual property rights, biotechnology, and knowledge flows from public research to firms.

Prof Mark Dodgson, Professor of Innovation Studies at the University of Queensland Business School

Prof Mark Dodgson is Professor of Innovation Studies at the University of Queensland (UQ) Business School, and Visiting Professor at Imperial College London His research interests are in the areas of corporate strategies and government policies for technology and innovation. He has previously worked as a Research Fellow at the Technical Change Centre, London (1983-85). He was Senior Fellow at the Science Policy Research Unit (SPRU) at the University of Sussex (1985-93), and was Professor of Management at the Australian National University (1993-2002). He was co-Founder of the National Graduate School of Management at the ANU and was its Executive Director. He has been on the Board and Advisory Boards of two multi-billion dollar companies and five start-ups.

Mark has contributed to the discussion about innovation in Australia for over 30 years. In 2019, he was appointed an Officer of the Order of Australia for distinguished service to education in the field of business innovation strategy, as a researcher, advisor and author.

He has written or edited 16 books on innovation, and his current major research interests include: innovation in large, complex projects; the playful work of entrepreneurs; philanthropy and entrepreneurs; innovation in China; the future of the innovative university; and innovation the 18th century English pottery and textile industries.

Appendix B – Workshop participants

Title	First Name	Surname	Position	Organisation
Dr	Renu	Agarwal	Associate Professor, Operations and Supply Chain Management	University of Technology, Sydney
Mr	Alex	Aitkin	Assistant Director	Australian Department of Industry, Innovation and Science
Prof	Anthony	Arundel	Professorial Fellow at United Nations University (UNU) Maastricht Economic and Social Research and Training Centre on Innovation and Technology	United Nations University - Maastricht University The Netherlands
Mr	Antonio	Balaguer	Assistant Director, Innovation Resource Section	Australian Department of Industry, Innovation and Science
Dr	Krisztian	Baranyai	Assistant Director	Office of Innovation and Science Australia
Mr	Pourus	Bharucha	Assistant Manager, Strategic Policy	Australian Department of Industry, Innovation and Science
Ms	Helena	Bujalka	Graduate	Office of Innovation and Science Australia
Dr	Alan	Bye	Vice President Technology (Strategy & Innovation)	BHP
Dr	Amanda	Caples	Lead Scientist	Victorian Department of Jobs, Precincts and Regions
Dr	Andrew	Charlton	Director	Alphabeta
Ms	Melinda	Cilento	CEO	CEDA
Ms	Jemma	Collova	APR Intern, Innovation Metrics Review Taskforce	Australian Department of Industry, Innovation and Science
Mr	Mark	Cully	Chief Economist	Australian Department of Industry, Innovation and Science
Prof	Per	Davidsson	Professor of Entrepreneurship	Queensland University of Technology
Dr	Ryan	Dawson	Assistant Director, Patent Analytics Hub	IP Australia
Dr	Charles	Day	Chief Executive Officer	Office of Innovation and Science Australia
Prof	Mark	Dodgson	Professor of Innovation Studies	University of Queensland, Business School
Prof	Maryann	Feldman	Heninger Distinguished Professor, Department of Public Policy	University of North Carolina
Dr	Alan	Finkel	Australia's Chief Scientist	Australia's Chief Scientist
Mr	Jason	Finley	Assistant Director, Science & Commercialisation Policy Division/ Innovation Metrics Review Taskforce	Australian Department of Industry, Innovation and Science
Dr	Cathy	Foley	CSIRO Chief Scientist	CSIRO

Title	First Name	Surname	Position	Organisation
Dr	Fernando	Galindo-Rueda	Senior Economist, Economic Analysis and Statistics Division, OECD Directorate for Science, Technology and Industry	OECD
Dr	Jenny	Gordon	Chief Economist	Nous Group
Dr	Margaret	Hartley	CEO	Australian Academy of Technology and Engineering
Dr	Erol	Harvey	Strategic Advisor	Bionics Institute
Ms	Jacky	Hodges	General Manager, Industry Statistics Division	Australian Bureau of Statistics
Mr	Ben	James	Acting Program Manager, Business Indicators Branch	Australian Bureau of Statistics
Prof	Ron	Johnston	Former Executive Director, Australian Centre for Innovation (recently retired)	University of Sydney
Ms	Lisa	Kerr	Senior Research Officer	Office of the Chief Scientist
Mr	Juan	Mateos-Garcia	Director of Innovation Mapping	Nesta
Mr	John	McGagh	Immediate Past President	Institution of Chemical Engineers
Dr	Ben	Mitra-Kahn	General Manager and Chief Economist	IP Australia
Dr	Char-Lee	Moyle	Office of the Chief Scientist	CSIRO
Prof	Pauline	Nestor	Vice-Provost of Research (retired)	Monash University
Mr	Emmanuel	Njuguna	Digital Economy Policy / Innovation Metrics Review Taskforce	Australian Department of Industry, Innovation and Science
Ms	Victoria	Savage	Assistant Director, Technology, Innovation and Business Characteristics Statistics Section	Australian Bureau of Statistics
Prof	Tom	Spurling	Professor of Innovation Studies	Swinburne University of Technology
Ms	Lauren	Stafford	Head of Innovation Partnerships	BHP
Prof	Scott	Stern	David Sarnoff Professor of Management, MIT Sloan School of Management	Massachusetts Institute of Technology (MIT)
Mr	Mark	Thomas	Group Manager, Procurement and Information Systems	Fortescue Metals Group Ltd
Mr	David	Turvey	General Manager, Insights and Evaluation Branch	Australian Department of Industry, Innovation and Science
Dr	Simon	Wakeman	Principal Advisor - Innovation Policy	New Zealand Ministry of Business, Innovation & Employment
Dr	Leonie	Walsh	Founder & Director	Productive Management Solutions
Mr	David	Waymouth	Director, Technology, Innovation and Business Characteristics Statistics Section	Australian Bureau of Statistics

Title	First Name	Surname	Position	Organisation
Prof	Beth	Webster	Pro Vice Chancellor (Research Policy and Impact), Director, Centre for Transformative Innovation	Swinburne University of Technology
Dr	Matt	Wenham	Executive Director	Australian Academy of Technology and Engineering
Mr	Stian	Westlake	Policy Adviser to the UK Minister of State for Universities, Science, Research and Innovation	UK Department for Business, Energy and Industrial Strategies (BEIS)
Ms	Christine	Williams	Principal Adviser, Industry Statistics Division	Australian Bureau of Statistics
Dr	Adam	Wright	Innovation System Policy	Office of the Chief Scientist
Dr	Sacha	Wunsch-Vincent	Co-Editor Global Innovation Index & Head Section, Economics and Statistics Division	World Intellectual Property Organization
Ms	Alix	Ziebell	Senior Policy Analyst	Australian Academy of Technology and Engineering

Appendix E: ATSE's Innovation Metrics Review literature review

Australian Academy of Technology & Engineering

Innovation Metrics Review – Literature Review

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Innovation Metrics Review – Literature Review

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This literature review was commissioned by the Australian Government Innovation Metrics Review Taskforce.

Design and production: Mosaic Studios

Australian Academy of
Technology & Engineering

Contents

Executive summary

Our understanding of innovation has evolved dramatically in the past fifty years: from linear, technology-based, and private firm-driven, with inputs measured by research and development (R&D) spending and outputs measured by numbers of patents, to an incredibly broad perspective that encompasses new ways of doing many things, for a variety of purposes.

There are many different definitions of innovation in common use. This makes innovation difficult to measure directly. Yet innovation is increasingly driving economic performance and is an important tool in addressing social and environmental issues. The demand to measure innovation and its impacts has grown correspondingly.

In the context of rising investment in intangible capital, the growth of the service economy and the uptake of digital technologies, innovation metrics are a key tool for policy makers. A primary goal of innovation indicators is to inform governments' and the wider public's assessment of innovation performance and policy impacts. This is in part attributable to demand for greater government accountability and increased demand for evidence of the impacts of innovation programs for use in monitoring and evaluation. There is growing interest in understanding the significance of a wider range of innovation inputs, outputs and impacts, and in assessing the sectoral, spatial and social distribution of innovation activity and impacts. But while policy has a strong appetite for simple models and clear causality, innovation studies have instead led to frameworks with greater complexity.

The Australian Academy of Technology and Engineering (ATSE) was commissioned by the Innovation Metrics Review Taskforce to undertake a literature review that summarises state-of-the-art thinking about the role and drivers of innovation in modern economies, examines conceptual frameworks and approaches to measuring innovation, highlights novel approaches in metrics and data collection and identifies any approaches that might help to better measure innovation activity in Australia. This review has examined these objectives through the lens of innovation inputs, processes, outputs and impacts, and at different levels – from the individual to the global.

Conceptual frameworks and approaches to measuring innovation

New perspectives on where, how, and why innovation occurs must inform the development of new innovation indicators. The concept of innovation as science and technology-based, carried out by high-tech firms and measured by R&D expenditure, numbers of scientists, engineers, and patents, is no longer adequate. The third European Community Innovation Survey showed that almost half of innovative European firms did not perform in-house R&D. Hence, investment in R&D, whether assessed by expenditure or personnel, is not an adequate indicator of investment in innovation.

A much broader perspective on innovation has developed through the field of innovation studies, which has influenced the development of new and broader innovation indicators. The work of the Organisation for Economic Development (OECD) has been influential, particularly the National Experts on Science and Technology Indicators (NESTI), the developers of the Oslo Manual for collecting, reporting and using data on innovation. The regular revision of the Oslo Manual definition of innovation has reflected these broadening perspectives from the field of innovation studies.

UK-based innovation foundation Nesta is also a world-leader in innovation analysis, with the goal of informing policies that drive growth. Nesta has developed new ways to use UK administrative data and industry code data to map innovation activity, and expanded their analyses by harvesting data from company websites. The European Union's European Innovation Scoreboards (EIS) project also measures complex innovation, with methodology based around four main types of indicators (drivers, investments, activities, and impacts), with ten innovation dimensions and a total of 27 indicators. This work will evolve as new work progresses on the use of administrative big data.

Looking at innovation measurement in modern economies also reveals some surprises – for example, Dutch organisations are widely regarded as being among the world's leading innovators, yet an OECD innovation policy review found that Dutch organisations' investments in R&D and knowledge-based capital are relatively low when compared to organisations in other countries. This is also an issue for Australia.

Novel approaches to metrics and data collection

There are many novel approaches to innovation metrics and data collection that attempt to measure innovation beyond product, service and process innovations, from the incremental to the radical. Through a survey of innovation in six 'low innovation' sectors, Nesta identified several types of innovation activity that do not involve R&D, and several types of innovation that would not be patented – in other words they would be 'hidden' from traditional innovation metrics.

Process innovations and business model innovations are evidently valuable tools for product innovation, which suggests it would be worthwhile for specialised surveys of start-up firms to experiment with measuring business process novelty. A reasonable level of indication of specific types of innovation could be gained by adding additional questions to existing surveys. These assessments could be supplemented by using passive data acquisition through, for example, web-scraping based on product and service announcements and administrative data from certifications.

New insights do not necessarily require different data collection processes but can be enabled by linking existing datasets. There is some discussion of whether a shift to big data can replace surveys as a method of statistical data collection. The OECD STI Outlook 2018 suggests that they are likely to complement each other, with big data allowing surveys to focus on information that cannot be otherwise obtained.

New analytical tools have also emerged alongside all the new data sources, and could be used to help create new metrics. Social Network Analysis (SNA) can be an effective tool for capturing the reality of innovation within evolving complex networks and for creating representational graphics that reveal complex stories in ways that everyone can grasp. To portray innovation fully, data systems should be capable of detecting knowledge linkages between people and companies over time.

Innovation systems perspectives

As the concept of innovation continues to grow beyond technologies and products, as our understanding of innovation deepens, and as policy interest in the systemic dimensions of innovation capability grows, there will be an increasing interest in new innovation indicators that assess the sources of innovation inputs and the role of cultural dimensions in more detail. Innovation systems perspectives present a challenge for innovation indicator design as they have more explicitly brought social and institutional dimensions into innovation analysis and policy, meaning a diverse range of organisations, relationships and institutions are potentially brought into scope and the boundary of an innovation system is indeterminate.

One promising approach is to specify the most critical 'functions' of an innovation system and aim to develop indicators for these, for example generation and diffusion of knowledge, skill formation, finance and demand. There is a compelling case for the development of more useful innovation systems assessment indicators through surveys and studies at the micro, meso and macro level. This development would be best advanced through collaboration in an international program of indicator development, including in national, regional and sectoral innovation systems and entrepreneurial ecosystems.

Approaches that could be applied to measure innovation activity in Australia

There seems to be a consensus that the definition of innovation in the 2018 Oslo Manual would be suitable for surveys of all sectors and most types of organisations. There are also particular sectors where a more focused approach would be of value.

Nesta have suggested a focus on sectoral innovation indicators rather than the development of internationally comparable indicators will be more successful in measuring hidden innovation. They also emphasise that greater recognition of the significance of 'low innovation' sectors for value creation and employment and a greater understanding of the real dynamics of innovation in these sectors would lead to change in the scope of innovation policy.

There are a number of industries in Australia where this focused approach could better measure innovation activity. In both the agriculture and mining sectors there are processes of creative accumulation based on continuous improvements, and processes of creative destruction when new technologies, capabilities and actors emerge. Understanding the dynamics of innovation in both sectors will also require an approach that encompasses the role of knowledge flows and external suppliers.

There has been extensive debate over the past decade on developing indicators for innovation in the public sector, with some now feeling there is adequate conceptual and methodological development to design a robust survey approach for public sector innovation in Australia. This survey which would share some elements with the Oslo Manual but differ significantly in others, to the extent that the OECD is considering developing a measurement manual specifically for the government sector. Experimentation with public sector innovation indicators is ongoing with large-scale surveys in Norway and Denmark, and the European Co-Val survey initiated in February 2019.

The literature shows that innovation in services is much less likely to involve R&D or to result in patents than product innovation. Hence, those traditional indicators are increasingly inadequate, and in fact misleading. Innovation in services is also more likely to be non-technological and to involve organisational and marketing innovations. Trademarks are therefore becoming a more useful indicator than patents. The significance of digital technologies for innovation in services means that firms' investment in such technologies might be a good indicator of innovation input effort.

Opportunities to improve

The literature signals a clear demand for a range of new or improved innovation indicators. There are several evident indicator gaps for innovation outputs and impacts, knowledge generation and flows, technological opportunity, entrepreneurship, capability, and the role of demand, culture, and support measures. There are particular gaps that need to be addressed in Australia given our reliance on mining and agriculture and their implications for the environment, our absence of large technology firms, and other specific issues. Further, no account is taken of gender, such as the number of women in technology education and careers, or as entrepreneurs. If the aim is better innovation systems, then the means is through greater diversity.

Based on the literature and the Australian context, this review has identified priority areas for the development of improved innovation indicators to better measure innovation activity in Australia, including some suggestions for new or improved indicators. Importantly, innovation metrics in Australia must evolve to capture hidden innovation and innovation systems. Intangible inputs to innovation must be captured more completely, such as firm human capital and the value of networks. Assessment of innovation inputs must go beyond funding and R&D personnel, and look to culture, knowledge flows, skills, and training. Measurement of innovation processes must looks at absorptive capacity, management capability, collaboration and reflect developments in the EU and OECD on assessing eco-innovation. We need to move beyond R&D as the measure of innovation output, and look at case studies for a more holistic view of innovation impacts and entrepreneurial innovation.

1. Introduction

Innovation creates value, manifested as improvements in safety, productivity, culture, environmental performance, social good, and other areas. Over the past fifty years there has been growing recognition of innovation's major role in creating value to support economic performance, and also the important role of innovation in addressing a range of social and environmental issues. In parallel, there is growing recognition of public policy's impact on innovation performance[1].

However, innovation and its impacts are difficult to define or measure. As Galindo-Rueda (2018) comments, the empirical study of innovation and innovation policy faces two challenges. First it must try to "measure how things that are themselves difficult to measure affect other things that are also difficult to measure". Second, as innovation is now seen as developing in a dynamic and interconnected system "understanding the process, products and eventual impact of science and innovation activities requires the ability to observe and understand action at multiple levels of analysis".

Galindo-Rueda (2018) also notes that the demand for convincing evidence of the impacts of innovation investments and policy has increased, as has the complexity of models and concepts – and the scepticism among many policy makers of such complex models and concepts. Equally, oversimplification can lead to the misuse of indicators. Galindo-Rueda reports that at the OECD's 2016 Blue Sky Forum on innovation indicators "the use of composite science and innovation indexes that combine multiple, widely available indicators into one and rank the performance of countries … came under intense criticism from a majority of Blue Sky participants who, although recognising the value of simplicity and its support towards communicating a high level message, saw considerable conceptual and practical problems in current practice"[2].

This literature review examines approaches to revealing and measuring innovation. It summarises cutting edge thinking regarding:

> the role and drivers of innovation in modern economies
> the demands for innovation-related assessment to inform policy, review performance or enable research
> conceptual frameworks and approaches to measuring innovation for such assessments, and
> novel approaches to measuring innovation that might be applied in Australia.

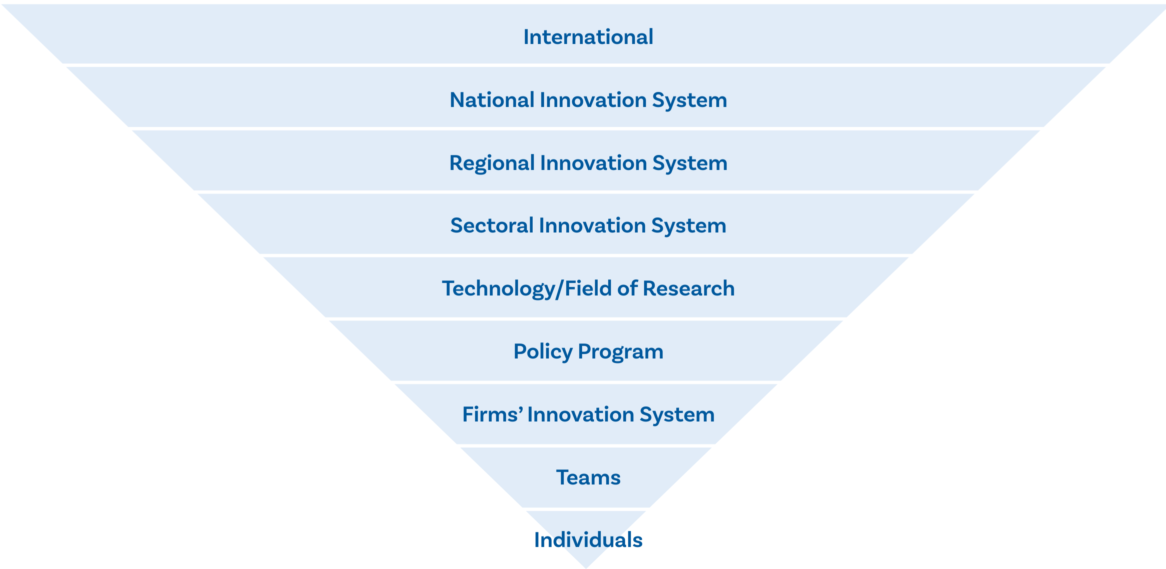
The review examines these issues through the lens of innovation inputs, processes, outputs and impacts at different levels of innovation – from individual contributions to international systems. **Table 1** gives examples of types of innovation inputs, processes, outputs and impacts, and **Figure 1** is a representation of the levels at which innovation occurs.

Table 1: Examples of innovation

INPUTS	PROCESSES	OUTPUTS	IMPACTS
> Human resources	> Adaptation	> Knowledge	> Productivity
> Licences	> Incremental innovation	> Human resources	> Market share
> R&D expenditure	> Radical innovation	> Publications	> Sales share
> Design	> Co-innovation	> Patents	> Sustainability
> Software	> Business model innovation	> Digital transformation	> Growth
> Management capability	> Entrepreneurship	> Designs	> New firms
> Tangible investment		> Products	> Inclusion
> Venture capital		> Services	
> Relationship capital		> Policies	
> Tacit knowledge			
> Culture			

1. Edler & Fagerberg, 2017; L f & Heshmati, 2006
2. Galindo-Rueda,2018, p. 9.

Figure 1: Innovation indicator targets and types



1.1 Objectives

This literature review has four objectives, to:

1. Summarise state-of-the-art thinking about the role and drivers of innovation in modern economies in the context of rising investment in intangible capital, the growth of the service economy, and the uptake of digital technologies
2. Examine conceptual frameworks and approaches to measuring innovation in key advanced economies, and evaluations and critiques of these
3. Highlight novel approaches to metrics and data collection
4. Identify any approaches that might help to better measure innovation activity in Australia, including in areas of the economy that are not currently measured

1.2 Structure

This literature review is organised in eight sections:

- **Section 2** provides a brief background on innovation indicators, the policy demand for indicators and the context for their development
- **Section 3** reviews some approaches to measuring innovation in key advanced economies
- **Section 4** reviews recent developments in the field of innovation studies
- **Section 5** outlines widening perspectives on the locus of innovation
- **Section 6** discusses the process of value creation through many types of innovation
- **Section 7** discusses the innovation systems perspective at the sector, region and national level
- **Section 8** discusses new perspectives, dynamics and trajectories in innovation, including entrepreneurship, digital technologies, and eco-innovation
- **Section 9** identifies gaps in current innovation indicators and opportunities to improve indicators in the Australian context.

1.3 Scope

The scope of innovation policy continues to widen, and our understanding of the dynamics and diversity of innovation deepens. This review focuses on the main developments in innovation indictor development and on issues considered to be most relevant to innovation policy and analysis in Australia.

While the boundaries of the field of innovation are difficult to define, this review focuses on recent literature in economics, management, and policy studies related to innovation. It focuses on the core, most cited literature and on reviews by Martin, 2012, Fagerberg *et al.*, 2005, Fagerberg, 2010, 2017, Fagerberg, *et al.* 2012, Metcalfe, 2007 and Malerba and Brusoni, 2007, with additional sources for specific issues.

2. Innovation indicators, policy and drivers

Hall and Jaffe (2012) define an indicator as "a set of facts or observations that tell us something meaningful about the underlying phenomena of interest"[3]. Noting that facts or observations used for indicators are often constructed from standardised primary data, they comment that assessing the meaningfulness of an indicator requires "specification of the underlying concept we are trying to understand, and the relationship between this concept and the process that generates the data"[4].

Explicit or implicit frameworks determine what aspects of complex reality are of interest, and what types of measurement might shed light on the key features of those aspects – i.e. the choice of what data is collected and how it is interpreted. The selection of comparators affects data quality in terms of the extent (coverage in terms of time, actors, geographies), reliability (reproducibility), and validity (meaningfulness in relation to underlying concept – most indicators are essentially proxies and their validity is always questionable).

Innovation is multidimensional and intangible and is therefore 'measured' indirectly using different units (dollar value, counts, days, proportions)[5]. Statistics construct a selective view of reality. The design and interpretation of indicators involves "...the enormous work of formatting, shaping, classifying, deducing, to provide data with a meaning they never had by themselves"[6].

There are three primary goals in designing and producing innovation indicators:

> Inform governments' and the wider public's assessment of innovation performance and policy impacts

> Contribute to innovation-related research (not least to improve indicators and policy)

> Inform actors within innovation systems in order to improve their decision-making and coordination ('collective learning') within innovation systems[7]

2.1 The policy community and the demand for innovation indicators

The policy and policy research communities which shape the demand for innovation indicators are becoming more diverse and sophisticated. One driver of this growth is the recognition that while innovation is a core issue for economic development, it is also a whole-of-government issue and relevant to all areas of administration and policy[8].

The increasing range of active users of innovation indicators and advocates for innovation policy development (such as policy research centres, think tanks, international organisations, consultancy firms, and professional organisations) are also drivers of the growth of innovation indicator use. Many of these organisations develop innovation indicators, and forecast increased demand for such indicators.

Increased demand for greater government accountability and transparency, and for evidence of impacts of innovation programs, have also contributed to demand for improved indicators in all areas of policy. Understanding of the significance, diversity and ubiquity of innovation has led to a clearer recognition of the limitations of established indicators[9]. The Organisation for Economic Co-operation and Development (OECD) *Innovation Strategy 2015* emphasises that policy learning rests on strong capabilities for evaluation and monitoring, including incorporating policy monitoring and evaluation at the design stage of policymaking[10].

2.2 The widening and re-framing of innovation policy

Just as innovation is increasingly seen as relevant to a wide range of policy objectives, so policy in a wide range of areas is increasingly seen as relevant to innovation[11].

Views are changing regarding government's role in shaping the rate and direction of innovation-related experimentation in an economy. There is correspondingly increased demand for indicators that show the outcomes and impacts of adopting such a role[12]. **Table 2** provides an indicative summary of new demands for improved innovation indicators.

3. Hall & Jaffe, 2012, p.2.
4. Hall & Jaffe, 2012, p.2.
5. Grupp & Schubert, 2010
6. Latour, 1999, quoted in Barre, 2010, p.227. Therein lies the risk that indicators will become seen as unambiguous facts.
7. Hall & Jaffe, 2012; NAS, 2017, p. 10; Lepori, *et al.*, 2008; Lepori & Reale, 2012; Barre, 2010.
8. Georghiou, 2013
9. Martin, B.R., 2016
10. Gault, 2018, p621- Gault argues that better measurement of innovation outcomes and impacts is essential for effective policy learning.
11. Smits, *et al.*, 2010
12. Geels, F., 2005; Mazzucato, M., 2015a; 2015

Table 2: Examples of types of new demands for relevant innovation indicators[13]

Addressing a wider set of objectives – what is value creation	> Economic – including employment
	> Health – ageing, etc.
	> Environmental – response to climate change, energy, eco-innovation
	> Social – inclusion, inequality, diffusion
Performance Issues	> Digital transformation – productivity, employment, diffusion
	> Skills and capabilities – human resources, immigration
	> Regional development – increasing role of regional governments
	> International collaboration – development and comparative performance
	> International investment and participation in national innovation systems
	> Entrepreneurship – startups, HGFs, employment, regions
Performance assessment for policy reviews	> Ensuring the efficiency of public investments in S&T
	> Useful international comparative innovation performance
	> Perceived performance gaps – country specific performance problems

2.3 Context for development of innovation indicators

The shortcomings of indicators as contributors to policy often stem from a lack of clarity in the underlying concepts and models[14]. Hence, the development, application, interpretation and impact of innovation indicators involve a complex learning process among indicator developers, survey participants and indicator users[15].

A major shortcoming of indicators is that we use what is readily available, not what might be conceptually or theoretically required. Innovation surveys go some way to addressing this problem, but the widespread use (and misinterpretation) of patent data, patent licensing by universities and bibliometrics is due to focusing on data that are readily available in the absence of better, more appropriate data.

Gault (2013) provides an example of how surveys and innovation indicators can themselves change behaviour: surveys based on the OECD's Oslo Manual stimulated participating firms to review their innovation management approaches in the light of the implicit frameworks in the survey form. Such learning can also have negative effects. When new policy priorities are assessed through a narrow range of specific indicators, particularly when performance based on those indicators is related to funding, actors are likely to change their behavior to prioritise the aspects of performance captured by those indicators[16]. Such gaming reduces the value of the indicator and can orient behavior in ways that do not contribute to the policy goal.

The priorities for innovation indicator development are explored **Sections 5** to **8** of this review and addressed through the approach outlined in **Figure 2**.

Figure 2: Framework for innovation indicator development

	TRADITIONAL APPROACH	NEW APPROACHES
LOCUS	**Manufacturing**	> All sectors, including services & the public sector
PROCESSES	**R&D-based innovation**	> All types of innovation: non-technological, business model, institutional > All types of input to innovation
CONTEXT	**For-profit firms**	> Firms, value chains > National, sectoral, regional & technological innovation systems
GOALS	**Growth Productivity**	> Growth & productivity > Policy impacts > Social inclusion & sustainability > Environmental sustainability > Responding to techno-economic shifts

13. Borras & Edquist, 2016; National Academies of Sciences, Engineering, and Medicine, 2017; Izsak *et al.*, 2013; National Research Council, 2012; Morlacchi & Martin, 2009; Head, 2010.
14. Borras & Edquist, 2016
15. Gault, 2013.
16. Martin, cited in National Academies of Sciences, Engineering, and Medicine, 2017.

3. Frameworks and approaches to measuring innovation

Innovation is still widely conceptualised, defined and measured according to the dominant perception held when the field of innovation studies formed fifty years ago, namely[17]:

> Innovation is technology-based and draws on advances in science and technology

> Innovation is an activity carried out by private firms, particularly those in hi-tech manufacturing

> Innovation inputs are reasonably well indicated by research and development expenditure and the allocation of scientists and engineers, and innovation outputs are indicated by patents

This view of innovation is also shared by the general public, journalists, politicians and management scholars, in Australia and internationally. However, a much broader perspective on innovation has developed in the growing field of innovation studies. For example, Smits et al. expansively define innovation as "the development and adoption of new and improved ways of addressing social and economic needs and wants"[18]. This perspective has influenced the development of new and broader innovation indicators.

The increasing development of innovation indicators has also been shaped by:

> Change in models of processes through which innovations are developed and have impacts

> Change in the nature of innovation

> Change in policy priorities, and consequently perceptions of the value of different outputs and impacts

> Change in the availability or quality of information[19]

A wide range of statistics relevant to innovation have become available in areas beyond science and technology, particularly in areas of education, information society statistics, globalisation and the role of multinational enterprises. Hence, some indicators used for innovation analysis were developed for this purpose, many others were developed for other purposes.

A workshop of the American National Academies of Science, Engineering and Medicine in 2017 came to the broad conclusion that innovation metrics should aim to capture the components of innovation accurately and comprehensively, while maintaining a balance between the levels of standardisation necessary to enable comparisons across time and countries. With active experimentation necessary to increase understanding, metrics should respond to new developments and priorities.

Participants at the 'Advancing Concepts and Models for Measuring Innovation' workshop also broadly agreed that[20]:

> While a single unified indicator framework is attractive, such an approach would suggest a level of understanding of innovation processes and impacts that is not justified. Macro level metrics must be supported by robust micro level understanding of the processes and hence the meaning

> There are risks that the measurable will become important rather than effort be directed to making the important measurable (supported by Martin 2017, p.14)

> Mainstream innovation metrics were largely designed to capture innovation in the manufacturing sector, but the increasing importance of services innovation (in the services and in the manufacturing sectors) and the recognition of the significance of innovation outside the business sector (for example in the non-profit, public and household sectors) require the development of more appropriate indicators

> Increasing interest in understanding and assessing a wider range of benefits of innovation (including health and environmental impacts) warrants multiple approaches to measurement and indicators

> There is also increasing interest in understanding and assessing a wider range of inputs to innovation, including skills, knowledge and culture, and in better taking into account the cumulative nature of innovation capability and processes[21]

> While most mainstream approaches to innovation metrics, such as the Oslo Manual, have aimed at the national level, indicators of innovation at the local level are clearly important for research and for policy

> The spatial distribution of innovation and entrepreneurship is highly skewed, so national or even regional averages can be highly misleading - the McNamara Fallacy

> The distribution of highly significant innovation and entrepreneurial activity is similarly skewed, with very small proportions accounting for high shares of impacts, thus indicators based on averages have little meaning and approaches are needed that provide greater insight

17. Martin, 2016
18. Smits, *et al.*. 2010, p.1
19. Smith, 2005; Gault, 2013, 2016, 2018; Colecchia, 2006; Arundel & Smith, 2013
20. National Academies of Sciences, Engineering, and Medicine, 2017.pp 99-106
21. Stern, 2017 in National Academies of Sciences, Engineering, and Medicine, 2017

> Innovation is increasingly a distributed and interactive activity, and it is therefore essential to understand the increasingly complex division of labour in open innovation

Building on these new perspectives, innovation indicators and manuals have been developed by various national and international organisations. Some relevant examples are explored below.

3.1 The Organisation for Economic Co-operation and Development (OECD)

Work coordinated by the OECD has had a major influence on innovation indicator development within OECD countries. The OECD's Blue Sky Forum on science, technology and innovation (STI) data and indicators is carried out under the OECD's Committee for Scientific and Technology Policy and organised by the National Experts on Science and Technology Indicators (NESTI). NESTI is responsible for monitoring, supervising, and co-ordinating statistical work on STI, contributing to the development of indicators and quantitative analyses needed to meet the requirements and priorities of the OECD Committee for Scientific and Technological Policy. NESTI was responsible for the development of the Frascati Manual for R&D statistics (since 1962), the Canberra Manual which addresses human STI resources (1995) and the Oslo Manual (latest edition 2018) which addresses innovation.

The Oslo Manual for collecting, reporting and using data on innovation was first published in 1992 and is used by statistical offices in most OECD countries. A second edition was published in 1997, a third in 2005, and a fourth in 2018. Previous editions of the Oslo Manual focused on firm-level innovation in business enterprises, but the more generic definition in the 2018 edition is suitable for a wider range of organisations[22]. The general definition of innovation in the 2018 edition is intended to be applicable to all types of innovating agents, to most types of innovation and through markets or other forms of availability to users. It is also the definition of innovation being used in the Innovation Metrics Review:

> *An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)*[23].

This definition uses the generic term 'unit' to describe the actor responsible for innovations. It refers to any institutional unit in any sector, including households and their members.

The OECD *Science, Technology and Industry Scoreboard*, published every two years, provides a compendium of STI data for member countries and often includes data from some other countries. The 2017 edition is the latest available. NESTI delegates are involved in contributing national data to this publication. Some tables do not show data for all member countries. This is usually because the data is not collected in that country, or the latest data available is too old to warrant inclusion.

3.2 The United Kingdom

The leading thinking on innovation metrics in the United Kingdom (UK) continues to be from Nesta. Nesta describes itself as a UK-based global innovation foundation. Nesta's work is cited elsewhere in this literature review. In its 2016 *Guide to new data and measurement in innovation policy,* Nesta noted that "good innovation policy requires accurate, reliable and timely data, but getting this data is becoming harder as change in the economy speeds up"[24]. It has developed new ways to use UK administrative data to map innovation activity in Wales, and for some sectors which they have defined with high level groupings of industry code data. Nesta have also expanded their analyses by harvesting data from company websites. 'Arloesiadur: An innovation dashboard for Wales' is a collaboration between Nesta and the Welsh Government. Nesta has used new data to measure and visualise Wales' industry, research, and tech networks with the goal of informing policies that drive growth.

Nesta also uses methods like horizon scanning, speculative design, data mapping and scenarios to explore alternative futures with experts and the public. These techniques have been applied to analysis of the impacts of new technologies such as artificial intelligence.

22. National Academies of Sciences, Engineering, and Medicine, 2017
23. OECD, 2018. Oslo Manual-2018, OECD, Paris: p57
24. Nesta 2016

3.3 The Netherlands

Dutch organisations are widely regarded as being among the world's leading innovators, with strong technological capabilities and performance. However, an OECD innovation policy review (OECD 2014) found that Dutch organisations' investments in R&D and knowledge-based capital are relatively low when compared to organisations in other countries. This is also an issue for Australia.

In the review of innovation policy, the OECD concluded that it is important for Dutch organisations to seek collaboration between business, educational institutions, and government, i.e. the 'triple helix'. PricewaterhouseCoopers (PwC) undertook a follow-up study in the Netherlands, to better understand the underlying reasons behind the underperformance relative to their OECD peers. This survey was based on PwC's annual *Global Innovation 1000* survey, and focused on large and mid-sized organisations. This resulted in a set of 111 responses from public and private organisations based in the Netherlands (PwC 2016)[25].

3.4 Denmark

Denmark has also invested in a survey[26], but the subject was government innovation. This reflects increasing interest in government innovation in Europe. The survey, carried out in collaboration with Statistics Denmark, analysed 1,255 workplaces located in different levels of government. The aim of this work was to shed light on what increases and holds back innovation in the public sector.

The Centre that undertook this survey has also looked at global trends and specific examples of innovation in the public sector around the world, including work on the 'future of government'. This project has been undertaken in partnership with the Victorian State Government Department of Premier and Cabinet and the Victorian Public Sector Commission, examining cutting-edge ways governments are transforming themselves to better serve citizens.

3.5 Canada

The Conference Board of Canada regularly analyses and publishes innovation report cards, including a comparative ranking of Canada's innovation performance against sixteen peer countries and comparative ranking of the Canadian Provinces.

To measure innovation performance, the Conference Board evaluates nine report card indicators, which align with traditional measures of innovation:

- Public research and development (R&D)
- Researchers engaged in R&D
- Scientific articles
- Entrepreneurial ambition
- Venture capital investment
- Business enterprise R&D (business R&D)
- ICT investment
- Patents
- Labour productivity

The 2018 report ranks Canada 12th of 16 peer countries—down three positions—and earns a 'C' on innovation (see **Figure 3.1** and **3.2**)[27]. The Board also evaluates the performance of the Provinces on enterprise entry rates but notes that there are no comparable international data for this indicator.

25. PwC 2016
26. The Centre for Offentlig Innovation 2018, Denmark releases world's first survey on government innovation, accessed on 21 February 2019 at https://apolitical.co/solution_article/denmark-releases-worlds-first-survey-government-innovation/
27. Conference Board of Canada 2018, Innovation, accessed on 21 February 2019 at https://www.conferenceboard.ca/hcp/provincial/innovation.aspx?AspxAutoDetectCookieSupport=1

Figure 3.1: Country ranking – Innovation[28]

REPORT CARD

Innovation

Rank	Country/Province	Grade
1	Sweden	A
2	Switzerland	A
3	Denmark	A
4	U.S.	A
5	Finland	B
6	Austria	B
7	Ont.	B
8	Netherlands	B
9	Que.	C
10	Belgium	C
11	Japan	C
12	Norway	C
13	Australia	C
14	**Canada**	C
15	Germany	C
16	France	D
17	B.C.	D
18	Ireland	D
19	Alta.	D
20	U.K.	D
21	N.S.	D-
22	N.L.	D-
23	Man.	D-
24	Sask.	D-
25	P.E.I.	D-
26	N.B.	D-

Note: Data for the most recent year available were used. For details on methodology and data sources, see the Methodology & Data section of this website.
Source: The Conference Board of Canada.

Figure 3.2: Provincial and Territory Ranking – Innovation[29]

REPORT CARD

Innovation Indicators

	Canada	N.L.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.
Public R&D	B	B	B	A+	C	A	A	B	D	D	C
Researchers	D	D-	D-	D-	D-	C	C	D-	D-	D-	D-
Scientific articles	C	C	D	B	D	C	B	C	C	C	C
Entrepreneurial ambition	A	B	n.a.	C	n.a.	A	A+	A	A	A+	A+
Venture capital	C	D	D	C	D	B	C	D	D	D	B
Business R&D	D	D-	D-	D-	D-	C	D	D-	D-	D-	D-
ICT investment	C	D	D	D	C	D	C	D	D-	C	D
Patents	D	D-	D	D-	D-	D	D	D-	D-	D	D
Enterprise entry	n.a.	A	A	C	C	D	B	B	B	A	A
Labour productivity	D	C	D-	D-	D	D	D	D	C	B	D

Note: Data for the most recent year available were used. For details on methodology and data sources, see the Methodology & Data section of this website.
Source: The Conference Board of Canada.

Statistics Canada takes a broader approach and has identified the desirable properties of innovation indicators as relevance, accuracy, timeliness, accessibility, interpretability, and coherence[30].

3.6 The European Union

The European Union continues to support the development of innovation indicators through the European Innovation Scoreboards (EIS) Project. The 2018 edition of the Scoreboard shows that the EU's innovation performance continues to improve and that progress is accelerating. The Scoreboard shows that, since 2010, the EU's average innovation performance has increased by 5.8 percentage points. The 2018 Scoreboard Methodology Report[31] uses the same framework as the 2017 edition, based around four main types of indicators, ten innovation dimensions and a total of 27 indicators (see **Table 3**).

28. Conference Board of Canada 2018, Innovation, accessed on 21 February 2019 at https://www.conferenceboard.ca/hcp/provincial/innovation.aspx?AspxAutoDetectCookieSupport=1
29. Conference Board of Canada 2018, Innovation, accessed on 21 February 2019 at https://www.conferenceboard.ca/hcp/provincial/innovation.aspx?AspxAutoDetectCookieSupport=1
30. Gault, 2013
31. European Commission 2018, European Innovation Scoreboard 2018: Methodology Report, 15 June 2018, accessed on 21 February 2019 at https://ec.europa.eu/docsroom/documents/30081/attachments/1/translations/en/renditions/native

- **Framework conditions** captures the main drivers of innovation performance external to the firm and differentiates between three innovation dimensions
- **Investments** captures investments made in both the public and business sector and differentiates between two innovation dimensions
- **Innovation activities** captures different aspects of innovation in the business sector and differentiates between three dimensions
- **Impacts** captures the effects of firms' innovation activities and differentiates between two innovation dimensions

Table 3: Measurement framework of the European Innovation Scoreboard

Framework conditions	Framework activities
Human resources	**Innovators**
1.1.1 New doctorate graduates	3.1.1 SMEs with product or process innovations
1.1.2 Population aged 25-34 with tertiary education	3.2.1 SMEs with marketing or organisational innovations
1.1.3 Lifelong learning	3.1.3 SMEs innovating in-house
Attractive research systems	**Linkages**
1.2.1 International scientific co-publications	3.2.1 Innovative SMEs collaborating with others
1.2.2 To 10% most cited publications	3.2.2 Public-private c-publications
1.2.3 Foreign doctorate students	3.2.3 Private co-funding of public R&D
Innovation friendly environment	**Intellectual assets**
1.3.1 Broadband penetration	3.3.1 PCT patent applications
1.3.2 Opportunity-driven entrepreneurship	3.3.2 Trademark applications
	3.3.3 Design applications
Investments	**Impacts**
Finance and support	**Employment impacts**
2.1.1 R&D expenditure in the public sector	4.1.1 Employment in knowledge-intensive activities
2.1.2 Venture capital expenditures	4.1.2 Employment in fast growing enterprises of innovative sectors
Firm investments	**Sales impacts**
2.2.1 R&D expenditure in the business sector	4.2.1 Medium and high-tech product exports
2.2.2 Non-R&D innovation expenditures	4.2.2 Knowledge-intensive services exports
2.2.3 Enterprises providing training to develop of upgrade ICT skills of their personnel	4.2.3 Sale of new-to-market and new-to-firm product innovations

Note: SMEs are defined as having 10 to 249 employees
Source: EC 2018, EIIS 2018 Methodology Report

The Scoreboard is set to evolve as new work progresses on the use of administrative data. A 2018 paper[32] presents details:

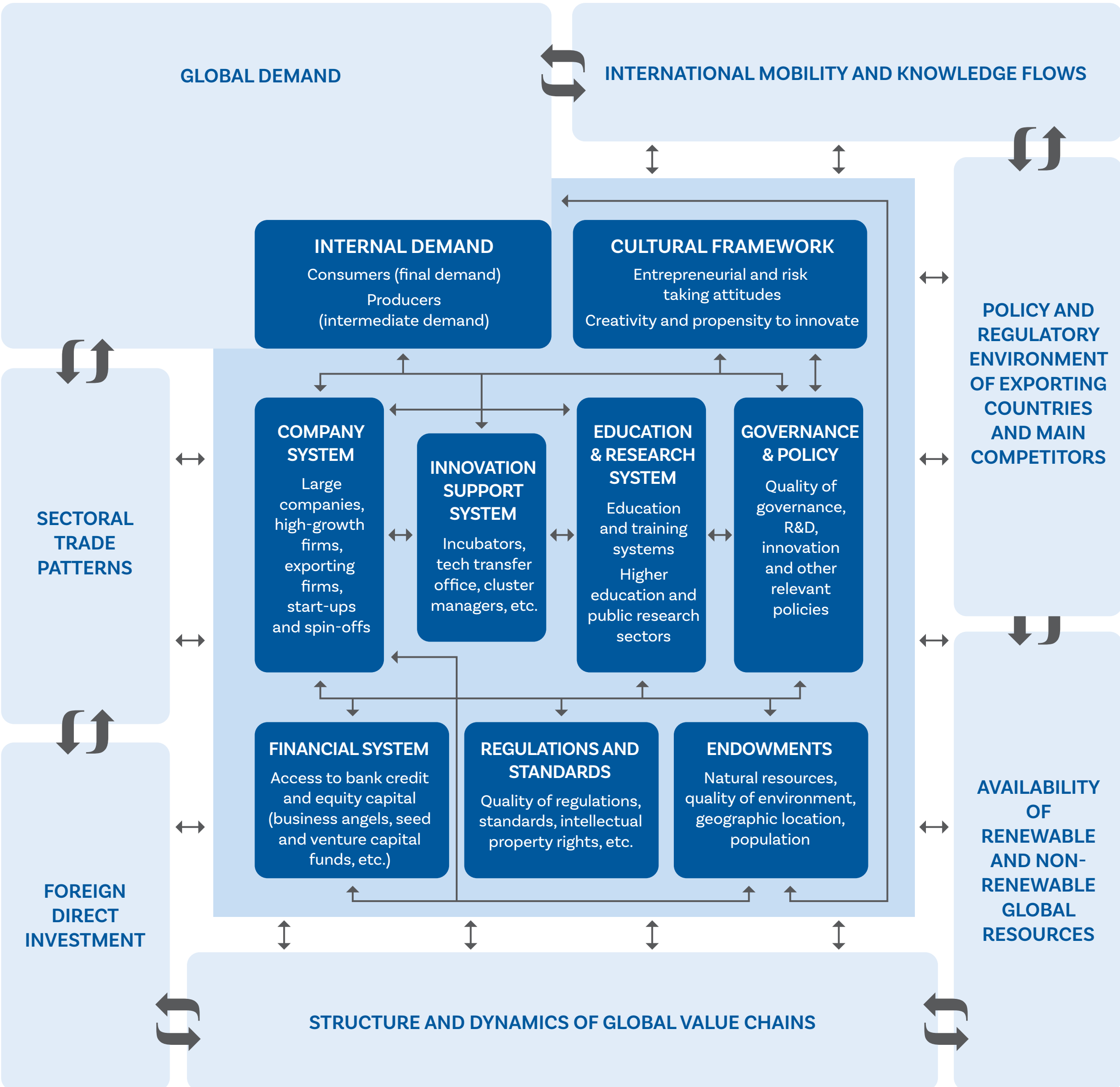
- The growing use of administrative data, referred to as 'Big data', is leading to a review of the state of the art in the measurement of research and innovation activity. The paper notes that more sectoral and geographic detail as well as improved timeliness are possible
- Strategies to integrate Big data into research and innovation policy are to be explored through a seven-stage process

32. European Commission 2018, EIS 2018: Exploratory Report B: Toward the incorporation of Big data in the European Innovation Scoreboard, 19 June 2018, accessed on 21 February 2019 at https://ec.europa.eu/docsroom/documents/30232/attachments/1/translations/en/renditions/native

> Five pilots with real policy questions and big data to test the framework and assess opportunities and challenges. The use different data sources and methods that could feed into different sections of the EIS. This includes analyses of:
  - Skills supply using Big data scraped from university websites
  - Open digital innovation based on data from GitHub, a collaborative coding site
  - Access to finance from crowdfunding platforms
  - University spinoffs via websites and online directories
  - Start-up support ecosystems such as Accelerators and Incubators

The EIS 2018 also proposes an Open Innovation System model (**Figure 4**).

Figure 4: European Innovation Scoreboard 2018 – Open Innovation Model[33]



Source: EIS 2018 - Exploratory report C: Supplementary analyses and contextualisation of innovation performance data

A high-level panel convened by the EU Commissioner for Research and Innovation proposed ten desirable properties of innovation indicators: simple and understandable, sizeable and direct, objective, currently computable, stable, internationally comparable, decomposable, low susceptibility to manipulation, easy to handle technically, and sensitive to stakeholder's views[34].

33. EU 2018, EIS 2018: Exploratory report C: Supplementary analyses and contextualisation of innovation performance data, access on 21 February 22019 at https://ec.europa.eu/docsroom/documents/30222
34. Gault, 2013, p446

3.7 Other recent activity on innovation metrics

New Zealand's Productivity Commission produced a Working paper in 2015 that examined innovative activity in New Zealand firms (NZ Productivity Commission 2015)[35]. The Commission noted that the proportion of the country's firms engaged in innovation ranges from 0.2 per cent to 40 per cent depending on how innovation is measured. While there is a fairly high correlation between different measures of innovation output, firm-level measure of R&D intensity are only weakly correlated with innovation output measures.

In a recent article[36], McKinsey argued that that, from a firm viewpoint, two simple metrics can provide important information about the effectiveness of R&D spending. McKinsey calls these indicators R&D conversion metrics: R&D-to-product (RDP) conversion and new-products-to-margin (NPM) conversion. Their core components – gross margin, R&D, and sales from new products – are not new, but combining them can reveal fresh insight on the relative innovation performance of business units, within an organization and relative to external peers.

The first metric, RDP, is computed by taking the ratio of R&D spend (as a percentage of sales) to sales from new products. This allows organisations to track the efficacy with which R&D dollars translate into new-product sales. The second metric, NPM, takes the ratio of gross margin percentage to sales from new products, which provides an indication of the contribution that new-product sales make to margin uplift.

McKinsey argues that these measures can be applied at different levels—product level or firm level. The problem with them would appear to be that they are not able to take the lag in conversion of R&D results to products into account.

35. New Zealand Productivity Commission 2015, Measuring the innovative activity of New Zealand firms, Working Paper 2015/2, June 2015, accessed on 21 February 2018 at https://www.productivity.govt.nz/sites/default/files/nzpc-motu-working-paper-measuring-innovative-activity.pdf

36. McKinsey 2018, Taking the measure of innovation, McKinsey Quarterly, April 20018, accessed on 21 February 2019 at https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/taking-the-measure-of-innovation

4. The evolution of innovation thinking

Innovation has become a significant focus in many fields, including economics, management, policy studies, organisational studies, history, geography and sociology. Each field has developed distinctive, and often complementary, frameworks and research methods. Even within economics quite different approaches to conceptualising innovation have developed[37].

There is now a large and diverse international community of innovation scholars and an extensive and rapidly growing body of knowledge. New perspectives from innovation studies have implications for innovation metrics. In considering appropriate innovation metrics for the Australian economy and society, this review considers seven key learnings from innovation studies:

- Innovation is a pervasive and broad phenomenon, and its characteristics vary across sectors
- Innovation has different levels of significance and novelty
- The knowledge base has widened and innovation is increasingly interactive
- Sectoral patterns of innovation
- Capabilities and management in innovation
- Entrepreneurship as a key form of innovation
- National, regional and sectoral innovation systems

This section summarises state-of-the-art thinking about innovation in modern economies, and the evolution of innovation in the context of rising investment in intangible capital, the growth of the service economy, and the uptake of digital technologies.

4.1 Innovation is pervasive and broad

The historical foundation of innovation policy is in linear models that assumed new scientific knowledge was the key input to innovation. It was assumed that progress in science was the key limiting factor and that investment in science in the public sector and subsidies for research in the private sector (to address 'market failures') would be sufficient to ensure economic benefits. While sectors such as biotechnology are closely linked to frontier science, most sectors are not. In most industries the linkages to science are indirect, largely through people-embodied knowledge, and often have long lead times[38].

In some industries, typically those that are R&D intensive and 'science-based,' interaction with universities and research organisations is a major source of new ideas and knowledge. In others, links with the knowledge infrastructure are more indirect and interactions with customers, suppliers and competitors are much more important. Therefore, a singular focus on R&D in 'high tech' sectors is a narrow beam that will fail to illuminate a great deal about innovation[39].

Innovation is a pervasive and broad phenomenon, and its characteristics and those of innovation processes vary across sectors. Innovation is important in the **public sector** – a large component of the economy of most OECD countries – and includes education, defence, health, social services, and administration[40]. There is also a growing focus on the role of the public sector in supporting innovation in other sectors through its policies, for example through regulation and procurement[41]. The significance of innovation in the **service sectors** has been recognised as they now dominate economic activity in OECD economies, including Australia, and the nature of services innovation has become a focus of analysis[42]. Frameworks, concepts and methods are being developed to understand and characterise activity in the new field of **social** innovation[43]. Advances in **software and hardware** provide sophisticated toolkits that enable users to undertake significant product and process adaptation and re-design[44].

37. Malerba & Brusoni, 2007
38. Salter & Martin 2001.
39. Dodgson, 2018
40. Osborne & Brown, 2013
41. For example, a special issue of the journal Research Policy focuses on mission-oriented R&D, an contains an extensive set of case studies on public-sector innovation for public-sector missions as well as for adoption within the civilian economy (Research Policy. Volume 41, Issue 10, December 2012)
42. Gallouj & Savona, 2009; Gallouj & Djellai, 2010; Djellal, *et al* 2013.
43. Moulaert, 2013; Bekkers *et al.*, 2013
44. Colecchia, 2006 and von Hippel, 2005

There are many types of innovation beyond product, service and process innovations, including organisational[45], managerial[46], and marketing innovations. All are significant sources of value creation. Different types of innovation are often interrelated, as a major product or service innovation may be linked to process and organisational innovations. Interrelated innovations are often associated with new business models, so it is useful to characterise business model innovation, such as a high street shop moving to a virtual e-commerce site, as a type of innovation.

The factors that drive and shape innovation vary between sectors, and as such a policy that promotes innovation in one sector may be ineffective in others[47]. For example, patterns of innovation in services sectors are different from those in manufacturing sectors, usually involving more interaction with users through processes of experimentation and continuous development.

4.2 Innovation has different levels of significance and novelty

Innovation ranges from incremental to radical or revolutionary. The cumulative impact of many incremental innovations can be as significant as a radical innovation. Innovations at the more radical end of the innovation spectrum often open trajectories of ongoing incremental innovation. Some technologies (for example the steam engine, internal combustion engine, or integrated circuit) have pervasive impacts over time. They evolve through continuous improvements that lead to exponential and sustained trajectories of improvement in performance and declines in cost – these have been termed General Purpose Technologies (GPTs). Inter-related innovations linked to GPTs lead to the emergence of new 'technology systems' (for example electricity, steam). These new technology systems sustain waves of structural change that lead to the emergence of new inter-related innovations industries and the transformation of national and regional innovation systems – i.e. to the emergence of new 'techno-economic paradigms'[48].

While 'new to the world' innovations indicate a high level of novelty (and hence risk and uncertainty) the majority of innovations are at lower levels of novelty. These 'new to the industry' or even 'new to the firm' innovations are associated with processes of knowledge diffusion.

4.3 The knowledge base has widened, and innovation is increasingly interactive

There is substantial evidence that the knowledge base for innovation in most sectors has become increasingly diverse and complex. To maintain currency many firms have increased their level of collaboration with other firms and organisations, rather than try to maintain such a broad knowledge base in-house[49]. Innovation is therefore increasingly a distributed activity with a complex division of innovative labour[50].

The extent of interaction with external organisations has generally increased over the past fifty years and the mechanisms of that interaction (alliances, contracting, formal or informal collaboration) have become more diverse in a trend toward 'open innovation'[51]. In many sectors, users are active participants in innovation or have significant role in shaping the rate and direction of innovation in suppliers[52].

The effective acquisition of external knowledge is particularly important for small firms and hence for overall innovativeness. In Australia small firms account for a particularly high proportion of employment, as they do in other countries. Absorptive capacity, or the capacity to acquire, assimilate, transform, diffuse and apply imported knowledge, is therefore an important issue for innovation policy (see further discussion in section 6.2.5). Firms with high absorptive capacity are more likely to interact with research organisations, innovate, and make effective use of new production and product technology. Differences in absorptive capacity mean that firms have unequal access to innovation-related information and information flows through networks. The resulting information asymmetries are central to understanding innovative behaviour and knowledge diffusion.

45. Sapprasert & Clausen, 2012
46. Damanpour & Aravind, 2012
47. Pavitt, 1984; Hirsch-Kreinsen, 2008; Grimpe & Sofka, 2009
48. Lipsey *et al.* 2005, Perez, 2010
49. Herstad *et al.* 2014.
50. Aslesen & Freel, 2012. Dahlander & Gann, 2010
51. Chesbrough, 2003; Dahlander & Gann, 2010; Aslesen & Freel, 2012; Colecchia, 2006
52. Von Hippel; The role of demand in shaping and driving innovation is discussed further below.

The increasing role of external interactions in innovation means that firms are now embedded in 'innovation networks'. The extent and quality of innovation networks is an external resource of significance for firm-level innovation capacity. Inter-organisational relations in innovation networks include market and non-market interactions for which trust and social capital are important foundations. Such networks are increasingly international due to the globalisation of value chains, the rise in international investment and the wider dispersion of research and innovation capacity[53].

4.4 Capabilities and management shape innovation

Management decisions regarding innovation tend to be based on perceptions and assumptions rather than purely objective analysis, due to the inherent complexities and uncertainties of innovation. Innovative activity and outcomes at the firm level are shaped by management perceptions of (inter alia) demand, opportunity, risk, capability to design and implement innovation programs, and probability of appropriating the benefits of innovation[54]. Innovation performance at the firm level is shaped by (inter alia) investment (financial, human resources, relationship capital), capabilities (human resources, culture, organisation and routines) and external relationships – all of which are the result of current and prior management decisions and the development path of the firm[55].

Analysis of the development and innovation behaviour of firms has emphasized the evolutionary processes of learning and investment through which firms develop capabilities, routines and assets – demonstrating that business organisations, markets and technologies co-evolve[56]. In the context of more rapid change, a firm's capacity to develop new capabilities and assets ('dynamic capabilities') is particularly important[57]. The competencies and culture of the firms in a sector, region or economy are shaped by their history, and that legacy must be taken into account in predicting and assessing the impact of innovation policy instruments. For example, incentives for R&D are likely to be ineffective if firms have no ambitious strategies for innovation due to lack of competition or demand, short planning horizons or lack of competence. Determination of the most effective policy levers for encouraging innovation requires staying abreast of current and emerging innovation practices in firms[58].

4.5 Firms innovate in the context of regional and national innovation systems

The development of the innovation systems perspective has had a significant impact on innovation studies and presents a central challenge for innovation policy, indicator design and analysis. The innovation systems perspective emphasises the extent to which firms' industrial, economic, institutional and social context influences their innovation strategy and activity[59]. From this perspective, the scope for innovation policy and analysis widens to include, for example, education, the finance system, regulation and procurement across the public sector, social institutions[60], networks and linkages. Innovation systems can be analysed at a national, regional, sectoral or technology level[61]. Borras and Edquist (2016) counsel policy makers to consider "all important economic, social, political, organizational, institutional and other input factors that influence the development, diffusion and use of innovations"[62].

The innovation systems approach presents a challenge in the design and construction of innovation-related metrics. A diverse range of organisations, relationships and institutions are potentially brought into scope and the boundary of an innovation system is indeterminate. One promising approach is to specify the most critical 'functions' of an innovation system and aim to develop indicators for these, for example:[63]

> Generation of knowledge (e.g. R&D)

> Diffusion of knowledge (e.g. education, linkages facilitating knowledge flows)

53. Herstad, *et al.,* 2014
54. Teece, 2006
55. Teece, 2010
56. Martin, 2012.
57. Dynamic capabilities – "the skills, procedures, organizational structures and decision rules that firms utilize to create and capture value" (Teece 2010, p. 680); Zollo and Winter, 2002
58. Dodgson, 2017.
59. Fagerberg, 2013, Martin, 2012; Akçomak & Ter Weel, 2009; Baumol, 2002; Baumol *et al.*. 2007.
60. Including the role of social institutions in shaping trust, risk tolerance, and social capital more generally – Fagerberg, 2013.
61. Nelson, 1993; Lundvall, 1992; Dodgson *et al.,* 2011
62. Borras & Edquist, 2016
63. Fagerberg, 2013; Hekkert & Negro, 2009; Hekkert, *et al.,* 2006

> Skill formation (e.g. training programs)
> Provision of finance (e.g. financial and capital markets)
> Level and shaping of demand (through standards, regulations, procurement)
> Institutional continuity and change (laws, attitudes, behaviours)

There have been three particularly important extensions of the innovation systems approach, which share the same underlying conceptual framework but enable different policy foci[64].

> Regional innovation systems[65]
> Sectoral innovation systems[66]
> Technology innovation systems[67]

These innovation systems are discussed further in **Section 7**.

A significant application of the innovation systems approach, particularly drawing on technology innovation systems, has been the development of frameworks for policy aiming to promote experimentation and to drive socio-technical change through, for example, 'strategic niche management,' 'transition management,' or 'strategic innovation system management'[68]. As technologies, industries and societies co-evolve, innovation systems must also evolve in response[69]. However, the drivers and processes of system-level evolution are not well understood.

64. Borras & Edquist, 2006 argue that national, regional and sectoral innovation systems complement each other.
65. Cooke and Morgan, 1998; Saxenian, 1994
66. Malerba & Adams, 2014
67. A focus on the actors, knowledge flows and institutions at the level of specific technologies enables a more useful understanding of the dynamics of innovation as a basis for policy to address 'barriers' to desirable change; Bergek, *et al.,* 2008; Hekkert, *et al.* 2006; Hekkert & Negro, 2009; Geels, 2002
68. Geels, 2002; Geels & Schot, 2007; Markard *et al.,* 2012; Kemp *et al..* 1998; Winskel & Moran, 2008; Foxon & Pearson, 2008
69. The 1982 work of Nelson & Winter, An Evolutionary Theory of Economic Change, is the most cited work in the field of innovation studies – Martin, 2012.

5. Where innovation happens – beyond research and development

Attitudes to what are considered to be productive sectors and activities have changed over time[70]. The Oslo Manual definition of innovation has been extended to include services sectors and non-technological forms of innovation. The US National Academies of Sciences, Engineering, and Medicine (2017) has suggested that that in the future coverage could extend to households, the public sector and the non-profit sector. Gault (2016, 2018) proposed a generic definition of innovation for use in surveys that would be a suitable for all sectors and most types of formal organisation, which was adopted in the 2018 version of the Oslo Manual.

Innovation studies have shown that innovation is much more widely distributed than R&D, and that innovation is a characteristic of all human activity. However, indicators and approaches to survey and analysis, developed initially for the manufacturing sector are not appropriate for all sectors. In both agriculture and the mining sector there are processes of creative accumulation, based on continuous improvements in technology, organisation and governance, and processes of creative destruction, when new technologies, capabilities and actors emerge. The agriculture industry has been slower than the mining industry to exploit the potential of digital technologies but is now beginning to do so. Indicators of innovation at the firm or sector level should be designed to capture the dynamics of both types of innovation – i.e. continuity and discontinuity. However, at this stage of industry development it is the latter that is most important.

In both industries, the role of suppliers in innovation and knowledge diffusion is vital. Many of those suppliers are international firms, some of which have a (generally low) level of innovation-related support activity in Australia. The challenges of production and problem solving that stimulate innovation for these industries can lead to the formation of new local innovation-based ventures. That is the historical origin of most of the international suppliers to these industries. But if that innovation is within the local arms of international suppliers, or in research organisations which subsequently licence that technology to international firms, that potential for enterprise development is likely to be lost. Hence, a narrow focus, in policy or in assessment, on how innovation in these industries benefits the performance of the agricultural and mining producers would miss some of the most important longer potentially highly significant longer-term value creating processes.

5.1 Agriculture

Agriculture is a significant contributor to Australia's gross domestic product (GDP) and exports. ABARES (2017) reports that agricultural output in 2016-17 was $63.8 billion, thus contributing 3.8 per cent to GDP. Rural industries (agriculture, fisheries and forestry) account for over fifteen per cent of Australia's merchandise exports. Agriculture is vital for maintaining employment and communities across rural and regional Australia.

A long history of innovation lies behind the export success and productivity of the agriculture industry. It is increasingly technology- and knowledge-intensive and draws on a widening knowledge base. Understanding the dynamics of innovation in this sector will therefore require an inclusive approach that encompasses the role of knowledge flows and external suppliers[71].

Due to increasing market and technological opportunity there is a strong potential for sustained growth in output, product diversity and profitability. Increasing technological opportunity is driven by, in particular, the development and increasingly wide applications of transformational technologies. Digital technologies and biotechnology are enabling 'game changing' innovations. They often provide routes to productivity improvement that address otherwise difficult problems that limit performance, for example, labour scarcity, a need for pest control with reduced use of agri-chemicals, differentiation through enhanced product attributes, more effective use of expensive inputs.

There have been many significant and substantial reports on rural industries, and innovation in those industries, over the past decade[72]. These reports discuss the strong currents of change that are reshaping and transforming rural industries: changing patterns of market demand; new trajectories of technological innovation; shifts in the knowledge base for production and innovation; declining public support for RD&E; climate change; and structural change as the number of farms declines.

70. Mazzucato, 2018
71. Howard, J. *et al.*, 2018; Scott-Kemmis, 2013.
72. ABARES, 2017; Australian Farm Institute, 2016; CSIRO Futures, 2017; Productivity Commission, 2011; Rural Research and Development Council, 2011

Most of the reports are concerned, explicitly or implicitly, with whether Australia's rural innovation system[73] is addressing, and has the capability to adequately address, the opportunities and challenges it faces. Is it continuing to evolve and strengthen so that it is 'fit for purpose'? Does it stimulate and support innovation across rural industries? If there are weaknesses and gaps in performance or capability, what are the priorities for action to address these? The reports identify a wide range of barriers and impediments to innovation in agriculture, with the main themes summarized below.

> **Inadequate investment in research**

A declining proportion of Australia's investment in R&D has been allocated to agriculture. Research intensity (the ratio of public investment in R&D to gross agricultural domestic product) has more than halved over the past twenty years. Australia's share of international agricultural publications has steadily declined over the past twenty years. Public R&D investment in agriculture has declined in real terms over the past ten years. Responding to the widening frontier of technological opportunity will require a substantial increase in R&D investments, often in new areas of knowledge such as digital technologies, in the context of an integrated strategy for industry development.

> **Reduced public sector support for extension**

Most State governments have reduced their role in rural extension and many farmers rely on suppliers and fee-for-service advisors for advice.

> **Slow rates of productivity growth**

Rates of productivity improvement in some sectors have remained low since the mid-1990s. However, the Productivity Commission (2011) reports that overall agricultural productivity growth rates have changed little over decades.

> **Insufficient product differentiation**

With increasing competition, product differentiation - based on quality and branding with traceability and provenance to support sustainability and ethical production claims – will be increasingly important in winning market share and enabling premium pricing. There is little analysis in the reports of the proportion of exports that could be higher value-added products and how higher levels of value adding can be developed.

> **Limited value-adding and participation in global value chains**

While bulk commodities will be likely to account for the major share of Australia's agricultural exports, the increasing scope for value added products will require the development of deeper market knowledge and more extensive links with marketing agencies and distributors.

> **Human resource constraints**

The education level of farmers and operators is improving, however evidence suggests that current education levels contribute to slow uptake of new technologies and a wide range of productivity levels. The demand for agricultural science graduates exceeds supply. The early career opportunities for agricultural science researchers and the financial support during post-graduate study are strong disincentives for this career choice. With increasing and changing skill and knowledge requirements a lack of appropriate human resources could be a serious constraint on innovation and productivity growth.

> **Low rates of uptake of new technologies**

While many farmers are innovative, inadequate skill and knowledge among some farmers and operators has led to slow rates of uptake of new technologies. With the increasing capital intensity of operations access to capital will often also be a constraint on investment in new technologies.

> **Impacts of climate change**

Long term changes in weather patterns will impact the viability of current land use in some areas. Increasing variability of rainfall, temperatures and wind will threaten the viability of particular industries in many areas and at least require changes in species, practices and infrastructure.

73. The firms and organisations in the public and private sectors, the relationships among them, and the policies and institutions that shape their role in the creation, import, diffusion and application of knowledge.

> **Inappropriate research governance**

  Agricultural research is increasingly allocated to short term (near to market) objectives as a result of governance structures. The governance arrangements limit the scope for long-term (potentially) transformative research, the types of inter-disciplinary research that are increasingly required to enable the more complex 'whole of system' change, collaboration among researchers and coordination both of research investments and of participation in international research.

Due to the widening knowledge base for innovation in rural industries the linkages between the agricultural innovation system and the national innovation system are of increasing importance.

5.2 Mining

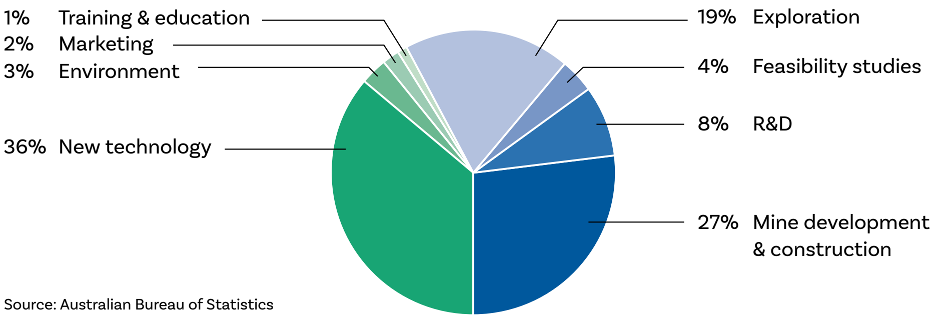
The mining industry has become an increasingly critical driver of industry development and innovation in Australia[74]. While innovation through adaptation has been a characteristic and a necessity, frontier developments can be found across geological mapping, exploration technologies, mining and metallurgy innovations, institutional innovation and supplier development[75].

Australia is a global centre of mining production, research and innovation and major mining companies have long been among the largest business investors in R&D. The wider constellation of mining-related research and innovation organisations, and the links between them, have been characterised as a "dynamic minerals innovation complex"[76].

The Australian mining industry's investment in R&D grew strongly in the last decade with higher demand for mineral commodities from China and other emerging economies, especially in the period between 2005 and 2009. Major mining companies consolidated their position among the largest business investors in R&D in Australia with mining R&D expenditure of A$3.8 billion in 2010-11 (21.4 per cent of total business R&D expenditure), the second largest industry share behind manufacturing. However, expenditure on R&D in the mining industry dropped sharply in recent years, including a drop of 34 per cent (A$954 million) in 2015-16 alone[77]. It is now only the fourth largest contributor at 11 per cent, behind manufacturing (23 per cent), professional, scientific and technical services (23 per cent), and financial and insurance services (19 per cent).

The Australian experience shows there is a lot more to innovation in the mining sector than R&D (**Figure 5**). A 1997 ABS study found a strong focus on process improvement[78]. In fact, R&D was only a small component of the overall innovation expenditure by the sector: five per cent in the case of coal mining and eight per cent in the case of metal ore mining. Overall, the 1997 study showed that 42 per cent of mining businesses had undertaken technological innovation over the previous three years. The comparable figure for manufacturing firms at the time was 26 per cent[79]. The most recent survey in 2016-17 found that the mining industry had the highest proportion of collaborative arrangements at 22 per cent[80]. The 2016-17 survey also found that 50 per cent of the mining industry measure performance by innovation status to a moderate or major extent, more than any other industry after information media and telecommunications.

Figure 5: Distribution of Input Costs for Mining Innovation (ABS cat. no. 8121.0, 1997)



Source: Australian Bureau of Statistics

74. Upstill & Hall, P., 2006; Bryant, 2012.
75. See for example Francis, Emma. 2015. "The Australian Mining Industry: More than just shovels and being the lucky country" IP Australia Research paper.
76. Dodgson & Vandermark, 2000;
77. ABS, Research and Experimental Development, Businesses, Australia, 2015-16 http://www.abs.gov.au/ausstats/abs@.nsf/mf/8104.0/
78. ABS, ABS cat. no. 8121.0, 1997
79. Cited in Scott-Kemmis, 2013
80. ABS, Selected characteristics of Australian Business 2016-17 http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/8167.0Main+Features12016-17?OpenDocument

Throughout the history of Australian mining, frontier developments can be found across diverse areas such as:

> Geological mapping and exploration technologies
> Mining and metallurgy innovations
> Institutional innovation
> Technology-intensive supplier development

Mining projects involve an enormous range of activities from exploration, resource assessment, site development, engineering design, construction, procurement and installation of plant, equipment and buildings. Ongoing operations require a diverse range of support services such as drilling, engineering consulting, finance, insurance, property and business services, legal, accounting, computer system design, marketing, rental and hiring of equipment.

A vibrant home-grown mining equipment, technology and services (METS) sector supplying inputs to the Australian mining industry has developed. With revenue exceeding A$90 billion in 2012 and total employment estimated at around 265,000 people, the rise of the METS sector has multiplied and diversified the benefits Australia derives from its natural resource endowment[81]. Export revenues substantially exceed those of the wine industry and, on some measures, the automotive industry.

Mining is critical to the Australian economy and accounts for the majority of Australian exports. Mining has also become increasingly knowledge-intensive, and increasingly intensive in the use of external knowledge-based inputs. As in agriculture, understanding the dynamics of innovation in mining will require an approach that encompasses the role of knowledge flows and external suppliers[82].

5.3 Services

The significance of services industries is increasing globally. Service industries currently account for at least seventy per cent of Australia's GDP and a similar proportion in most OECD economies. Services are also an increasingly important form of output in all sectors, including manufacturing[83]. The Community Innovation Surveys in Europe have found that sixty-six per cent of product innovators also introduced new services[84].

In 1997 the second edition of the Oslo Manual extended the sectoral coverage of the survey to include services. In 2005 the third edition included non-technological innovations such as marketing and organisational innovation[85]. However, services innovation often involves the development of new customer interfaces and also the development of new business models[86].

It was often presumed that service sectors were essentially non-innovative, but extensive research into innovation in a diverse range of service sectors over the past twenty years has shown that this is not the case[87]. Some service sectors, particularly Knowledge Intensive Business Services (KIBS) such as IT consulting, play a systemic role in knowledge transfer and innovation throughout the economy[88]. The rising importance of innovation in services, and particularly the role of KIBS, is due in large part to the application of digital technologies and their impacts on processes of value creation throughout the economy[89].

The now extensive literature shows that services innovation is much less likely to involve R&D and to result in patents than in product innovation in terms of goods[90]. Hence, those traditional indicators are increasingly inadequate, and in fact misleading, as indicators of innovative activity in an economy[91]. Innovation in services is also more likely than in goods innovation to be non-technological and to involve organisational and marketing innovations[92]. Trademarks are therefore becoming a more useful indicator than patents. Innovation in services is more likely to be carried out by personnel who are not categorised as R&D staff than in the manufacturing sector[93].

81. Mining Equipment, Technology and Services: A roadmap for unlocking future growth opportunities for Australia. May 2017. https://www.mining3.com/wp-content/uploads/2017/05/METS-Roadmap-2017.pdf
82. Howard, J. et *al.,* 2018; Scott-Kemmis, 2013.
83. DFAT, 2017; Gustafsson, 2016.
84. Hollanders, H., 2008
85. OECD/Eurostat, 1997; OECD/Eurostat, 2005
86. Hollanders, H., 2008
87. For example, Djellal *et al.,* 2013
88. Service firms in consulting, design, engineering, information technology and R&D, for example, can have an active role in innovation in their clients. Djellal *et al.,* 2013
89. Gallouj and Djellal, 2010; Howells, J., 2000; Djellal et al., 2013; Morrar, 2014. The increased importance of services is also due to the growth of telecommunications and information technology services and their role in the uptake of digital-based services and applications throughout the economy. The growth and increased dynamism of service sectors also generates a stronger demand for improved performance by their suppliers.
90. See for example Tether, B. 2014.
91. Hollanders, H., 2008; Abreu, *et al.,* 2010; National Academies of Sciences Engineering and Medicine, 2017.
92. Gallouj and Djellal, 2010; Abreu, *et al.,* 2010
93. Hall & Jaffe, 2018.

Firms in other sectors increasingly also provide services and engage in service innovation. Product and service innovations are often combined. Hall and Jaffe (2012) and Potts (2009) make the point that innovation activities in the service sector are likely to be carried out in close association with production activities and by personnel also involved in production – rather than as distinct R&D activity involving R&D personnel. Both studies also note the pervasive significance of digital technologies for innovation in service sectors. The significance of digital technologies for innovation in services leads Hall and Jaffe (2012) to suggest that firms' investment in such technologies might be a good indicator of innovation input effort.

Potts (2009) and Bakhshi and McVittie (2008) assess the role of the 'creative industries' in innovation, a component of the service sector that includes, for example, architecture, advertising, fashion, design, interface software, and publishing. Potts (2009) notes the evidence for the growth of the contribution of the 'creative industries' to employment, exports and value added.

5.4 Public sector innovation

In OECD countries including Australia, the public sector contributes over twenty per cent of GDP, making it a key sector in considering innovation. Innovation occurs and is supported throughout the public sector, including in large projects led by the public sector such as infrastructure, health and defence, which also often involve temporary coalitions between government and private firms[94].

Arundel et al. (2016) consider that the economic weight of the public sector has led to growing policy interest in how to "… encourage innovation in the public sector with the goal of improving productivity, the quality of public services and addressing societal challenges."[95] According to Arundel et al. this "…requires an ability to measure the inputs, processes and outcomes of public sector innovation in order to determine what works and to benchmark performance." [96]

Arundel (2018) provides survey reports which show that innovation rates in the public sector in Australia exceed those in the private sector. He also cites evidence that the use of design-thinking methods and collaboration strongly increase the probability that the most important innovation is a novel process or service. However, a major barrier to innovation in the public sector is "tight policy-driven deadlines based on reacting to events outside the control of management, leading to a lack of time to minimize risk and uncertainty."[97]

Gault (2016) notes that there has been extensive debate over the past decade on developing indicators for innovation in the public sector. Arundel *et al.* (2016) review the literature on public sector innovation and the methods and findings of several surveys of innovation in the public sector[98]. They conclude that there is now adequate conceptual and methodological development to design a robust survey approach for public sector innovation. While the approach would share some elements with the Oslo Manual, they consider it would differ significantly in other elements. Arundel suggests that important policy questions for public sector innovation surveys would include[99]:

> Who makes the key decisions – where do good ideas for innovation come from and does the source of the idea influence results?
> What in-house capabilities are required to innovate – how does innovation occur?
> Does innovation require taking risks?
> What are the barriers to innovation and how are they overcome?

Arundel (2018) considers that the 4th edition of the Oslo Manual is more useful for measuring innovation in the public sector than the 3rd edition, but the OECD is considering developing a measurement manual specifically for the government sector. He notes that experimentation with public sector innovation indicators is ongoing with large-scale surveys in Norway and Denmark, and the European Co-Val survey initiated in February 2019.

94. See for example Davies & Hobday, 2005.
95. Arundel, *et al.*, 2016, p.1. See also Bason, C., 2010; Bloch & Bugge, 2013; European Commission, 2011; Hughes, *et al.*, 2011; OECD, 2014; Bloch, C. 2013; Gault, 2016
96. Arundel, *et al.*, 2016
97. Arundel, 2018.
98. Arundel, *et al.*, 2016, note that the first large-scale public sector innovation survey was the 2008-2009 MEPIN survey of public sector organisations in Scandinavia, and cite Bugge *et al.*, 2011.
99. Arundel, 2018.

5.5 Intermediary organisations

Research translation is enhanced and promoted in many modern economies by intermediary organisations between research and industry. In Australia, leading examples include the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Cooperative Research Centres (CRC) Program. However, Bell *et al.* (2015) found that greater use of innovation intermediaries would enhance collaboration and increase research translation in Australia[100]. In Europe, successful examples include Fraunhofer – an application-oriented research organisation – and research and technology organisations (RTOs) in the United Kingdom.

5.6 Informal, non-business or household innovation

Von Hippel and De Jong (2013) have shown that a significant number of innovations have been developed by individuals or groups outside of organisations. These innovations have often been diffused freely – for example, user-developed software such as Linux and user-developed devices such as snowboards[101]. This innovation activity is not captured in current surveys or productivity estimates, as market-based transactions are not involved.

100. Bell, *et al*, 2015.
101. Von Hippel, 2017; de Jong, 2016; de Jong & von Hippel, 2013.

6. The diversity of innovation activity

This section focuses on types of innovation and innovation sources and processes. It discusses the process of value creation through various types of innovation in addition to those involving R&D, and those focused on product and process innovation. This section also discusses the increasing role of external inputs to firm-level innovation, including formal and informal collaboration. Increasing understanding of innovation has led to the development of new indicators, but also to concern regarding the adequacy and interpretation of the indicators in use.

6.1 Types of innovation

Innovations range from minor improvements (incremental innovations) to major new products or processes that might be the basis for a new industry (radical innovations). However, there are no standardised indicators to assess the level of novelty, and even less to assess the significance (in competitive, economic or other terms) of an innovation.

Arundel *et al.* (2013) have shown that there is a great deal of subjectivity in how survey respondents interpret questions on 'what is an innovation' and the level of novelty of their innovations[102]. They found that subjectivity is greatest in types of innovation other than product innovation – i.e. in process, marketing, or organisational innovation – and in services, low-tech sectors, and among small firms.

Greater awareness of the scope and diversity of innovation has been achieved through changes to the definitions used in innovation surveys, and in the sectoral scope of such surveys. In particular, the 1997 extension of the Oslo Manual to include services sectors and the 2005 extension to include some non-technological innovation[103]. Gault (2013) and Martin (2017) consider that more work is needed to better understand and characterise the diversity of innovation and to develop appropriate indicators. Several types of innovation warrant greater effort in characterisation and indicator development. For example, the adaptation of acquired process equipment and technologies is a form of user innovation[104] that is particularly important in smaller firms and in economies such as Australia[105].

6.1.1 Process innovation

Process innovation includes aspects related to task redesign, process routing, and resource reallocation. It requires training and up skilling of employees, which results in increased effectiveness of the employees and the overall organisation[106]. It is generally understood that improved process efficiency (e.g. supply chain restructure, streamlined operational procedures and automation) can significantly increase the productivity of labour, leading to product innovation. Process innovation is distinct from organisational/managerial innovations, although empirical research has shown that business managers find it difficult to differentiate between the two[107].

Managerial practices are known to be important for workplace performance and productivity, although less is known about the specific impacts of management on process innovation[108]. Recent econometric analysis suggests that neither operational process innovations nor organisational/managerial innovations have independent impacts on turnover growth across firms in Australia, after controlling for factors such as different types of innovation, firm strategy, skills, business age, size, industry division, and macroeconomic effects[109].

Other forms of process innovations such as the adoptions of new methodologies (e.g. the use of new gene editing technologies to develop novel plant varieties) are evidently valuable tools for product innovation. This highlights a clear need to characterise process innovation and identify relevant indicators. In addition, it would be worthwhile for specialised surveys of start-up firms to experiment with measuring business process novelty.

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102. Arundel, *et al.*, 2013
103. OECD/Eurostat, 1997; OECD/Eurostat, 2005
104. Gault, 2013
105. In Australia over 2006-07, the propensity for new to market product innovation was similar whether the firm performs R&D or does not. OECD, 2010, p. 23.
106. Sachdeva & Agarwal, 2011
107. OECD/Eurostat, 2018
108. Bertrand & Schoar, 2003; Bloom & Van Reenen, 2007.
109. Department of Industry, Innovation and Science, 2017.Australian Innovation System Report 2017. Commonwealth of Australia

6.1.2 Business model innovation

An extensive literature on business model innovation has developed over the past 10 years[110]. Such innovation typically involves a combination of innovation in products or services in business processes and structure. It is often enabled by the availability of new technologies, particularly digital technologies, that make it feasible and profitable to generate and offer a new 'value proposition' (product or service or combination of both, with modes of delivery and support) to a specific target market whose needs were under-served by established suppliers[111]. Business model innovation can be a particularly powerful form of systemic innovation that can disrupt industries, as in the cases of online share trading, low cost airlines, streaming services for films and music, Uber, and Airbnb.

Business model innovation may be radical, involving a complete transformation of the firm and its business recipe, or it may be incremental, involving more modest change and re-alignment. The starting point for developing a new business model, or renovating an established one, has often been insight into how to meet the needs of an unserved or underserved customer group. Good insight into the behaviour of the target users and the context of their use of the product or service is usually required to make innovation in a business model enduring and effective.

6.1.3 Entrepreneurship

Entrepreneurship, the formation of new ventures, is a form of business experiment[112]. While most new ventures have a low level of novelty, innovative new ventures have played a major role in the development of new technologies and new industries[113]. New ventures have many origins, but it is common for spin-offs from existing firms, universities and research institutes to play a major role in the evolution of industries and related technologies[114]. Entrepreneurship is particularly important in periods of major techno-economic change when new trajectories and industries are being formed.[115]

It is essential to consider the quality of entrepreneurial activity as well as the quantity. High growth new ventures account for a small proportion of new firms, typically less than five percent, but often account for the majority of net employment growth in an economy[116]. It is also clear that more innovative entrepreneurial activity is spatially highly concentrated[117]. While the primary focus of the literature on entrepreneurship has been on the individual, more recently there has been greater recognition of contextual influences on entrepreneurial behaviour.[118]

The extent to which entrepreneurship is spatially concentrated has led to the development of frameworks for characterising and analysing entrepreneurial ecosystems and their role in supporting new firm formation and growth[119]. Entrepreneurship may also be the vehicle for other forms of innovation[120]. The majority of new firm formation involves little novelty in that the business models used (type of product or service, organisational structure, etc.) essentially replicate those that have been previously established in the industry. While new firm formation can be considered a form of innovation, existing statistics on new firm entries and exits provide a reasonable overall perspective on this aspect of business dynamics.

Entrepreneurship that involves significant novelty in products, services, business processes and organisation is a business experiment of potentially great significance for an economy[121]. Therefore assessing the level of novelty in new firm formation (i.e. startups) and the rate of formation of high novelty startups is an important objective.

6.1.4 Other types of innovation

From time to time there will be strong policy interest in assessing specific types of innovation activity, characterised in terms of the nature of the technology or the type of objective. Currently, the extent and type of innovation related to the development and application of digital technologies is of particular interest. Innovations that can contribute to achieving improved environmental performance ('eco-innovations'), either within the innovating enterprise, or by users, are likely to attract increasing attention from policy makers and analysts.

110. Chesbrough, 2010; Chesbrough, 2007; Amit & Zott, 2012; Zott & Amit, R, 2010; Massa & Tucci, 2013; Teece, 2010
111. Scott-Kemmis, 2012, provides a number of examples of business model innovation in Australian industry.
112. Metcalfe, 2007; Lindholm-Dahlstrand, *et al.,* 2017
113. For this reason, small firm policy is not a form of entrepreneurship policy.
114. Klepper, 2015.
115. Naudé, 2014; Gilbert, *et al.* 2006; Audretsch, 2007; Van Praag & Versloot, 2007; Acs, 2006; Audretsch, & Keilbach, 2010.
116. Acs, *et al.,* 2014. High growth firms are typically defined as those with employment growth of over 20% per annum over more than three years. Office of the Chief Economist.
117. The best know example is that of Silicon Valley.
118. Autio, *et al.,* 2014.
119. Mason & Brown, 2014; Isenberg, 2010, Colecchia, 2006.
120. Szirmai *et al.,* 2011.
121. Foster & Metcalfe, 2003; Metcalfe, S. (ed), 2018.

Environmental sustainability in general, and addressing climate change in particular, are compelling innovation policy priorities. A considerable literature has developed on the issue of eco-innovation and on indicators of eco-innovation[122]. A reasonable level of indication of these types of innovation could be gained by adding additional questions to existing surveys. These assessments could be supplemented by using passive data acquisition through, for example, web-scraping based on product and service announcements and administrative data from certifications.

As the scope of innovation assessment extends to other sectors, such as the public sector, and to levels of innovation-related performance beyond the firm (e.g. regional and national innovation systems) there will be demand for new types of indicator. In the case of the public sector, this might extend to characterising types of 'policy innovation'. In the case of innovation systems this might extend to forms of organisational and institutional innovation. As the concept of innovation continues to grow beyond technologies and products, as our understanding of innovation deepens and as a policy interest in the systemic dimensions of innovation capability grows, there is likely to be an increasing interest in new innovation indicators such as those that assess in more detail the sources of innovation inputs and the role of cultural dimensions such as trust and risk avoidance.

6.2 Innovation Processes and Inputs

Although the following discussion could apply to any type of organisation (e.g. public sector, non-profit) the focus is initially on the for-profit firm, which has been the focus of the overwhelming majority of the literature on innovation processes.

Much of the recent research into firm-level innovation strategy, capability and performance has been framed by the resource-based view of the firm and by the evolutionary perspective[123]. A review of that – now extensive and concept-rich but empirically more limited – literature with a view to developing a foundation for indicator development is beyond the scope of this review. However, three key points can be made:[124]

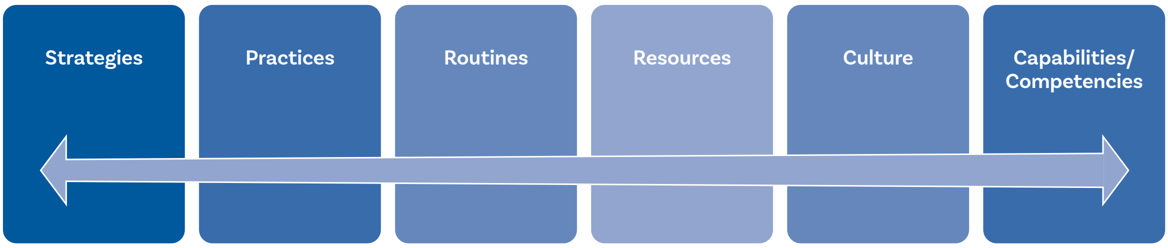
> Firms' capacity to innovate is strongly shaped by their resources, which include tangible assets (e.g. equipment) and intangible assets (e.g. capabilities, external relationships, reputation, intellectual property)

> Firms' perceptions of opportunities for innovation and for appropriating the benefits of innovation will be strongly shaped by their capabilities and routines (i.e. micro institutions)

> Capabilities (and competencies – the terms are used interchangeably for this discussion) are accumulated over time through complex learning processes shaped by firms' strategies, challenges and interactions with other organisations

Figure 6 is a simplified explication, for the purpose of the following discussion, of major conceptual categories draw from this literature.

Figure 6: Foundation of Firms' Innovation and Innovativeness



122. For example: Horbach, 2005; Andersen, 2006; Reid & Miedzinski, 2008; Arundel & Kemp, 2009; Cheng & Shiu, 2012.
123. Teece, 2009, 2010; Terziovski, 2010; Chesbrough & Teece, 1996; Wang & Chen, 2008; Wang & Ahmed, 2007.
124. Drawing on, in particular, Teece, 2007 and Helfat & Peteraf, 2009.

6.2.1 Innovation activities – assessing 'hidden' innovation

Innovation support policies have long focused on forms of incentive for firms to invest in R&D. However, the third European Community Innovation Survey (CIS-3) shows that almost half of innovative European firms (aggregated across fifteen countries) did not perform in-house R&D. Hence, investment in R&D, whether assessed by expenditure or personnel, is not an adequate indicator of investment in innovation[125]. If a range of other innovation activities (and hence related capabilities and investments) are as, or in many firms more, important, than R&D then there may be a case for a major review of innovation policy. The challenge for innovation indicators is to characterise and assess the significance of those 'non-R&D' activities.[126]

The term 'hidden innovation' is used to refer to types of innovation or innovation activity that are not visible through innovation indicators based on R&D activities[127]. Until recently innovation was conceptualised, defined and measured in terms of what was seen as 'real innovation'– i.e. primarily technology-based innovation for manufacturing, involving R&D investment and patenting, from large companies and their internal labs. This encouraged innovation researchers to develop metrics for measuring innovation through input indicators such as R&D funding and number of researcher personnel, and output indicators based on patents and citations. Through a survey of innovation in six 'low innovation' sectors, NESTA (2007) identified several types of innovation activity that do not involve R&D and several types of innovation (e.g. organisational, business model, new combinations of novel technologies, small scale local innovations) that would not be patented[128]. The report suggests that hidden innovation is often more about absorbing than generating ideas.

Hall and Jaffe (2012) argue that there are many types of input to innovation that in many sectors and countries are more important than R&D. For example, training staff in association with the introduction of new or improved products or processes, design intended to improve the product or service, and the acquisition of new hardware or software[129]. Firms' investments in intangible assets such as software and databases, R&D and other intellectual property, brand equity, and human capital, has been increasing. In some countries (Finland, United States and the UK) it exceeds investment in machinery and equipment.[130]

Focusing on non-R&D innovation in manufacturing firms, Barge-Gil et al. (2011) identify the role of technology forecasting, design and training in innovation in a sample of Spanish firms. Focusing on the services sector, Abreu *et al.* (2008) emphasise the importance of business model innovation, as well as workforce training. Drawing on the German Community Innovation Survey (which is based on the Oslo Manual) Rammer *et al.,* (2009) emphasise the role of external knowledge sourcing, for example from suppliers, or formal co-operations with external partners. Hall and Jaffe (2012) emphasise the significance of expenditure on design in many sectors.

While it recognises the importance of relevant indicators for policy, NESTA (2007) suggests a focus on sectoral innovation indicators (and sectoral innovation policy) rather than the development of internationally comparable indicators of 'hidden innovation'. It also emphasises that greater recognition of the significance of 'low innovation' sectors for value creation and employment and a greater understanding of the real dynamics of innovation in these sectors would lead to change in the scope of innovation policy. In particular, NESTA (2006 and 2007) argues that a wide range of policies beyond traditional R&D and technology-focused innovation policy instruments influence innovation in these low R&D-intensity sectors, such as taxation policy, regulation, and skills. Focusing on the innovation in the service sector, Abreu (2010) also emphasises the importance of policies to enhance workforce learning and training to support non-R&D innovation.

The significance of non-R&D innovation inputs and expenditures is a challenge for those growth accounting approaches that relate R&D activity with Total Factor Productivity. The credibility of growth accounting analyses is reduced by lack of coverage of non-R&D sources of investment in innovation. The empirical-based literature shows non-R&D innovation activities can be major contributors to firms' productivity:

> *...in the case of Europe and for the period 2004-2008, the average sums invested in non-R&D activities was 10% higher than the resources devoted to R&D (1.55% versus 1.40%, as average percentages of the years 2004, 2006 and 2008 expressed as a share of GDP). The non-R&D intensive sector still accounts for 40-60% of the industrial value added (depending on the country) and 50% of all industrial employees... Additionally, more than 50% of all innovating firms in the EU ...do not perform R&D.*[131]

125. Huang *et al.,* 2008.
126. Abreu, *et al.,* 2010; Barge-Gil, *et al.,* 2011; Abreu, *et al.,* 2008; Rammer, *et al.,* 2009.
127. Gault, 2013; Hall & Jaffe, 2018; NESTA, 2007.
128. NESTA, 2006; NESTA, 2007.
129. Hall & Jaffe, 2018.
130. Corrado *et al.,* 2005.
131. National Academies of Sciences, Engineering, and Medicine, 2017.

6.2.2 Design and innovation

Design has mattered as a competitive device for a long time, and yet it has been on the fringes of innovation measurement and, as a result, is not well understood[132]. The number of design rights is increasing, however[133].

Design has become increasingly important for value creation in both the manufacturing and services sectors, including but not only through innovation. Although they may be critical for competitive success and complement technological innovation, design activities may involve no technological or R&D activity. There are no recognised standards for assessing the quantity or quality of design activity.[134]

One aspect of design is as the creative process and interface between technology and user needs. Innovation in user-centered design is based on the observation that the usefulness and desirability of a product or service is not determined by its technological sophistication, but rather by whether people experience it as a valuable addition to their lives. The user's needs are not only satisfied by aesthetics, form and function, but through experience.

Innovation in user experience (UX) design leads to products and services that offer a point of difference from their competitors through design excellence. It adds value to existing inventions by improving the way in which the user interacts with the technology. Innovative UX design is the key difference between an iPhone and a Nokia phone, between Google and Yahoo!, or between Airbnb and Craigslist.

Design innovation is not only important in high tech sectors, but also increasingly in the public and service sectors. Companies like Honda, Microsoft, Nike and Procter and Gamble invest heavily in design and have both utility and design rights and patents, as does Australian company Breville. Controlling for factors such as investment in R&D, investments in software, branding, the age and size of companies, sector and country, research has found firms that spend on design are more likely to innovate and have higher sales from innovation[135]. However, it is not adequate to simply measure the amount of spending on design; it is also important to define the quality of design inputs (including key design staff), the arrangement of the spending (concentrated spending appears to have a greater impact than if it is fragmented), and whether the design is a central element of the product or service.[136]

While there is persuasive evidence that design is an increasingly important activity for the creation of novelty and value, design activities in firms are taking on a more systemic role, far beyond a focus on physical appearance of products or the characteristics of services. For example, it could be considered that Apple designed the iPod (and its packaging), the value system (with links to iTunes, etc.), the outsourced procurement and production system, and many aspects of the user experience.

6.2.3 Innovation strategies

There is an extensive literature on innovation strategy which discusses dimensions such as, inter alia, the level of emphasis on:[137]

- Strategic intent to seek opportunities for growth
- Leading innovation in an industry, or being a fast follower
- Exploration (seeking new knowledge) or effectively exploiting the knowledge field (exploitation)
- Low risk incremental or more radical projects, and product or process innovation projects in a firm's innovation 'portfolio'
- Internal knowledge generation or the external sourcing of knowledge

Literature relevant to the analysis of innovation strategy has been developed in many different fields, resulting in the current state of knowledge about the strategic management of innovation being "characterised by conflicting theoretical predictions, persisting knowledge gaps and theoretical inconsistencies."[138] Nevertheless, whether firms have a strategic intent to grow and significantly improve other aspects performance is fundamental for all strategies of a business, including innovation strategy. Hence, understanding the extent to which firms have an intent to grow or improve other aspects of performance is a key indicator.

132. National Academies of Sciences Engineering and Medicine. 2017.
133. National Academies of Sciences, Engineering and Medicine, 2017. P.38 – While the design function is not easily defined and measured this report refers to a recent attempt to develop data on design.
134. Tether in National Academies of Sciences, Engineering, and Medicine, 2017; Nomen, *et al.,* 2014.
135. Galindo-Rueda & Millot, 2015.
136. National Academies of Sciences Engineering and Medicine. 2017.
137. For example, Tidd & Bessant, 2009.
138. Keupp *et al.,* 2012.p. 367

6.2.4 Innovation-related practices

Strategies are implemented and resources mobilised and integrated through management practices. Although systematic knowledge remains limited there is considerable and persuasive evidence for the key role of management practices on innovation performance[139]. Hence, from a policy (and management) perspective, assessing the quality of management practice is likely to be equally or more important than assessing the level of R&D expenditure.

The work of Bloom and Van Reenen (2007, 2010) provides an exemplar of an empirical approach to assessing the levels of implementation of a range of management practices in firms in several countries. The approach specified eighteen management practices and for each identified what they considered to be best practice and worst practice. This approach was also used to assess management practices in Australian firms (Green *et al.,* 2009). The Australian Bureau of Statistics (ABS) has also led a comprehensive project to survey management capability in its Business Characteristics Survey[140]. The survey covers areas such as culture of promotions, decision making, and technological awareness. While this approach was based on a broad set of management practices, a similar approach could focus on innovation-related management practices. Spielkamp *et al.* (2008) discuss the extent to which specific management practices have contributed to innovation performance in SMEs, namely human resource management, team working, co-operating with external partners, and sourcing relevant knowledge from clients, suppliers and competitors.

A similar approach to assessing firm level 'innovation capability' is used in innovation capability audits. There is now an extensive literature on approaches to conceptualising and assessing 'innovation capability,' much of which focuses on assessing specific practices[141]. It is beyond the scope of this review to assess the merits of each of these frameworks, but the literature does suggest that assessment based on the extent to which firms implement a range of innovation management practices would provide valuable insight.

6.2.5 Deeper levels – routines, capabilities, culture and resources

The effectiveness of firms' innovation-related activities, strategies and practices depends on their underpinning capabilities, coordinating routines, cultures and resources (such as finance, physical assets, relationship assets, etc.). There is a large and diverse literature with little consensus on frameworks, concepts or approaches to developing empirical indicators of complex and often ambiguous concepts. One particular conceptual construction that appears to offer a practical and useful approach amendable to estimating empirical content is the concept of 'absorptive capacity'[142]. For example, NESTA (2007) emphasises the importance of absorptive capacity for many types of non-R&D innovation. In some cases, this term is used at the level of an innovation system to suggest a capacity to acquire and diffuse imported knowledge, but this discussion concerns the use of the concept at the level of the firm.

Cohen and Levinthal (1990) conceptualised absorptive capacity as the 'organizational routines and strategic processes' through which their firms acquire, assimilate, transform, and apply knowledge, and that this involved four component capacities:

> **Acquisition capacity** – a firm's ability to locate, identify, value and acquire external knowledge that is critical to its operations
> **Assimilation capacity** – a firm's ability to absorb external knowledge that it will later analyse, process, interpret, understand, internalize and classify
> **Transformation capacity** – a firm's ability to develop and refine the internal routines that facilitate the combination of previous knowledge with the newly acquired or assimilated knowledge
> **Application (or exploitation) capacity** – a firm's ability to incorporate acquired, assimilated and transformed knowledge into their existing and future operations and routines

Absorptive capacity is seen as having a mediating role in the relationship between external knowledge and innovation. As the acquisition and effective application of external knowledge has a key role in innovation, the concept has attracted a great deal of interest and a very extensive literature has developed around the topic.

139. For example in The Oxford Handbook of Innovation Management, Dodgson, *et al*, 2014.
140. Results at http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8172.02015-16?OpenDocument
141. Tidd & Bessant, 2009; Björkdahl &Börjesson, 2012; Gamal, *et al.,* 2011; Adams, *et al.,* 2006; Cormican & O'Sullican, 2004; Cooper & Kleinschmidt, 1991, 1995; Cooper, *et al.,* 2004; Diedrichs, *et al.,* 2006; Goffin & Pfeiffer, 1999; Smith *et al.,* 2008.
142. The 1990 Cohen and Levinthal paper has over 30,000 citations.

While this conceptualisation of a capacity would seem to be useful and unambiguous, translating the concept into a practical measurement approach is difficult. The constituent elements that are likely to form the four components of the capacity are quite diverse and vary across sectors[143]. For example, links to the science base are vital in some industries, but irrelevant in others. Substantial discussion of the conceptual framework and approaches to measurement continue in the literature.[144]

Research on absorptive capacity has found that firms can more easily add to knowledge and diversify in areas in which they already have a knowledge base. But firms face particular challenges in external knowledge acquisition where:

> They have few linkages with the firms or organisations from which they seek to acquire knowledge

> The fields of knowledge and innovation are new to the firm

> The pace of change in technology is rapid and unpredictable[145]

Kostopoulos *et al.* (2011) developed and tested a 17-item assessment tool for absorptive capacity on a large sample of Spanish firms. This approach reduces the problem of sectoral differences in the importance of the different elements of absorptive capacity by asking firms to assess their performance relative to other firms in their industry. It may be feasible to use some aspects of the approach in a survey such as the Australian Bureau of Statistics (ABS) Business Characteristics Survey.

Human resources and human resource management are a critically important components of firms' resources. Focusing on the Australian context, Smith *et al.,* (2011) provide a guide to the voluminous literature on these issues.

6.2.6 Innovation and firm culture

The role of corporate culture in innovation performance has attracted increasing interest and there are increasing attempts to characterise and enable assessment of culture (or climate)[146]. Hao *et al.* (2017) review several quite different frameworks for assessing a company's innovation capability or performance and note that a number of these frameworks incorporate indicators of corporate culture.

Two particular aspects of culture that are likely to strongly shape innovation strategies and performance are attitudes to risk and the time horizon used for planning. Most of the recent literature on risk aversion and innovation concerns the public sector, the agricultural industry or entrepreneurship surveys. However, the scope for indicators of risk aversion in innovation surveys warrants further assessment.

There is also a related and increasing literature on the relationship between corporate governance and innovation, with specific regard to the impact of 'short-termism' on investments in building capability and undertaking innovation[147]. This also warrants further assessment with a view to developing indicators.

6.3 Intangible capital

A company's capacity to innovate greatly depends on intangible assets, including the knowledge it possesses and the manner in which it is able to employ these assets. Intangible assets include types of intellectual capital such as the possession of adequate professional competencies, good relations within the workforce, organisational technology and the capacity to attract and retain the best professionals. Intellectual capital is considered to encompass elements such as knowledge-based capital, processes, organisational structure, relationship capital, design and human capital[148]. Innovation research, both at the firm and system level, consistently finds that quantitative measures of activities such as R&D or outputs such as patents, 'explain' a small proportion of variance in performance – except at high levels of aggregation. The research points to the importance of intangible characteristics such as culture, prior experience, learning rates, networks and mentorship. Awano, *et al.* (2010) found from a survey in the UK that in services firms and smaller firms, non-R&D forms of intangible investment were substantially more important than R&D investment.

143. Scott-Kemmis, *et al.* 2008, review the literature on absorptive capacity and provide several case studies that aim characterise the process of knowledge absorption and application in Australian firms.

144. For example Camisón & Forés, 2010; Zahra & George, 2002; Todorova & Durisin, 2007; Fabrizio, 2009.

145. Scott-Kemmis, *et al.,* 2008.

146. Ahmed, 1998; Martins & Terblance, 2003; Tellis, *et al.,* 2009; Tidd & Bessant, 2009; Buschgens *et al.,* 2013

147. Quinn, 1979; Barringer & Bluedorn,1999; Ruff, 2006; Hamel, 2006; Mazzucato, 2015, 2018

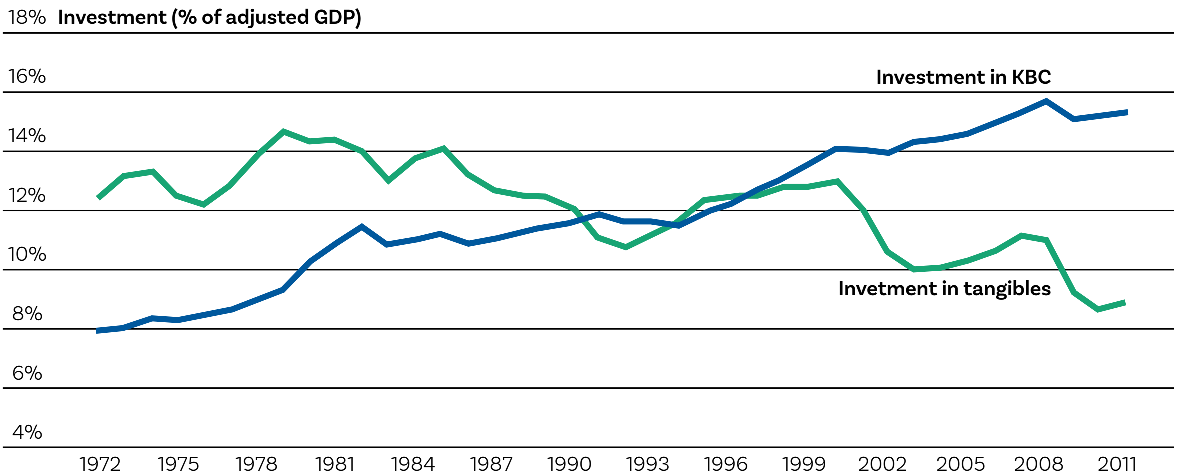
148. Mariz-Pérez *et al.,* 2012

The proportion of the value of modern firms accounted for by intangible capital has risen steeply over the last thirty years or so. While it is universally accepted that intangibles are the most important assets and liabilities in our economy, accurately identifying, measuring and valuing intangibles are difficult and related tasks. The lack of an explicit valuation of intangible assets may encourage information asymmetries and inefficiencies on stock markets[149]. This is important because it makes it harder for firms to capture their investments – intangible capital is harder to protect and tends to diffuse, benefiting parties other than its creators. This in turn means that firms are more likely to underinvest, with consequent effects on productivity because labour does not have enough (intangible) capital to work with.

From a policy perspective, this strengthens the case for government intervention in creating intangible assets, for example by investing in the research system and elsewhere. It also strengthens the case for clear intellectual property rights and fostering a financial services sector able to finance intangible-intensive businesses.[150]

Corrado, *et al.* (2013) define a set of intangible investments and using available data arrive at estimates of these investments for several countries. While acknowledging that much intangible investment cannot be adequately measured with current data, they conclude the relative levels of tangible and intangible investment vary across counties, that the shift to intangible investment is striking and that 'future investment will look much more intangible than tangible' [151] (**Figure 7**). Their estimates indicate that once intangible investments are included with tangible investments, capital deepening becomes the dominant source of growth in the EU and the US. They also find a correlation between capital deepening and MFP, which suggests that there are likely to be spillovers from intangible investment – and hence a case for public policy to support such investment.

Figure 7: Business investment in knowledge-based capital (KBC) and in tangible assets in the United States (% GDP, 1972-2011)[152]



Advancing the measurement of intangible capital (also termed knowledge-based capital) is clearly critical for innovation policy and would help to improve understanding of the sources of employment and productivity growth and the design of evidence-based policies[153]. A cross country effort is currently being made to create consistent economy-wide estimates of intangible investment under the SPINTAN project funded by the EU.[154]

Intangible capital can broadly be considered intellectual property (IP), and some of that IP is protected by IP rights (IPR) in the form of patents, copyrights, trademarks, plant breeder's rights and design rights, which provide legal protection of knowledge-based capital[155]. Well-defined IPRs are important in some industries to provide firms with the incentive to innovate and to promote knowledge diffusion via the public disclosure of ideas, and across most industries in protecting the branding and names of products and services[156].

149. Vallejo-Alonso, *et al.,* 2011
150. Haskel & Westlake, 2017
151. Corrado, *et al.,* 2013, p.284; see also OECD, 2013; Belitz & Mouel, 2018; Webster, 2000; Grasenick & Low, 2004
152. Unpublished update of Corrado, C.A. and C.R. Hulten (2010), "How do you Measure a 'Technological Revolution?", American Economic Review: Papers & Proceedings 100 (May 2010): 99–104 in Pilat https://www.slideshare.net/innovationoecd/2015-innovation-strategy-pptThe Innovation Imperative – Main Messages
153. Haskel & Wallis, 2013
154. http://www.spintan.net/
155. OECD. 2013
156. Andrews & Criscuolo, 2013

The Australian Bureau of Statistics (ABS) measures four categories of IP assets recognised in the 2008 System of National Accounts (SNA08) framework[157], but also includes a fifth category of knowledge-based capital – economic competencies), not all of which can be mapped onto IPRs[158].

This approach does not capture all forms of intangible investment and the gaps may be particularly important in some sectors and for some types of firm. One recognised gap is the measurement of some intangibles, especially copyright content creation and software creation, which would benefit from improved measurement. One of the most important gaps is in the area of relationship capital (and related concepts such as social capital and collaboration capability) which is increasingly important for formal collaboration, informal collaboration and the flow of tacit knowledge through networks[159]. Den Hartog *et al.,* (1997) found that in some industries investment in developing customers and market channels was significant. The assessment of how best to measure investment in human capital will be one particularly important dimension in the Australian context, where such investments will be closely related to absorptive capacity[160].

6.4 Measuring the diversity of innovation activity – the Oslo Manual

The Oslo Manual proposes a separate definition of innovation as a *process* and as an *outcome*:[161]

> **Innovation activities** include all developmental, financial and commercial activities undertaken by a firm that are intended to result in an innovation for the firm

> **A business innovation** is a new or improved product or business process

In order to reduce the complexity of its previous approach the Oslo Manual has introduced a significant change to the basic definitions of a business product and process innovation, which are:

> **A product innovation** is a new or improved good or service that differs significantly from the firm's previous goods or services and that has been introduced on the market

> **A business process innovation** is a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and that has been brought into use by the firm

The manual suggests eight types of activities that firms can undertake in pursuit of innovation:

- Research and experimental development (R&D) activities
- Engineering, design and other creative work activities
- Marketing and brand equity activities
- Intellectual property (IP) related activities
- Employee training activities
- Software development and database activities
- Activities relating to the acquisition or lease of tangible assets
- Innovation management activities

This proposed list of activities includes most types of non-R&D activity that commentators have identified as contributing to 'hidden innovation', and hence, if taken up by national statistical agencies will largely address this perceived gap in innovation indicators. The manual recommends collecting data on whether or not firms conduct each of these activities and whether they do so in pursuit of innovation, on expenditure on those activities for innovation, and on whether the activities are conducted in-house or procured from external sources – but recognises that challenges remain for effective data collection.

A section of the Oslo Manual newly added in 2018 addresses the issue of business capabilities, including the knowledge, competencies and resources that a firm accumulates over time. This section comments that "collecting data on business capabilities is of critical importance for analyses of the effect of innovation on firm performance and why some firms engage in innovation activities and others do not."[162]

157. UN, *et al.* 2008
158. Corrado, *et al.,* 2013 use a similar framework for their estimates.
159. Blomqvist & Levy, 2006; Moran, 2005; Gu & Lev, 2011
160. Bontis, 1998; Pickett, 2005; Kianto, *et al.*, 2010; Baron, A., 2011
161. OECD, DSTI/STP/NESTI, 2018 Oslo Manual 2018, Guidelines for collecting, reporting and using data on innovation. OECD, Paris, p. 21
162. OECD, DSTI/STP/NESTI, 2018 Oslo Manual 2018, Guidelines for collecting, reporting and using data on innovation. OECD, Paris, p. 23.

Recognising that many different business capabilities can potentially support innovation activities, the 2018 Oslo Manual provides measurement options for four types of capabilities that are relevant for research on the innovation performance of all firms:

> The resources controlled by a firm
> The general management capabilities of a firm
> The skills of the workforce and how a firm manages its human resources
> The ability to design, develop and adopt technological tools and data resources, with the latter providing an increasingly important source of information for innovation

The adequacy of these proposed options for assessing key elements of firm's innovation-related capabilities should be assessed for feasibility of application in Australia.

7. Beyond the firm – Innovation systems perspectives

As discussed briefly above, the innovation systems perspective has had a profound influence on innovation studies and innovation policy. The influence of this perspective arises from three insights:

1. **Innovation is increasingly a distributed activity:** Innovation is less an intra-firm process as it is increasingly interactive and distributed across organisations, fields of knowledge, and regions, in a complex division of innovative labour. Hence, a focus on innovation at the firm level is not adequate. Firms' capabilities for innovation are also developed outside the context of specific innovation projects through flows of knowledge through personnel and other mechanisms. Studies also show that the majority of the knowledge flows from external sources are informal, through non-market mechanisms, and hence are not priced[163]. As the significance, within a firm, of different sources and channels varies from innovation to innovation, firm to firm and sector to sector, aggregation across all of the innovations within a firm across firms and sectors reduces the signal to noise, and is likely to provide a misleading perspective.[164]
2. **Innovation activity at the firm level is strongly shaped by a firm's context:** The development of firms' capacities to innovate, their incentives to innovate and the resources they can draw on to innovate are strongly shaped by their economic, institutional and social environment[165]. The 2018 Oslo Manual states on the system view of innovation that it "stresses the importance of external factors that can influence a firm's incentives to innovate, the types of innovation activities that it undertakes, and its innovation capabilities and outcomes" and that such factors include "the activities of customers, competitors and suppliers; labour market, legal, regulatory, competitive and economic conditions; and the supply of technological and other types of knowledge of value to innovation."[166]
3. **Significant features of a firm's context could be national, sectoral or regional:** Linkages and knowledge flows are increasingly dispersed, enabled by IT, facilitated by globalisation and in large part driven by the search for talent. However, it is clear that there are strong centripetal forces that lead to spatial concentrations of innovative and entrepreneurial activity.

The novel approaches of innovation systems perspectives introduce wider scope and more complexity to innovation policy and analysis. It is perhaps not surprising that the simplicity of the 'linear model' – both conceptually and in term of policy targets and rationales – continues to have a strong influence. Developing approaches to assessing the performance of innovation systems, and of systems-oriented policies, that are conceptually sound yet enable a useful of comparability, remains a challenge. The systems perspective and the implications of this perspective for indicators are discussed below.

7.1 Innovation Systems Perspectives

The innovation systems perspective emphasises the extent to which the industrial, economic, institutional (i.e. formal laws and regulations, informal habits and conventions,) and social context influences firm-level innovation strategy and activity[167]. Lasit and Borras (2016) found that:

> *During the past two decades the innovation system approach has gained substantive endorsement among scholars and policy-makers alike. This approach sees innovation as a complex social process of cumulative nature, embedded in complex institutional and organizational national contexts….. It brings forward the notion of innovation as the outcome of complex interactions and dynamics in the idiosyncratic socio-economic context of an economy.*[168]

Institutional frameworks tend to be conservative and can be a form of 'lock in' preventing change[169]. Hence, an innovation policy that has been effective in one context may be ineffective in another. One important implication of this perspective is that the scope of innovation analysis and policy widens beyond the industrial system and knowledge infrastructure to include, for example, education, the finance system, regulation and procurement across the public sector, social institutions[170], networks and linkages[171].

163. National Academies of Sciences, Engineering, and Medicine, 2017, p.33.
164. Cohen cited in National Academies of Sciences, Engineering, and Medicine, 2017 and Arora cited in Cohen cited in National Academies of Sciences, Engineering, and Medicine, 2017.
165. Chaminade, *et al.*, 2018;
166. OECD, Oslo Manual, 2018. OECD, Paris. p. 138.
167. Fagerberg, 2013, Martin, 2012; Hall & Soskice, (eds) 2001; Akçomak & Ter Weel, 2009; Baumol, 2002; Baumol *et al.*, (2007); Godin, 2009.
168. Laatsit & Borras, 2016, p.3.
169. Dodgson *et al.*, 2011. This has become a key issue for the design of multi-level strategies for transformative system change, for example, toward a lower-carbon economy.
170. Including the role of social institutions in shaping trust, risk tolerance, and social capital more generally – Fagerberg, 2013.
171. Carlsson, 2007.

Firms and innovation systems accumulate what could be considered 'relationship capital'[172]. Whether the focus is at the firm level or at one of the systems levels, the role of cumulativeness in innovation emphasises the limitations of approaches that assess innovation inputs and outputs from a transactional perspective.[173]

One of the aspects of innovation systems that has become more significant for innovation policy is the shaping and role of the demand side[174]. The level of demand shapes investment in production facilities and the entry of new firms, while the nature of demand can provide a stimulus for innovation. Government regulation and procurement policies can have major impacts on innovation and entrepreneurship.[175]

Innovation systems perspectives are inherently dynamic; technologies, industries and societies co-evolve, and hence innovation systems evolve[176]. The evolution of industries often involves periods of disruptive change, characterised by levels of 'creative destruction' when established firms, competencies, networks, industries and regional economies are challenged and periods of more incremental change ('creative accumulation') when newly established firms are consolidated. Within these evolutionary processes the diffusion of technologies – principally the diffusion of knowledge – is a key process, again highlighting the significance of absorptive capacity and not only knowledge generating capacity. It is the diffusion of innovations through their uptake and adaptation throughout an economy that generates the impact of innovation[177].

National innovation systems have been variously defined as:[178]

> The network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies[179]

> All important economic, social, political, organizational, institutional and other input factors that influence the development, diffusion and use of innovations[180]

> A set of institutions whose interactions determine the innovative performance of national firms[181].

There have been a number of important extensions of the national innovation systems approach. These share much of the same underlying conceptual frameworks but apply that framework to 'systems' with different boundaries – nation, sector, region, technology – and that leads to different emphases of the key dimensions of the 'systems'[182]. The entrepreneurial ecosystem concept is also included in this discussion.

7.1.1 Sectoral Innovation Systems (SIS)

The concept of sectoral innovation systems is derived from the national innovation systems approach, with a more strongly evolutionary economics orientation. It focuses on market and non-market interactions among firms and related organisations involved in developing, producing and marketing a specific set of products. In the conceptual framework developed for sectoral innovation systems assessment, particular attention is paid to the knowledge base of the sector, patterns of learning and collaboration, the structure of demand the role of competition in shaping the selection environment, and the role of and of institutions that shape these processes. From the outset the approach considered the processes of co-evolution that could transform the sector and the sectoral innovation system.[183]

7.1.2 Regional Innovation Systems (RIS)

Despite the increasing role of digital technologies in enabling interacting innovation, activity remains geographically concentrated[184]. ICT can enable a broader and faster exchange of codified knowledge and ideas, but transfer of tacit knowledge tends to rely on proximity[185].

172. OECD, 2008.
173. National Academies of Sciences, Engineering, and Medicine, 2017, p.90.
174. Porter, 1990, had also emphasised the role of demand as a strong endogenous driver of innovation and capability upgrading in industrial clusters. Von Hippel, 1986 identified the role 'lead users' as sources of innovation.
175. Edler & Georghiou, 2007; Jaffe *et al.*, 1995.
176. The 1982 work of Nelson & Winter, An Evolutionary Theory of Economic Change, is the most cited work in the field of innovation studies – Martin, 2012.
177. Gassmann, 2006; Fagerberg, 2013.
178. Balzat & Hanusch, 2004; Lundvall, 2007; Nasierowski, 2009.
179. OECD, 1997.
180. Borras & Edquist, 2016.
181. Lundvall, 2007.
182. Borras & Edquist, 2006 argue that national, regional and sectoral innovation systems complement each other.
183. Malerba, 2002; Malerba & Adams, 2014.
184. Cooke and Morgan, 1998; Saxenian, 1994; Cooke, *et al.*, 1997; OECD, 2008; Lowe, 2009; Zabala-Iturriagagoitia, *et al.,* 2007.
185. Sonn & Storper, 2008.

Two approaches in the innovation-related literature on regional dynamics have been particularly influential: regional innovation systems (RIS) and industrial clusters. Whereas the frameworks for assessing industrial clusters focus on firms in related industries within a geographical area, the RIS approach concerns "...interacting knowledge generation and exploitation subsystems linked to global, national and other regional systems" [186].

7.1.3 Technology innovation systems (TIS)

The technology innovation systems approach is to some extent a hybrid of the sectoral and RIS approaches. It focuses on specific technologies and on the firms (and other organisations) involved in the generation, diffusion and application of a technology, within an economic or industrial area and institutional infrastructure. The emphasis is on the evolution of the knowledge or competency base and on the influence of a range of 'functions' that shape the evolution of the TIS[187].

7.1.4 Entrepreneurial Ecosystems

There is increasing research in many countries aiming to identify, understand and measure the key dimensions of entrepreneurial ecosystems[188], defined as:

> *A set of interconnected entrepreneurial actors (both potential and existing), entrepreneurial organizations (e.g., firms, venture capitalists, business angels, and banks), institutions (universities, public sector agencies, and financial bodies), and entrepreneurial processes (e.g. the business birth rate, numbers of high growth firms, levels of 'blockbuster entrepreneurship', number of serial entrepreneurs, degree of sell-out mentality within firms, and levels of entrepreneurial ambition) which formally and informally coalesce to connect, mediate and govern the performance within the local entrepreneurial environment.*[189]

The significance of entrepreneurial ecosystems is developed further in **Section 8**.

7.2 Implications of the systems perspective for policy and for indicator design

Innovation systems approaches have more explicitly brought social and institutional dimensions into innovation analysis and policy. Elaborating the components of an innovation system provides a rich framework for performance analysis but a challenging palette for policy. Some approaches to innovation system description and assessment detail the many components and elements of an innovation system and enable a level of international comparison at the component level and in terms of an overall characterisation.

Innovation system analysis for assessing policy priorities has focused on the identification of bottlenecks, deficiencies or weaknesses, which are conceived as problems or 'system failures' in relation to the expected dynamics and processes of innovation[190]. In practice, these more internal assessments of innovation system performance often employ benchmarks based on international 'best practice' for specific dimensions of performance.

A significant application of the innovation systems approach, particularly drawing on that of TIS (see **section 7.1.3** above), has been the development of frameworks for policy aiming to promote experimentation and to drive socio-technical change through, for example, strategic niche management, transition management, and strategic innovation system management[191]. Initiatives pursuing such policy objectives would require customised indicators in addition to a background range of innovation indicators.

With their emphasis on the context-specific dynamics of innovation and the co-evolution of actors and institutions (and hence of the specific history of the 'system'), systems approaches signal the risks of reductionism that are inevitably required for indicator development and interpretation. One of those risks arises from inappropriate aggregation of individual indicators. One of the characteristics of innovation is that its occurrence and significance is highly unevenly distributed – across firms, sectors, regions and time. For example, through the 1980s and 1990s it was the view, based on statistical analysis, that SMEs were the major contributor to employment growth.

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186. National Academies of Sciences, Engineering, and Medicine, 2017, p.83; Asheim & Coenen, 2005; Andersson, *et al.,* 2004; Asheim, *et al.,* (Eds), 2006; Benneworth *et al.,* 2003; Beaudry & Breschi, 2003; Martin & Sunley, 2003; Porter, M.E., 2001.
187. Carlsson & Stankiewicz, 1991.It is argued that a focus on the actors, knowledge flows and institutions at the level of specific technologies enables a more useful understanding of the dynamics of innovation as a basis for policy to address 'barriers' to desirable change; Bergek, *et al.,* 2008; Hekkert, *et al.,* 2006; Hekkert & Negro, 2009; Geels, 2002.
188. Malecki, 2018.
189. Mason & Brown, p.9. An extensive list of alternative definitions is in Malecki, 2018.
190. Woolthuis *et al.,* 2005; Rubalcaba *et al.,* 2010; Martin & Trippl, 2014.
191. Geels, 2002; Geels & Schot, 2007; Markard *et al.,* 2012; Kemp *et al.,* 1998; Winskel & Moran, 2008; Foxon & Pearson, 2008.

This view had a major impact on the level of policy focus on SMEs. However, careful research in the late 1990s, subsequently repeated in many countries (including Australia), found that in fact a very small number of 'high growth firms' (typically around five per cent of all firms) accounted for over fifty per cent of net employment growth[192].

A second risk is the aggregation of indicators assessing different dimensions of performance to arrive at an overall performance index. Such singular numbers have significant limitations when it comes to the development of policy, and can be even be misleading. Composite indicators are discussed further in **section 9.2.5** below.

A third risk that is signalled by the innovation systems approach, with its emphasis on *sui generis* dynamics, is that of policy benchmarking. Chaminade *et al.* (2018) emphasised that context matters, and "the idea of international benchmarking looking for 'best practice' policy in a specific field to be generally applied across national systems is inadequate."[193]

7.2.1 Challenges in evaluating innovation systems

It is clear that despite general acceptance of the innovation systems framework, developing appropriate approaches to evaluation remains a challenge. Three particular challenges are identified in the literature:

How can the performance of an innovation system best be assessed?

The innovation systems approaches provide conceptually rich frameworks that contribute to insight in the interpretation of patterns of innovation. However, evaluating the performance of measures that aim to improve national or regional innovation performance remains challenging. As Laatsit and Borras (2016) remark: "… conceptual inconclusiveness [around systems evaluations] has resulted in the inability to grasp country-level empirical observations meaningfully because too broad concepts are poorly equipped to operationalize the analysis and data collection."[194]

What indicators are likely to be most appropriate?

While some dimensions of innovation system performance are reasonably readily assessed with established indicators more comprehensive approaches to the development and assessment of innovation systems-related indicators remains challenging.

> *With more than 30 years of national system of innovation theoretical approaches, there is still a considerable lack of knowledge on how to assess the effectiveness of complex policy systems…. the holistic view of innovation policies …with the focus on interaction and interactive learning between organizations…has raised awareness about the need of more sophisticated tools to enable policy-makers better grasp the complexity of the impact of policy instruments…. The innovation system approach and the theoretical framework it suggests "have proved difficult to use in the practice of evaluation, resulting in a gap between evaluation practice and Science Technology Innovation (STI) policy theory" (Molas-Gallart and Davies 2006). In spite of some very few attempts to link innovation system theory with evaluation frameworks, the literature of innovation system approach continues to have a largely 'unfinished business' of bringing together theory and the practice of policy-making and its evaluation…*[195]

How is systemic change at all levels best assessed?

Central to the evolutionary economics perspective is the co-evolution of all components of an innovation system, yet incorporating systemic change into assessments and evaluations is challenging. Laatsit and Borras (2016) quote Feller (2007) as describing the complex cause:

> *Existing evaluations touch only lightly, however, on how the strategies, behaviour, performance of the sectors or actors described in the national innovation taxonomy change as a result of the cumulative, long term impact of a cluster of programs*[196]

192. Decker *et al.*, 2014; Haltiwanger *et al.*, 2013; Davidson & Delmar, 2003, 2006.
193. Chaminade *et al.*, 2018, p.4.
194. Laatsit & Borras, 2016, p2.
195. Laatsit & Borras, 2016, p2-4.
196. Laatsit & Borras, 2016, p3.

7.2.2 Innovation System Functions and Innovation Indicators

The innovation systems approach presents a challenge for innovation policy and analysis, including the design and construction of innovation-related metrics. A wide and diverse range of organisations, relationships and institutions are potentially in scope and the boundary of an innovation system may be indeterminate. One promising approach is to specify the most critical 'functions' of an innovation system and aim to develop indicators for these[197]. **Table 4** draws on a number of proposals for identifying and characterising system functions to illustrate the approach. The table shows the extent to which there is a high level of homology in these functions across the hierarchy of system levels. This extends to the firm level, where a firm's system of innovation can be conceptualised and assessed through a functions approach.

Table 4: Innovation System Functions – An Illustrative Integrative Framework[200]

Functions of Innovation Systems	National, Regional and Sectoral Innovation Systems	Entrepreneurial Ecosystems	Firms
Knowledge generation and Technological opportunity	Investment in R&D and other knowledge generation processes	Knowledge generation in firms and research organisations	Investment in R&D and other knowledge generation processes
Knowledge and support flows	Linkages for knowledge diffusion, access to services, interaction	Access to knowledge and to support services – mentoring, incubation, accelerators	Acquisition of knowledge; absorptive capacity
Capability formation	Skill formation, accumulation of competencies, appropriation	Talent formation and attraction, capability development, entrepreneurial experience	Competency development: hiring, training, experience
Finance flows	Access to finance at reasonable terms	Access to risk finance	Investment in innovation and production capacity
Demand	Level and spur to innovation – regulation, policy, openness of product markets	Level and spur to innovation – regulation, policy, openness of product markets	Innovation strategy that shapes the demand for innovation
Governance	Institutional role in shaping culture and levels of trust, risk. Role of strategies and missions	Institutional role in shaping culture and levels of trust, risk	Leadership and corporate governance shapes culture, risk tolerance etc.
Entrepreneurship	Creation and change in organisations/actors	Creation and change in actors in the ecosystem, including large firms	Intrapreneurship, entry to new markets, fields, technologies
Overall	Coherence, synergies, blocks and limiting factors, response to new challenges		

From this perspective a combination of micro, meso and macro assessments would contribute to innovation system assessments of greater value to policy evaluation and development. The functions at each level may interact to develop synergies or there may be mismatches between the micro, meso and macro levels, for example when the NIS or RIS does not support an emerging technology or industry[198].

The 2018 Oslo Manual proposes a new approach to data collection at the firm level, with an approach that would enable both the assessment of some aspects of a firm's innovation system but also a micro level perspective on the interaction between the firm's innovation system and the innovation systems beyond the firm[199]. One part of the proposed data collection is a set of questions on innovation drivers and barriers that would provide a valuable 'bottom-up' perspective on the main functions of higher-level innovation systems. This proposed framework is set out in **Table 5**.

197. Fagerberg, 2013.
198. Laatsit & Borras, 2016.
199. OECD, 2018, Oslo Manual- 2018, OECD, Paris. Chapter 7.
200. The table draws on Hekkert & Negro, 2009; Hekkert, *et al.*, 2006; Borras & Edquist, 2006, 2016; Chaminade *et al.*, 2018; Mahroum & Al-Saleh, 2013; Eggink, 2013; Grønning & Fosstenløkken, 2015. NB The purpose of this table is to provide an example of the major innovation system functions characterised by various authors and to suggest the scope for an integration that could be a basis for indicator development.

Table 5: Oslo Manual – 2018. Proposal for integrated collection of data on external drivers of innovation[201]

Potential impacts on:	Importance as a driver of innovation (low, medium, high, not relevant)
Markets	
> Domestic customers	
> Access to international markets	
> Suppliers and value chains	
> Availability/cost of skills	
> Availability/cost of finance	
> Competitors	
> Standards	
> Markets for knowledge	
> Digital platforms	
Public policy	
> Regulations	
> Functioning of courts and rules enforcement	
> Taxation	
> Public spending (level and priorities)	
> Government support for innovation	
> Government demand for innovations	
> Public infrastructure	
> General policy stability	
Society	
> Consumer responsiveness to innovation	
> Favourable public opinion towards innovation	
> Level of trust among economic actors	

201. OECD, 2018. Oslo Manual-2018. OECD, Paris. p. 160.

8. New dynamics, perspectives and trajectories in innovation

Along with economic impact, innovation has the capacity to influence non-market outcomes in such areas as health and environmental sustainability and has affects in workplaces and communities. However, connecting measures of innovation to economic and social outcomes is often even more challenging than quantifying innovation or its inputs[202].

This section focuses on a set of wider innovation issues that are becoming important for policy, in each case considering the difficult challenge of developing useful innovation indicators, including:

> **The key role of entrepreneurship in 'creative destruction'**

> **The pervasive impacts of digital transformation**

> **The challenge of eco-innovation and sustainability**

New innovation dynamics and trajectories can be used as an indicator of the energy in the economy. Business experiments and entrepreneurial activity are intrinsically innovative and highly dynamic, and measuring them could give an indication of how supportive the economy is toward all types of innovation.

8.1 Business experiments

The creation of a new venture is a form of business experiment that is vitally important in discovering new opportunities for value creation. The level and quality of such experimentation is a key indicator of the dynamism of an economy. The term entrepreneurship is sometimes used to refer to the formation of new firms and the championing of change in established organisations (intrapreneurship), but the following discussion is focused on new firm formation.

It is now widely recognised that new firm formation has a key role in the generation of employment and the diffusion of knowledge. However, most startups replicate established business models and have low levels of novelty and low growth ambitions. Innovation-based and growth-oriented startups are a form of business experiment that can discover new opportunities for value creation. Such firms can have major impacts on innovation, employment, industry development and structural change, and have a vitally important role in times of techno-economic change, when they are key sources of learning and dynamism[203]. Hence, it is important to be able to distinguish the replicative and the innovative startups in policy and through indicators[204].

As is the case with most innovation-related indicators, the development of entrepreneurship indicators faces the two perennial challenges:

> Developing indicators of the significance ('quality') of activity

> Taking into account the highly spatially skewed distribution of activity, particularly high potential activity

In their reviews of science, technology and innovation indicators, Gault (2013), Hall and Jaffe (2012) and US NRC (2012) place little emphasis on entrepreneurship-related indicators. In a wide-ranging review of innovation indicators for NESTA Allman *et al.* (2011) included an extensive discussion of entrepreneurship but suggested a set of fairly standard indicators including: attitude towards the risk of business failure, barriers to entrepreneurship, early-stage entrepreneurial activity, access to finance, stock market capitalisation, availability of venture capital, and access to finance.

In 2006 the OECD began its Entrepreneurship Indicators Programme (EIP) and Eurostat joined in 2007. The EIP aims to build the basis for internationally comparable statistics on entrepreneurship and its determinants[205]. The work to develop standard definitions and concepts as a basis for the collection of empirical data has had to address the fact that "…entrepreneurship is a multifaceted concept that manifests itself in many different ways, with the result that various definitions have emerged and no single definition has been generally agreed upon."[206] The OECD-Eurostat approach uses the following (ambiguous) definitions:

> **Entrepreneurs** are those persons (business owners) who seek to generate value through the creation or expansion of economic activity, by identifying and exploiting new products, processes or markets.

> **Entrepreneurial activity** is enterprising human action in pursuit of the generation of value through the creation or expansion of economic activity, by identifying and exploiting new products, processes or markets.

> **Entrepreneurship** is the phenomenon associated with entrepreneurial activity.[207]

202. National Academies of Sciences, Engineering, and Medicine, 2017, p.5.
203. Acs *et al.*, 2014; OECD, 2009; Szirmai, A. *et al.*, 2011 .
204. DIISR, 2009.
205. OECD 2009. p.5.
206. OECD 2009.
207. OECD 2009, p.6.

EIP do not propose a single indicator as a basis for assessing entrepreneurship or for comparisons across countries:

> *Since entrepreneurship is a very broad phenomenon which encompasses, for example, virtually all new firm creation, it is extremely important for policy analysts to be able to understand and distinguish different types of entrepreneurial performance. Indicators of firm births, deaths, high-growth firms, gazelles, etc., all capture different aspects of entrepreneurship and different types of entrepreneurs.*[208]

The EIP developed a framework for entrepreneurship indicators based on three categories:

1. **Determinants of Entrepreneurship**
   > Culture
   > Regulatory framework
   > R&D and technology
   > Entrepreneurial capabilities
   > Access to finance
   > Market conditions
2. **Entrepreneurial Performance**
   > Other indicators of entrepreneurial performance
   > Firm-based indicators Job creation
   > Employment-based indicators
3. **Impact**
   > Job Creation
   > Poverty reduction
   > Economic growth[209]

The 2009 EIP report compiled a wide range of statistics based on the indictors, listed in **Table 6**.

208. OECD, 2009. p.7-8.
209. This is based on Ahmad & Hoffmann, 2008.

Table 6: EIP Entrepreneurship and Entrepreneurial Ecosystem Indicators[210]

Proposed Indicators	
Structural indicators on enterprise population	
> Enterprises by size class > Employment by size class	> Value added by size class > Exports by size class
Entrepreneurial performance	
> Employer enterprise birth rates (manufacturing and services by industry, by size class) > Employer enterprise death rates (manufacturing and services, by industry, by size class) > One- and two-year survival rates (manufacturing and services) > Share of gazelles (employment)	> Share of one- and two-year-old employer enterprises in the population (manufacturing and services > Share of high-growth firms (employment) > Share of high-growth firms (turnover) > Share of gazelles (turnover) > Employment creation by enterprise births > Employment destruction by enterprise deaths
Timely indicators of entrepreneurship	
> Timely indicators on enterprise exits for selected countries	> Timely indicators on enterprise entries for selected countries
Entrepreneurial determinants	
> Knowledge creation and diffusion > Business R&D intensity, by size class of firms > Firms with new-to-market innovations, by size > Firms collaborating on innovation, by size > Turnover from e-commerce > Access to finance > Ease of access to loans > Business angels (networks) > Venture capital investments > Share of high-technology sectors in total venture capital > Entrepreneurial capabilities > Population with tertiary education > Self-employment by place of birth > International students in tertiary education	> Population aged 18-64 with training in starting a business > Regulatory framework > Ease of doing business > Barriers to entrepreneurship > Top statutory personal income tax rate > Top statutory corporate income tax rate > Market conditions > Competition law and policy indicator (main components) > Import burden > Export burden > Entrepreneurial culture > Preference for self-employment > Entrepreneurial perceptions > Positive image of entrepreneurship and entrepreneurs > Negative image of entrepreneurship and entrepreneurs

Unfortunately, the indicators compiled in the 2009 report included only two for Australia and so the scope for comparability is absent. DIISR (2009) proposes a focus on new ventures that introduce some form of technological or non-technological innovation, particularly those that grow, and proposes a limited set of entrepreneurship indicators, most of which would not provide international comparability. In Australia, the *Startup Muster report 2018* sought to identify the more innovative startups by restricting their coverage to early stage businesses that have a large addressable market and that use technology to capture that market quickly[211]. Unfortunately, this is an ambiguous definition that also does not facilitate international comparisons.

8.1.1 National Entrepreneurship Indicators

There have been a number of approaches to development of entrepreneurship indicators outside the scope of the OECD and NSOs. The most important of these focus on assessing entrepreneurship (performance or potential) at the national level. The most widely influential is that of the Global Entrepreneurship Monitor (GEM). GEM indicators are widely used in compilations of innovation and entrepreneurship indicators, largely because there are no alternatives that provide a similar level of coverage and claimed comparability[212].

210. OECD, 2009. p.9-10.
211. Startup Muster Report 2018. Startup Muster https://www.startupmuster.com/reports
212. GEM, 2017; Reynolds, 2017.

The Global Entrepreneurship Index uses many of the GEM indicators but supplements these with indicators from other sources[213]. Acs *et al.* (2014) acknowledge both the lack of agreed definitions of entrepreneurship and the many dimensions of entrepreneurial determinants, activity and impacts. They argue that a systemic approach to understanding country-level entrepreneurship is required, similar to the concepts of national systems of entrepreneurship, which they define as:

> *A National System of Entrepreneurship is the dynamic, institutionally embedded interaction between entrepreneurial attitudes, ability, and aspirations, by individuals, which drives the allocation of resources through the creation and operation of new ventures.*[214]

Acs et al. proposed a Global Entrepreneurship and Development Index (GEDI) based on three sets of indicators: output measures (i.e. new firm formation), attitudes to entrepreneurship-related activities, and framework measures. Using data from a range of international surveys and an innovative approach to weighting they construct a set of fifteen pillars of entrepreneurship:

- Opportunity perception
- Startup skills
- Risk acceptance
- Networking
- Cultural support
- Opportunity startup
- Technology sector
- Gender
- Quality of human resources
- Competition
- Product innovation
- Process innovation
- High growth
- Internationalization
- Risk capital

After taking into account systems-level constraints that arise from low levels of performance in any of these pillars that would form limiting factors, Acs *et al.* estimate an overall national GEDI[215].

8.1.2 Quality of Entrepreneurship

Since the early 2000s, the significance of high growth firms for employment and innovation has attracted increasing research and policy interest[216]. In many countries entrepreneurship policy is shifting focus to the quality rather than the quantity of entrepreneurship[217]. Guzman and Stern (2016 estimate measures of entrepreneurial quality based on predictive analytics and comprehensive business registries. They claim that their indicators are able to provide policy-useful predictions of the 'quality' – i.e. growth potential – of a cohort of start-ups and of entrepreneurial activity in a region[218].

OECD (2010) also suggest that more work needs to be done to develop metrics of entrepreneurial activity beyond the measures such as self-employment that are currently used. This includes the development of standardised indicators of entrepreneurial education. The report also notes that indicators of venture capital and business angel investment that enable comparability are improving[219]. The report cites research that shows the important role of young firms in net jobs growth and proposes better indicators of the survival of young firms.

213. Acs *et al.*, 2014.
214. Acs *et al.*, 2014, p.479.
215. The Global Entrepreneurship and Development Institute, accessed 25 February 2019 at https://thegedi.org/
216. Coad, *et al.*, 2014; Brown & Mawson, 2013; Henrekson & Johansson, 2008.
217. Stam, 2015; Stern, 2017.
218. Guzman & Stern, 2016.
219. OECD (2010) p. 67.

8.1.3 The Spatial Distribution of Entrepreneurial Activity – Entrepreneurship Ecosystems

The remarkable performance of Silicon Valley, Cambridge UK, and now many other emerging regional entrepreneurship 'hotspots' has raised interest in 'entrepreneurial ecosystems' and their most important common characteristics and their emergence and evolution over time[220]. Malecki (2017) provides a useful review of the key literature on entrepreneurial ecosystems which includes a compilation of definitions from key authors. He notes the many studies in several countries that have developed indicators of key dimensions of these ecosystems[221]. There is increasing interest in assessing culture in entrepreneurial ecosystems and in firm and all types of innovation system[222]. Malecki notes that the culture, institutions and networks of entrepreneurial ecosystems build up in a region over time and that several authors have sought to characterise stages of such evolution[223]. These should include the 'flow of nutrients' such as ideas, talent and capital, and the developing formal and informal interactions among actors. Malecki suggests that benchmarks can provide targets for local focus and policy[224].

8.2 Digital Technologies and Digital Transformation

Digital technologies are transformative General Purpose Technologies with pervasive impacts throughout economies and societies[225]. McKinsey Global Institute estimates that the applications of seven digital technologies will be the leading drivers of economic growth (**Table 7**).

Table 7: Estimated potential global economic impact of technologies from applications in 2025, including consumer surplus

Technologies	Estimated impact ($ trillion, annual to 2025)	
	Min	Max
1. Mobile Internet	3.7	10.8
2. Automation of Knowledge work	5.2	6.7
3. Internet of things	2.7	6.2
4. Cloud technology	1.7	6.2
5. Advanced robotics	1.7	4.5
6. Autonomous vehicles	0.2	1.9

Source McKinsey Global Institute (2013), Disruptive Technologies: Advances that will transform life, business and the global economy.

In an increasingly knowledge-based economy, access to information and communication technologies (ICT) enables the production, use and transfer of knowledge increasingly rapidly and at declining cost. As 'digital competence' is vitally important for innovation, diffusion and competitiveness, and also for employment and social inclusion, developing 'digital competence' throughout communities is a key policy priority. Hence, appropriate and effective education and training are critically important for digital transformation.

Digital innovation has become increasingly important in modern economies. Most innovations today are new products, services and processes made possible by digital technologies. The adoption of ICT in all sectors has led to improved innovation performance and productivity growth by reducing transaction costs, enhancing communication, and further enabling the diffusion of ideas within and between organisations. Firms using data-driven innovation have raised productivity faster than non-users by approximately five to ten per cent, according to the OECD. New digital technologies like 3D printing, quantum computing, blockchain and artificial intelligence are expected hold great opportunities for our innovators and entrepreneurs to capitalise on. Digital innovation can also have positive spill over effects within and across industries[226].

220. Alvedalen & Boschma, 2017 and Autio, *et al.,* 2014.
221. These include the major World Bank project on entrepreneurial ecosystems (Mayer, 2005, 2009, 2013 and Mulas, *et al.,* 2015), studies on the emergence and performance of entrepreneurial ecosystems in several US; cities (eg Cukier *et al.,* 2016) and the studies of the Startup Genome group (Gauthier, 2017); the Kauffman Foundation studies (Stangler & Masterson, 2015), and the WEF studies (World Economic Forum, 2013.)
222. Wallner & Menrad, 2011.
223. For example: O'Connor & Reed, 2015; Brown & Mason, 2017; Feldman, 2014.
224. Malecki, 2017, pp. 12-14.
225. Jovanovic & Rousseau, 2005; Basu & Fernald, 2007; Gambardella & McGahan, 2010.
226. OECD, 2016b.

Digital technologies have often been central to innovation in the service sector[227]. The effective application of digital technologies within firms frequently requires comprehensive change in business models and approaches to training and recruitment. Weaknesses in competencies at all levels, but particularly in management, limit the scope for innovation through the application of digital technologies[228].

The OECD report of 2015, *The Innovation Imperative: Contributing to Productivity, Growth and Well-Being*, emphasised the significance of digital technologies in innovation and for achieving a wide range of other policy objectives. The report drew attention to the challenge of effective skill development in increasingly innovation-intensive economies, through training and attracting talent through migration.

Australia invests just over two per cent of GDP on ICT, which is below the OECD average of 2.3 per cent, putting Australia at eighteenth out of thirty-two OECD countries[229]. However, investment in digital technologies alone is not enough to drive innovation and productivity growth. Effective use of ICT depends on complementary investment in management capability and knowledge-based capital, in particular, firm-specific skills and organisational change, including new business processes and business models[230].

The OECD Science, Technology and Industry Scoreboard 2017 provides a range of indicators of digital transformation across science, innovation, the economy, work and society. It used traditional in science, technology, innovation and industry indicators but also employed newer and more experimental indicators[231]. This comprehensive guide to issues and available indicators is organised in six sections:

> Knowledge economies and the digital transformation
> Knowledge, talent and skills
> Research excellence and collaboration
> Innovation in firms
> Leadership and competitiveness
> Society and the digital transformation

The 2018 OECD STI Outlook suggests digitalisation and the aftermath of the global financial crisis are also shaping the production and use of data and indicators. Innovation policies now need to address data access issues, become more agile, promote open science, data sharing and co-operation among innovators, and to review competition and intellectual property policy frameworks. The OECD also discusses digitalisation of science and innovation policy (DSIP) initiatives that can help build a picture of the incidence and impact of their science and innovation activities, and potential obstacles including privacy and confidentiality, interoperability standards, and potential misalignment of incentives between policy objectives and STI actors[232].

Data science, artificial intelligence (AI), machine learning and other new digital technologies have huge potential for scraping and combining data sets and even for predicting innovation performance. Social networking analysis is also a useful tool, as innovation arises from new connections between ideas[233].

8.3 Eco-Innovation and Sustainability

Environmental sustainability in general, and addressing climate change in particular, are compelling innovation policy priorities. A considerable literature has developed on the issue of eco-innovation and on indicators of eco-innovation[234].

The OECD has a substantial program in environmental innovation policy and assessment[235]. An OECD (2009) report on sustainable manufacturing defines eco-innovation as "the creation or implementation of new, or significantly improved, products (goods and services), processes, marketing methods, organisational structures and institutional arrangements which - with or without intent - lead to environmental improvements compared to relevant alternatives"[236].

227. Barrett, *et al.*, 2015; Wintjes, 2016.
228. Brynjolfsson & Hitt, 2000; Mithas *et al.*, 2011; Basu *et al.*, 2004; Morabito, 2014; Westerman *et al.*, 2014.
229. OECD, 2017c.
230. OECD, 2016b; DIIS, 2017.
231. OECD, 2017a.
232. OECD, 2018a.
233. Kastelle & Steen, 2014.
234. For example: Horbach, 2005; Andersen, 2006; Reid & Miedzinski, 2008; Arundel & Kemp, 2009; Cheng & Shiu, 2012
235. OECD, 2009; OECD, 2010 (Chapter 4. Measuring Eco-innovation: Existing Methods for Macro-Level Analysis); OECD, 2011a; OECD, 2011b; OECD, 2012; Environmental Policy and Technological Innovation (EPTI) - http://www.oecd.org/env/consumption-innovation/innovation.htm
236. OECD, 2008 p19.

Five benefits of measuring eco-innovation can be identified:

- Helping policy makers to understand, analyse, and benchmark the trend of eco-innovation activity
- Helping policy makers to identify drivers and barriers to eco-innovation
- Raising awareness of eco-innovation among stakeholders and encourage companies to increase eco-innovation efforts based on an analysis of the benefits
- Helping society to decouple economic growth from environmental degradation
- Making consumers aware of differences in the environmental consequences of products and life styles[237]

In a useful review Arundel and Kemp (2009) comment that:

> *The subject of eco-innovation is a rich and untapped field of research. One area for future research (besides measuring what companies do in terms of eco-innovation) is the macro-effects of eco-innovation, to complement studies on the micro-effects. Measuring the greenness of national systems of innovation (green taxes, education, collaboration, venture capital, subsidy schemes, environmental standards, education relevant to green issues) constitutes another important avenue for research.*[238]

They also argue that:

> *For measuring eco-innovation, no single method or indicator is likely to be sufficient. In general, one should therefore apply different methods for analysing eco-innovation – to see the "whole elephant" instead of just a part.....It would be of interest to develop a scoreboard for eco-innovation. [one approach] came up with a list of 24 indicators for five categories: i) firms, ii) conditions, iii) linkages, iv) radical/incremental innovation indicators, and v) overall performance.*[239]

The broad scope of eco-innovation is a substantial challenge for development of appropriate indicators, particularly if they are to enable seeing 'the whole elephant' (**Figure 8**).

Figure 8: Categories of Eco-Innovation[240]

<table>
<tr><td rowspan="7">Eco-innovation targets</td><td>Institutions</td><td colspan="4" rowspan="3">Primarily non-technological change</td></tr>
<tr><td>Organisations</td></tr>
<tr><td>Marketing methods</td></tr>
<tr><td>Processes</td><td colspan="4" rowspan="2">Primarily technological change</td></tr>
<tr><td>Products</td></tr>
<tr><td rowspan="2"></td><td>Modification</td><td>Re-design</td><td>Alternatives</td><td>Creation</td></tr>
<tr><td colspan="4">Eco-innovation mechanisms</td></tr>
</table>

A basic input-output-impact framework might include:

- Input measures: R&D expenditures, R&D personnel, and innovation expenditures (including investment in intangibles such as design expenditures and software and marketing costs)
- Intermediate output measures: Number of patents; numbers and types of scientific publications
- Direct output measures: Number of innovations, descriptions of individual innovations, data on sales of new products
- Indirect impact measures derived from aggregate data. Changes in resource efficiency and productivity using decomposition analysis

Andersen (2006) proposes that the key elements for developing eco-innovation indicators are:[241]

- Organisational development (companies): CSR/EMS data, environmental accounting/triple bottom line
- Eco-Entrepreneurship: the role of green upstarts for eco-innovation
- The financial sector
- Knowledge institutions and education

237. Based on Arundel & Kemp, 2009.
238. Arundel & Kemp, 2009, p.34.
239. Arundel & Kemp, 2009, p.34-5.
240. Environmental Policy and Technological Innovation (EPTI) - http://www.oecd.org/env/consumption-innovation/innovation.htm
241. Andersen, 2005, p.11

- Knowledge flows (input-output analysis, trade statistics, labour mobility, surveys/patent and text/bibliometric analysis on collaboration and knowledge sources)
- Governance and institutional set up: degree of innovation friendly environmental policy styles.

The European Commission's Measuring Eco-Innovation (MEP) project developed an approach bases on four types of technology (**Table 8**).

Table 8: MEI classification of eco-innovation[242]

A. Environmental technologies	> Pollution control technologies including waste water treatment technologies > Cleaning technologies that treat pollution released into the environment > Cleaner process technologies: new manufacturing processes that are less polluting and/or more resource efficient than relevant alternatives > Waste management equipment > Environmental monitoring and instrumentation > Green energy technologies > Water supply > Noise and vibration control
B. Organizational innovation for the environment	> Pollution prevention schemes > Environmental management and auditing systems: formal systems of environmental management involving measurement, reporting and responsibilities for dealing with issues of material use, energy, water and waste. Examples are EMAS and ISO 14001. > Chain management: cooperation between companies so as to close material loops and to avoid environmental damage across the value chain (from cradle to grave)
C. Product and service innovation offering environmental benefits	> New or environmentally improved products (goods) including eco-houses and buildings > Green financial products (such as eco-lease or climate mortgages) > Environmental services: solid and hazardous waste management, water and waste water management, environmental consulting, testing and engineering, other testing and analytical services > Services that are less pollution and resource intensive (car sharing is an example)
D. Green system innovations	> Alternative systems of production and consumption that are more environmentally benign than existing systems: biological agriculture and a renewables-based energy system are examples

An important policy objective will be to promote the generation and diffusion of eco-innovations, so it will be important to identify the barriers to uptake. One reasonably comprehensive identification of potential barriers by Arundel and Kemp (2009), based on earlier work by Ashford, is in **Table 9**.

242. Arundel & Kemp, 2009, p.10.

Table 9: Examples of Barriers to Eco-Innovation[243]

1. Technological barriers	> Availability of technology for specific applications. > Performance capability of technology under certain economic requirements and process design standards. > Lack of (some) alternative substances to substitute for the hazardous components. Transport, Storage and Communication (I), Financial Intermediation (J), Real Estate, Renting and Business Activity > Higher degree of sophistication with operation of some waste reduction technologies. > Scepticism in performance of certain technologies and therefore a reluctance to invest. > Process inflexibilities.
2. Financial barriers	> Research and development costs of technology. > Costs related to risk of process changes with regard to consumer acceptance and product quality. > Non-comprehensive cost evaluations and cost-benefit analysis as well as cost calculation method. > Lack of understanding and difficulty in predicting future liability costs (e.g., of waste disposal). > Short-term profitability calculations resulting in low tolerance for longer payback periods of equipment investment. > Alleged drawback in competitiveness as other companies are not investing in waste reduction technologies. > Lack of capital investment flexibility due to low profit margin. > Economies of scale preventing smaller companies from investing in waste reduction options (e.g., in-plant recovery technologies). > Possibilities that investment in process modification can be inefficient for old companies. > Company financially (and even technically) tied up due to recent investment in wastewater treatment plant. > Actual cost of current technologies masked in operating costs.
3. Labour force-related barriers	> Lack of person(s) in charge of management, control, and implementation of waste reduction technology. > Reluctance to employ trained engineers for the alleged time-consuming design of waste reduction technologies. > Inability to manage an additional program within the company and, therefore, reluctance to deal with a waste reduction program. > Increased management requirements with implementation of waste reduction technologies.
4. Regulatory barriers	> Disincentives to invest in reuse and recovery technologies due to RCRA permit application requirements for recycling facilities in addition to compliance requirements, application costs, and so forth (work-intensive). > Depreciation tax laws. > RCRA waivers available only for hazardous waste treatment technology or process. > Uncertainty about future environmental regulation. > Regulatory focus on compliance by use of conventional end-of-pipe treatment technology (may result in investment in those treatment technologies rather than waste reduction technologies). > Compliance with discharge standards, thus having "EPA off your back" provides no incentive to invest in waste reduction.
5. Consumer-related barriers	> Tight product specifications (e.g., military purposes). > Risk of customer loss if output properties change slightly or if product cannot be delivered for a certain period.
6. Supplier-related barriers	> Lack of supplier support in terms of product advertising, good maintenance service, expertise of process adjustments, and so forth.
7. Managerial barriers	> Lack of top management commitment. > Lack of engineering cooperation to break hierarchical separation of areas of responsibility (e.g., production engineers do not cooperate with environmental engineers in charge of the treatment and disposal of hazardous substances). > Reluctance on principle to initiate change in the company). > Lack of education, training, and motivation of employees (e.g., in good housekeeping methods or operation and maintenance of recovery technologies). > Lack of expertise of supervisors.

The development and implementation of a reasonably comprehensive set of indicators for eco-innovation will be demanding. It will be essential to first assess the scope for using existing information sources and for adapting existing indicators.

243. Arundel & Kemp, 2009 p.11 – based on earlier work by Ashford.

9. Opportunities to improve innovation measurement

There is increasing interest in developing indicators to assess dimensions of innovation performance not well covered by existing indicators and also in assessing the value of new data sources that might complement the indicators based on surveys and administrative data.

The literature signals clear demand for a range of new or improved innovation indicators. The gaps in available indicators arise for several reasons:

> New policy issues that have given rise to a demands for better evidence to support decisions
> New understanding about the nature of innovation that has reduced the credibility of existing indicators
> Recognition of the opportunity for new indicators to contribute to improved learning
> Coordination among innovation system actors

This section surveys the major innovation indicator gaps identified in the literature, which centre around outputs beyond R&D, knowledge generation and flows, capability, and entrepreneurship. The section then reviews approaches to improving innovation measurement, such as digital sources and tools, linking data, collaboration and social network analysis, surveys and compulsory data collection, and composite indicators. The section concludes by identifying priority areas for the development of improved innovation indicators to better measure innovation activity in Australia, including some suggestions for new or improved indicators.

9.1 Indicator gaps

The literature identifies several evident gaps in innovation indicators for innovation outputs and impacts, knowledge generation and flows, technological opportunity, entrepreneurship, capability, and the role of demand, culture, and support measures. **Table 10** provides a summary of the major indicator gaps identified in the literature, in relation to the key 'functions' of innovation.

Table 10: Indicator Gaps Identified in the Innovation Literature

Function	Major Indicator Gaps
Innovation inputs	> Assess sourcing of knowledge from local, national and international sources (NAS, 2017, p. 105) > Improve indicators for assessing innovation-related training, managerial practices and key innovation skills (OECD, 2010) > Assess the sources (local, national, international) of venture capital and angel investment (NAS, 2017, p.79). > Indicators that enable linking investment in human resources (e.g. in universities) with subsequent performance of employing firms (Hall and Jaffe, 2012) > Developing appropriate indicators of 'relationship capital and of overall absorptive capacity at different levels, from the firm level. (Davis, *et al.*, 2006) > Improved indicators of human capital at all levels (Becker and Huselid, 2006; Cabrilo, *et al.*, 2014) > Greater focus on business practices and workplace organisation (Gault, 2016, p8) > Indicators of innovation-related culture at different levels (Hao, *et al.*, 2017, Taylor and Wilson, 2012; Efrat, 2014) > Develop approaches to identify the significance of cumulative capability development (NAS, 2017, p.92)
Innovation processes	> Balance of short-term and long-term performance objectives in corporate governance. > Identify the role of supply chains and clusters in innovation knowledge flows and inducement (Davis *et al.*, 2006; Lund *et al.*, 2019) > Network problems that constrain the flow of knowledge (Woolthuis *et al.*, 2005) > Indicators of goal setting and performance in relation to sustainability and social objectives (Peiro-Signes, *et al.*, 2013; Luo, *et al.*, 2015) > Indicators of the functions and dynamics of entrepreneurial ecosystems (NAS, 2017, p.83; Henrekson and Johansson, 2008)
Innovation outputs	> Capturing a wider range of innovation outputs (including unpriced outputs) beyond those captured by patents, particularly in low-patenting sectors (NAS, 2017; Pereira and Romero, 2013) > Indicators of organisational and institutional innovation and system level change (Grønning and Fosstenløkken, 2015; Borras and Edquist, 2016) > Indicators of 'green' innovation or other specific types of innovation related to policy objectives (NAS, 2017, p. 18) > Improved indicators to enable a closer understanding of research-industry links in emerging technologies (Colecchia, 2006)

Function	Major Indicator Gaps
Innovation impacts	> Origins and spatial distribution of startups (Borras and Edquist, 2016) > The role of framework conditions in supporting entrepreneurship (Allman, *et al.*, 2011) > Improved indicators of the role of demand in environment and public sector innovation (DIISR, 2009, p 95) > Indicators of the role of public procurement in stimulating innovation (Chicot and Matt, 2018) > Indicators of the occurrence and growth of high growth firms (NAS, 2017, p.73-4; Coad, *et al.*, 2014)
Innovation systems	> Ensuring greater use of Oslo Manual based surveys to support the assessment of sectoral and regional innovation systems (NAS, 2017, p.101) > Mapping collaboration among actors in regions and fields (Lepori, *et al.*, 2008) > Increased globalisation of knowledge flows and innovation-related links and hence more complex international division of innovative effort (Colecchia, 2006) > Improved indicators on the global flows of highly qualified professionals in key areas (Colecchia, 2006)

There are particular gaps that need to be addressed in Australia given our reliance on mining and agriculture and their implications for the environment, our absence of large technology firms, and other specific issues. Also, there is no account taken of gender, such as the number of women in technology education and careers, or as entrepreneurs. If the aim is better innovation systems, then the means is through greater diversity. The data shows, for example, that women entrepreneurs attract less venture capital then men, but are more successful at using it when they are successful.

9.2 Approaches to improving innovation measurement

The OECD has played a key leadership and coordination role in innovation indicator development and compilation, drawing on the work of many national statistical offices and experts. In particular:

- The development of the Frascati, Canberra and Oslo (2018) Manuals
- Convening the Working Party of National Experts on S&T Indicators (NESTI)
- Holding the OECD Blue Sky Forums, where the OECD engages the global expert and policy on the future of STI data and indicators
- Compilation of the OECD STI Scoreboards

Several trends in the demand for, development, and use of innovation indictors were evident in OECD's 2016 Blue Sky Forum[244]:

- A stronger focus on 'human centred policy design', for example in approaches that sought to understand the motivations of individuals regarding career decisions or society's role in innovation systems
- A greater demand for higher levels of granularity in order to focus on sectors, regions, groups of firms or individuals
- While international flows of trade, investment and knowledge are increasingly significant for understanding innovation, "innovation critically depends on social, spatial and historical contexts that are largely local", and shared approaches are needed to enable the analysis of international and local dynamics
- Rising concerns regarding sustainability and equality are driving demand for new indicators to assess the role of innovation in progress in, for example, achieving climate change goals
- The use of digital technologies provides new opportunities to access and analyse data that was previously far more laborious to obtain from paper-based sources, 'administrative data' compiled for routine administrative purposes, and a diverse range of any type of digital 'data' that can now be 'read' by machines – but questions of quality remain
- Traditional statistical definitions of, for example, what is a research field, sector, firm or employee are less appropriate as boundaries blur and relationships become more complex
- As the business of data analytics grows, statistics can be used at "clickbait" and, as secrecy regarding methods and sources of data are competitive advantages, there is potential for dubious statistical "facts" and greater statistical noise

244. Galindo-Rueda, 2018.

9.2.1 Digital sources and tools

The 2018 OECD STI Outlook suggests digitalisation is shaping the production and use of data and indicators. It discusses how the digitalisation of science and innovation policy initiatives can help build a picture of the incidence and impact of their science and innovation activities, and potential obstacles including privacy and confidentiality, interoperability standards, and potential misalignment of incentives between policy objectives and STI actors, including the private sector[245].

The 4th edition of the OECD's Oslo Manual notes that digitalisation is also a key driver of measurement opportunities. In particular it notes the opportunity for the use of digital sources and tools:

- To collect information on innovation outside the business sector, even though these digital sources and tools were not originally developed for statistical purposes
- In identifier technology in combination with available sources to reduce respondent burden, such as identifying a most important business partner (supplier or customer) or innovation collaborator, thus avoiding complex matrix-based questions
- To obtain statistical data on innovation and business characteristics and to reduce respondent burden
- To implement leaner and more secure electronic methods for collecting survey data from respondents, minimising potential sources of bias and facilitating the collection of inputs from different divisions within a firm
- To collect qualitative information from respondents on their most important innovations or changes and apply semantic analysis tools in a semi- or entirely automated fashion to determine if the description is consistent with the responses

There is some discussion of whether a shift to big data can replace surveys as a method of statistical data collection. The accuracy of surveys is constrained by reliance on respondent's memories and records, and their willingness to truthfully participate. The OECD STI Outlook 2018 suggests that they are likely to complement each other, with big data allowing surveys to focus on information that cannot be otherwise obtained[246]. Callegaro and Young (2018) also discuss this issue and how the benefits and error properties of big data and surveys may be leveraged in ways that are complementary[247].

The OECD note that Current research information systems (CRIS) managers within universities hold critical research metadata that could be of value to the study of innovation[248].

9.2.2 Linking data

The draft OECD STI Outlook chapter discusses the opportunities of linking different data sources to provide insights that could potentially be created by linking different sources of data. It suggests that there are policy questions that could be addressed by meaningfully connecting existing sources instead of collecting new data[249].

Consultations with academics and government agencies have emphasised that new insights do not necessarily require different data collection processes but can be enabled by linking existing datasets. The Business Longitudinal Analysis Data Environment (BLADE) contains Department of Industry, Innovation and Science program data, but does not contain data from other portfolios that provide grants to support innovation. For example, there is considerable interested in expanding the Longitudinal Linked Employer-Employee Database.

9.2.3 Collaboration and social network analysis

Stakeholder consultations highlighted a number of issues with data on collaboration. Some suggested that having trusted collaboration data should be a high priority. Australia's poor performance internationally according to industry research collaboration indicators may, in part, be a statistical artefact. The Oslo Manual, and hence the Business Characteristics Survey (BCS), excludes 'fee for service' arrangements from counting as collaboration. Some stakeholders believe that fee for service arrangements are more common in Australia than overseas. Hence, if ABS were to report on fee for service arrangements separately, a possible artefact would be removed.

245. OECD, 2018.
246. OECD, 2018.
247. Callegaro & Yang, 2018.
248. OECD, 2018.
249. OECD, 2018. For assessments of the scope for longitudinal data in Australia see http://www.abs.gov.au/websitedbs/D3310114.nsf/home/Statistical+Data+Integration+-+Business+Longitudinal+Analysis+Data+Environment+(BLADE)

Stakeholders want to understand collaboration in a more granular way, for example, to answer the question "does collaboration differ according to industry or firm size?" BCS survey data on collaborations is unsurprisingly inconsistent with the results obtained from comprehensive administrative data from Australia's public sector research organisations. However, this is confusing to users and results in distrust of Australian collaboration data. As the extent of collaboration and interaction in innovation increases, it becomes more important to assess relationships between organisations – including which organisations are collaborating, whether the patterns of collaboration change over time and whether there are obstacles to collaboration[250].

New analytical tools have emerged alongside all the new data sources becoming available to help create new metrics. Social Network Analysis (SNA) can be an effective tool for capturing the reality of innovation within evolving complex networks and for creating representational graphics that reveal complex stories in ways that everyone can grasp.

As SNA has moved forward, sophisticated techniques in statistical network models, weighted network, multilevel networks[251] and longitudinal network analysis[252] have created further possibilities for understanding the interactions between network structures, agents and innovation. When the technical advances are combined with the recent increases in computing power, it has become much more feasible to use complex network analysis more broadly within innovation studies[253]. Network analysis data is usually sourced from interviews/surveys or databases/large data sets like patent data. Every university maintains administrative data that can also be exploited to advance the understanding of innovation processes. Different kinds of data (from sponsored projects, human resources or procurement) can be combined to map a collaborative network[254].

To portray innovation fully, data systems should be capable of detecting knowledge linkages between people and companies over time[255]. It should be noted that the ABS is looking at similar data links. **Table 11** below offers some potential indicators that network analysis can offer and describes their link to innovation. Importantly, statistical models for social networks allow us ways to identify and quantify such indicators below, and others such as clustering, to give us insights into the social infrastructure of innovation and its link to innovation success.

Table 11: Some key network measures and links to innovation performance[256]

Concepts	Common network measures	Link to innovation
Informal power	Centrality	Power provides actors with better access to and control over resources. Actors with higher centrality can leverage these advantages to improve innovation performance.
Strength of ties	Frequency of interaction. Frequent interaction produces strong ties	Strong ties are likely to communicate redundant information whereas weak ties convey novel information. Strong ties are thus contexts for exploitation, with weak ties being sources of exploration (March, 1991)
Social capital: Structural holes	Constraint measures: degree to which an actor's ties are non-redundant	An individual who spans multiple social worlds is able to benefit from transferring information and insights between these contexts. A structural hole describes the situation where an actor not only spans these social worlds but is spanning otherwise poorly connected worlds. The diversity of information resulting from this structural position puts these actors at a distinct advantage. Improved innovation performance is one of the many outcomes that result.
Social capital: Closure	Density	The density of relations within a social network improves coordination and reduces exchange risk. Organisations (e.g. project teams; firms) with these structural features are more likely to succeed when engaging in innovation.

250. Spurling, *et al.*, 2019.
251. Wang, *et al.*, 2016.
252. Ripley, *et al.*, 2012.
253. Terhorst, *et al.*, 2018.
254. National Academies of Sciences Engineering and Medicine, 2017.
255. National Academies of Sciences Engineering and Medicine, 2017.
256. Reproduced from Millist, *et al.*, 2017.

9.2.4 Survey methods and compulsory data collection

Surveys, such as those based on the OECD's Oslo Manual, have generated a great deal of valuable data. However, the use of surveys for comparative analysis requires that approaches to sampling are strictly comparable, and that steps are taken ensure respondents in different countries (and to a lesser extent different firms and sectors) interpret questions in the same way. If these levels of careful standardisation are not available caution is required in any comparative analysis.

How surveys are conducted influences the information respondents enter into survey forms. At the 2016 Blue Sky Forum, Hoskens *et al.* (2016) set out evidence showing that the information from surveys varied depending on whether the survey was in a paper or on-line format, voluntary or mandatory, and short or longer. This has implications for the design of surveys, for time series trends when survey methods change, and for international comparability.

To better assess the value of federal government interventions in the innovation sector the government may need to increase mandatory reporting requirements for recipients of direct and indirect support programs. The federal government currently spends around $9 billion a year on direct and indirect research and development support. Increasing the transparency around the value of these programs will be essential to justify this ongoing expenditure.

9.2.5 Scoreboards and composite indicators

Composite and scoreboard innovation indicators are increasingly influential. By enabling the combination of diverse dimensions of innovation performance into summary indices they promote and inform assessment of innovation-related performance and policy. Comparisons across countries and time, based on a set of constructed and credible key dimensions of performance, stimulates debate – and often an appetite for more detailed assessments of performance in dimensions of particular national relevance. The OECD 2008 Handbook on Constructing Composite Indicators advises that 'composite indicators must be seen as a means of initiating discussion and stimulating public interest'[257]. Comparative analysis can be a useful way of learning from other countries experience in terms of policy design, and it is relevant to furthering our understanding of what and how systemic features and specific activities affect innovation[258].

The development of composite innovation indicators is ongoing, driven by new or modified primary indicators, new understanding of the complex relationships in innovation systems, new policy priorities and improvements in the methodologies for the construction of indexes. Debate about the design and limitations of composite innovation indicators will also continue. While composite innovation indicators provide a valuable level of integration across diverse dimensions of performance and of comparability across countries and time, policy assessment at the country level will usually require a complementary set of indicators that focus on specific national innovation policy objectives and enable a more nuanced interpretation of apparent strengths and weaknesses. Ideally, composite indicators should be viewed as a suite in order to meaningfully influence policy decisions.

Globally, a range of composite indices and indicator collections have been developed, including the OECD STI Scoreboard, EU Innovation Union Scoreboard, World Economic Forum Competitiveness Report, and the Global Innovation Index (GII). These composite indices use both data that are readily available and innovation metrics developed in collaboration with public, private data sources or gathered via specific surveys. At first, these innovation metrics are combined using different weightings and methodologies to provide a headline number for international comparisons. The large number of components that lead to the overall ranking need to be examined before decision-makers can determine how to best interpret the results. The publishers of indices hence often actively encourage the use of the detailed data on the variable level and the analysis of policy-relevant strengths and weaknesses available in the respective country profiles.

Composite indicators need to have a sound conceptual and theoretical foundation, and the extent to which these indicators are useful in an aggregate index is highly related to this foundation[259]. One example of this is the Summary Innovation Indicator (SII) of the EU Innovation Union Scoreboard, which is based on 25 indicators[260]. However, this index has been critiqued by Edquist and Zabala-Iturriagagoitia, among others, as a poor tool for guiding innovation policy design because of the lack of theoretical and conceptual underpinning[261]. In the SII, performance is based on high value[262]. Borras and Edquist argue that the summary index:

257. OECD, 2008a, p.13.
258. Borras & Edquist, 2016, p. 12.
259. Borras & Edquist, 2016, p. 3.
260. http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en
261. Edquist and Zabala-Iturriagagoitia, 2015.
262. Borras & Edquist, 2016, p. 13.

..makes no distinction to show whether the 25 indicators reflect (a) innovation inputs, (b) innovation outputs, (c) indicators measuring intermediates between the previous two, or (d) consequences of innovations. The second problem is that all 25 indicators used in the index are given the same weight.[263]

Vertesy examined the main drivers of the SII, the EU Innovation Output Indicator (IOI), the Innovationsindikator (II) and the GII, and found that this equal weighting leads to underlying biases toward high ranking for certain activities – in the case of the IOI, II and SII the importance of R&D, patenting, and knowledge-intensive activities, and in the case of the GII, the importance of framework conditions for competitiveness and the rule of law[264]. Borras and Edquist propose that a performance approach of economic theory should be applied, that takes into account the ratio of output and inputs used in the production process[265]. They argue that such a ratio shows how efficiently countries or systems use their innovation inputs.

Averages at the level of individual indicators lose useful information and may be misleading, as significant innovation and entrepreneurship are highly unevenly distributed spatially and sectorally. Averages of averages, as used in many compound indexes, are dubious indicators of comparative performance regardless of the approach to weighting the contribution of the component scores. Indexes are useful for communication and awareness raising purposes because of their apparent simplicity, but their use risks motivating policy responses uninformed by an awareness of their sensitivity and by more detailed indicators and analysis[266]. Grupp and Schubert argue that "without a proper information basis composite indicator rankings alone tend to result in mere politicking, where measures are taken on an ad hoc basis without analysing the problem."[267] They suggest that multidimensional presentations such as spider diagrams, which provide at least a hint of priorities for policy attention, should always be used wherever composite innovation indexes are used.

9.2.6 Innovation systems assessment

There is a compelling case for the development of more useful innovation systems assessment indicators through surveys and studies at the micro, mesa and macro level. This development would be best advanced through collaboration in an international program of indicator development, including in national, regional and sectoral innovation systems and entrepreneurial ecosystems.

Firms benefiting from public support, such as the R&D tax concession, could reasonably be required to provide information on their innovation-related activities, as long as the security of this information was ensured. For example, all recipients of public support could be required to register and periodically complete a fairly detailed survey of their 'innovation system' and the interactions with their context. The firm should be assured that the information would be used only for research and not for decisions about support. However, after the removal of any potentially identifying information, the majority of the elements of the survey result could be compiled into a database that would enable the firm to review their comparative performance against other firms in the database.

9.3 Priority areas for improved innovation indicators in Australia

Based on the literature and the Australian context, this review has identified priority areas for the development of improved innovation indicators to better measure innovation activity in Australia, including some suggestions for new or improved indicators. These priorities and the specific suggestions for new or improved indicators are set out in **Table 12** over the following pages, grouped by function of innovation inputs, processes, outputs and impacts.

Importantly, innovation metrics in Australia must evolve to capture hidden innovation, and innovation systems. Intangible inputs to innovation must be captured more completely, such as firm human capital and the value of networks. Assessment of innovation inputs must go beyond funding and R&D personnel, and look to culture, knowledge flows, skills, and training. Measurement of innovation processes must looks at absorptive capacity, management capability, collaboration and reflect developments in the EU and OECD on assessing eco-innovation. We need to move beyond R&D as the measure of innovation output, and look at case studies for a more holistic view of innovation impacts and entrepreneurial innovation. Australia must also review the adequacy of existing indicators and databases on the movement of knowledge and personnel in, and out, of the country.

263. Borras and Edquist, 2013.
264. Vertesy, 2016, p. 16.
265. Borras & Edquist, 2016.
266. Grupp & Schubert, 2010, p.70.
267. Grupp & Schubert, 2010, p.76.

Table 12: Innovation Indicator Development Priorities for Australian Policy

Function	Challenge	Currently available indicators and information sources	Suggestions for new or improved indicators
Innovation Inputs	> Assess the relative effectiveness of direct and indirect R&D support. > Assess the mobility of qualified personnel between research organisations and industry. > Assess the role of demand and regulation in stimulating and supporting eco-innovation > Assess the opportunities and barriers to Agtech innovation and entrepreneurship > Assess the role and effectiveness of digital transformation for mining companies and their suppliers. > Identify and quantify the diverse range of hidden inputs to innovation. > Assess the role of culture in firms' innovation performance	> Many of these types of input are addressed in the BCS. > The Canberra Manual is intended to provide guidelines for the measurement of human resources devoted to science and technology, and the analysis of such data. > The ABS management capability survey deals with some aspect of business culture: promotions, participation in decision making, etc. A comparative study with the US shows that US and Australian firms are quite different in many of these aspects. > The SNA framework includes: – Computer software and databases – Research and Development – Mineral (and petroleum) exploration – Entertainment, literary and artistic originals – Economic competencies > Surveys include R&D, R&D personnel and some non-R&D expenditures > Indicators of collaboration among research organisations based on publications.	> Determine what new taxonomies capture capabilities and types of capabilities and check if the BCS provides enough data for developing these taxonomies. > Develop firm-level indicators of culture that would enable international comparison (Note: ABS has already started work on this). > Improve the indicators of inter-firm knowledge flows and collaboration > Develop indicators to support policy in better understanding investment in intangibles. > Explore the use of web-based data from, e.g. product and services releases and contracts and new ventures. > Develop approaches to identifying and assessing workforce skills for innovation. > Develop approaches and indicators to identify and assess the role of institutional innovation in mining. > Develop indicators to inform the education and training sector regarding skill types required.
Innovation Processes	> A high proportion of Australian firms are adept users and adapters of knowledge from external sources – what capabilities enable effective absorptive capacity? > Assess the role of international linkages for national and sectoral absorptive capacity > What impedes/promotes knowledge diffusion in Australian industry and the public sector? > It is essential to have a comprehensive and robust set of indicators of the progress of digital transformation across all sectors and regions and to identify the barriers to uptake, innovation and capability development. > Develop a comprehensive perspective on the mining innovation system, including the role of suppliers. > Improve understanding of the motivations and outcomes of collaboration among firms and with research organisations	> Oslo Manual-based surveys provide a foundation of useful indicators of firm-level innovation. > Current indicators of IT diffusion do not capture the significance of digital transformation. > Deloitte produced 'Innovation in mining Australia 2016' in association with Diggers and Dealers and the Association of Mining and Exploration Companies (AMEC). > Publications with industry co-authors provide indicators of formal collaboration > Early AIS reports had environmental indicators.	> Collaborate with other countries to develop robust indicators of absorptive capacity > Object based innovation survey to address absorptive capacity. > Apply the Oslo Manual 2018 guidelines for firm-level innovation management assessment > Develop indicators of management capabilities for leading digital transformation in all sectors. > Develop approaches and indicators to identify and assess the role of institutional innovation in mining. > Develop indicators of relationship capital and collaboration capability > Develop a comprehensive approach to assessing the development of eco-innovation capabilities and activities and review the frameworks being developed in the EU and the OECD.

Function	Challenge	Currently available indicators and information sources	Suggestions for new or improved indicators
Innovation outputs	> Assess what promotes and impedes the uptake of new digital and biotech agricultural technologies (i.e. Agtech) > As climate change is a systemic threat to Australia's welfare it is essential to assess how best to steer and support innovation in 'eco-innovation' and address barriers to innovation.	> GEM data quality has been relatively low due to its small sample size (2000 individuals) particularly for those questions that refer to outcomes of entrepreneurial activity. However, it is understood that the sample of the GEM survey will be increased to 10,000 individuals, which will make GEM data much more useful. > There is a diverse range of indicators of specific aspects of environmental performance, but not of the links with innovation.	> Develop indicators for a comprehensive agricultural sectoral innovation system assessment and collaborate with other countries to develop these frameworks.
Innovation Impacts	> Assess the role of Leadership, Design Thinking and Human-Centred Innovation firms' innovation strategies and performance. > Identifying the origin of innovative new firms in Australia – in the US a high proportion of innovative startups are spinoffs from established firms. > Assessing Australian entrepreneurship performance and enabling meaningful international comparisons > Assess whether agricultural innovation and application mitigating the impacts of climate change > Assess the formation of innovation-based new ventures providing inputs to the agricultural sector or transforming its outputs into high value products. > Assess the role of demand from the mining sector for innovation, entrepreneurship and enterprise development in Australia.	> ABS surveys VC and Later Stage Private Equity > BLADE has been used for a range of assessments of entrepreneurial performance. > There are no sound indicators enabling international comparisons of entrepreneurial performance. > OECD Entrepreneurship at a Glance – but Australian data is lacking. > There is a lack of indicators of sector level innovation-related performance apart from productivity estimates. > ABS BCS and MCS collects data that can be used to produce indicators for most sectors	> On the basis of a set of case studies, develop firm-level indicators of culture that would enable international comparison (Note: ABS has already started work on this). > Develop indicators of entrepreneurial quality – i.e. indicators beyond the GEM's TEA (total early-stage entrepreneurial activity). > Collaborate with other groups, e.g. Startup Genome, to develop and apply indicators of entrepreneurial ecosystems. > Develop indicators of other potentially transformative technologies, including biotechnology. > Assess the effectiveness of the governance systems for the agricultural innovation system. > Develop approaches and indicators to identify and assess the role of institutional innovation in Agriculture. > Develop an approach to assessing the role of innovation in the overall mining and mining-related sector for the performance of the mining industry and the generation of new innovation-based suppliers. > Develop indicators of innovation policy learning and innovation.

Function	Challenge	Currently available indicators and information sources	Suggestions for new or improved indicators
Innovation systems	> Assessing the significance of global flows of knowledge and innovation-relevant personnel to and from Australia. > Assessing the rate, directions and drivers of change in all functions of national and other innovation systems – how and why are innovation system evolving? > Assess the role of foreign subsidiaries in the national and sectoral innovation systems > Assess the role of demand and regulation in innovation systems.	> A wide range of indicators is available from ILO and within Australia from the Department of Immigration and Border Protection, but these do not enable assessment of significance or of absorptive capacity. > The World Economic Forum provides some estimates of the role of procurement, but the quality and level of standardisation of this data is not clear.	> Review the adequacy of existing indicators and databases on international knowledge and personnel flows. > Apply the 2018 Oslo Manual approach to 'bottom up' assessment of innovation system performance. > Develop indicators of the role of demand, regulation and culture in the dynamics of the Australian national and also sectoral innovation systems. > Develop indicators for the characteristics, performance and evolution of sectoral innovation systems. > Develop experimental indicators of each 'function' of innovation systems working both at the sectoral and the national levels and combining macro, meso and micro indicators. > Develop indicators of the role of culture, including risk aversion, and of institutional innovation in innovation systems.

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Appendix F: Compendium of metrics

Key points

- **The Innovation Metrics Compendium documents which existing metrics the Review considered**
- **The Innovation Metrics Compendium is used to demonstrate the degree of coverage provided by existing metrics.**

Purpose

This Innovation Metrics Compendium was developed in order to provide an indication of:

- the quantum of metrics currently available relating to various areas of the innovation system
- how usable and reliable those metrics are.

A key purpose in undertaking this work was to determine if – and if so, on what topics – the Review needed to develop new indicators on, based on the Review framework, either because there were gaps in coverage or significant quality issues associated with existing metrics.

Where possible, the Review used the best existing metrics available. Existing metrics are more likely to be collected by other countries and thus support international comparison.

This table of metrics shows only the classification of metrics against the Innovation Metrics Review Framework discussed in the Review process and methodology. As indicated in the Review process and methodology, the Review also considered the quality of metrics against assessment criteria developed by the Review.

The assessment of metrics within the framework has not been published, as the Review considered only whether each of the metrics were fit for Australian purposes.

Caveat

This document and the assessment of how fit for Australian purposes each of the metrics are should be considered as permanently in progress. This is because:

- there is a large (and, arguably, almost inexhaustible) supply of metrics that could be added to the Compendium, beyond the 597 considered here
- it can take hours, or even days, to evaluate even a single metric thoroughly and comprehensively.

As a consequence of the above, the time necessary to perform both a comprehensive and thorough analysis of existing metrics was well beyond that available to the Review. Therefore, the contents of this Compendium should be considered as indicative and provisional.

Structure

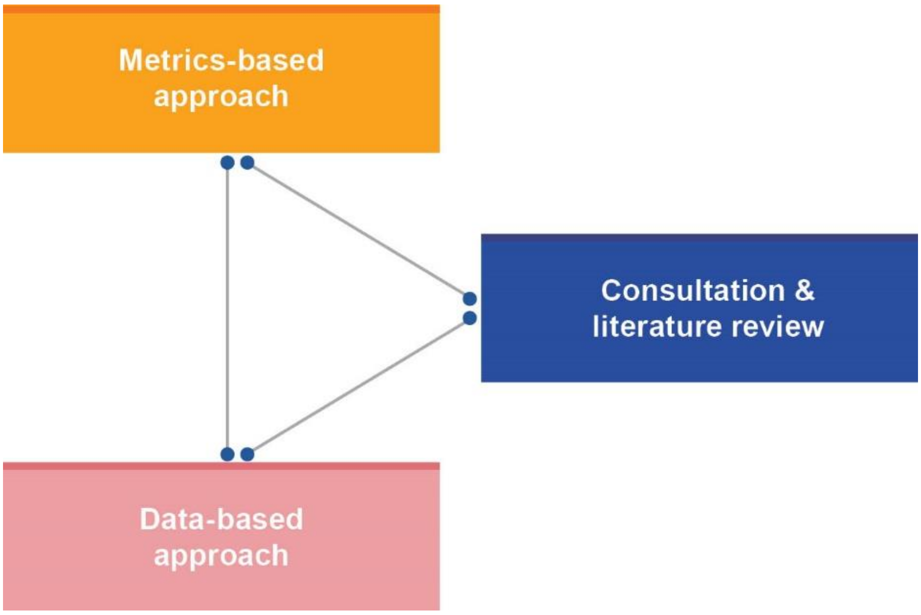
The structure of the Compendium is provided by the Innovation Metrics Framework discussed in the Review process, and methodology that was developed as part of the Review. This Framework was then populated using a triangulation approach, as shown in Figure F.1. Two types of metrics were sourced:

- established metrics – metrics that are currently in use for measuring innovation system performance
- data sources identified by the Review.

The included metrics were identified in a variety of ways, but most notably based upon:

- their regular use within DIIS
- their identification during consultations, discussions and desk-based research undertaken as part of the Review.

Figure F.1: Triangulation approach to identifying metrics to populate the innovation metrics compendium against the Review's innovation framework



The Compendium includes the following columns:

- Type: This column indicates the type of metric that has been included (i.e. Established or Data sources). Established metrics are labelled with the metrics collection that they were sourced from (e.g. Global Innovation Index

(GII); OECD Main Science and Technology Indicators (MSTI); OECD STI Scoreboard (STIS)). A glossary linking labels with metric source titles is included below

- Metric: This column provides a summary description of the metric or data source. More detailed information about the data upon which a metric is based – and how it was calculated – should be sought from the listed source (refer Note 1 and Note 2 below)
- Data source: This column provides detail on the data sources that underpin the metric, or other descriptive information.

Table F.1: Glossary of included data sources

ABS	Australian Bureau of Statistics
AISR	Australian Innovation Systems Report
ARC	Australian Research Council
ARTG	Australian Register of Therapeutic Goods
CRC	Cooperative Research Centre
DET	Department of Education, Science and Training
DIIS	Department of Industry, Innovation and Science
EAAG	OECD Entrepreneurship At A Glance
EIS	European Innovation Scoreboard
EP	Entrepreneurs' Programme
GCR	Global Competitiveness Report
GII	Global Innovation Index
HDI	Human Development Index
HEFP	Higher Education Finance Publication
HERDC	Higher Education Research Data Collection
IC	Innovation Connections
IPA	IP Australia
ISA 2016	Innovation and Science Australia (ISA), Performance Review of the Australian Innovation, Science and Research System
ISA 2018	ISA Australia 2030 Prosperity through Innovation
MSTI	OECD Main Science and Technology Indicators
NCVER	National Centre for Vocational Education Research

NSRC	National Survey of Research Commercialisation
QILT	Quality Indicators for Learning and Teaching
PMR	OECD's Product Market Regulation
RDTI	Research and Development Tax Incentive
RRDC	Rural R&D Corporations
SRIBT	Science, Research and Innovation Budget Tables
STIS	OECD Science, Technology and Innovation Scoreboard

Note 1

In some instances, the name of a metric includes identifying information from the source (e.g. an index number). This information is included to make it easier to locate that metric within the source documentation.

Note 2

Metrics drawn from the Executive Opinion Survey and other similar surveys are based upon questions with the following type of structure:

Box 1: Example of a typical Survey question

To what extent is the judiciary in your country independent from influences of members of government, citizens, or firms?

Heavily influenced < **1 2 3 4 5 6 7** > Entirely independent

Circling 1... means you agree completely with the answer on the left-hand side

Circling 2... means you largely agree with the left-hand side

Circling 3... means you somewhat agree with the left-hand side

Circling 4... means your opinion is indifferent between the two answers

Circling 5... means you somewhat agree with the right-hand side

Circling 6... means you largely agree with the right-hand side

Circling 7... means you agree completely with the answer on the right-hand side

Table F.2: Compendium of metrics

Type	Metric	Data source
1	OPERATING ENVIRONMENT	
1.1	Domestic governance and institutional environment	
PMR	Public ownership	OECD Product Market Regulation database.
1.1.1	Political environment	
GII	1.1.1 Political stability & safety	World Bank, Worldwide Governance Indicators, 2016 update. (http://info.worldbank.org/governance/wgi/index.aspx#home)
GCR	8.06 Workers' rights	International Trade Union Confederation (ITUC); World Economic Forum (WEF). (see Note 2)
GCR	1.05 Social capital	Legatum Institute.
GCR	1.14 Incidence of corruption	WEF, Executive Opinion Survey. (see Note 2)
1.1.2	Legislative and regulatory environment	
PMR	Product market regulation	OECD Product Market Regulation database.
PMR	Distortions induced by state involvement	OECD Product Market Regulation database.
PMR	Involvement in business operations	OECD Product Market Regulation database.

PMR	Simplification and Evaluation of Regulations	OECD Product Market Regulation database.
ISA 2018	E-government Index	WIPO, Cornell University, INSEAD: *Section 1.1.2 Government effectiveness* https://www.globalinnovationindex.org/analysis-indicator
ISA 2018	Government effectiveness index	WIPO, Cornell University, INSEAD: *Section 3.1.3 Government online services* https://www.globalinnovationindex.org/analysis-indicator
GII	1.1.2 Government effectiveness	World Bank, Worldwide Governance Indicators, 2016 update. (http://info.worldbank.org/governance/wgi/index.aspx#home)
GII	1.2.1 Regulatory quality	World Bank, Worldwide Governance Indicators, 2016 update. (http://info.worldbank.org/governance/wgi/index.aspx#home)
GII	1.2.2 Rule of law	World Bank, Worldwide Governance Indicators, 2016 update. (http://info.worldbank.org/governance/wgi/index.aspx#home)
GII	1.3.3 Ease of paying taxes	World Bank, Ease of Doing Business Index 2017: Equal Opportunity for All (2014–16). (http://www.doingbusiness.org/reports/global-reports/doing-business-2017)
GII	4.2.1 Ease of protecting minority investors	World Bank, Ease of Doing Business Index 2017: Equal Opportunity for All (2016). (http://www.doingbusiness.org/reports/global-reports/doing-business-2017)
AISR	ISO 14001 environmental certificates, per billion PPP$ GDP	Cornell University, INSEAD, WIPO (2012–16) Global Innovation Index, GII 2012–16, URL: http://www.globalinnovationindex.org;
ABS	Adherence to standards, % of respondents	ABS Selected Characteristics of Australian Business, cat. no. 8167.0, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8167.0
ABS	Government regulations or compliance, % of respondents	ABS Selected Characteristics of Australian Business, cat. no. 8167.0, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8167.0
GCR	7.01 Distortive effect of taxes and subsidies on competition	WEF, Executive Opinion Survey. (see Note 2)
GCR	8.02 Hiring and firing practices	WEF, Executive Opinion Survey. (see Note 2)
GCR	8.05 Active labour policies	WEF, Executive Opinion Survey. (see Note 2)

GCR	8.07 Ease of hiring foreign labour	WEF, Executive Opinion Survey. (see Note 2)
GCR	1.04 Reliability of police services	WEF, Executive Opinion Survey. (see Note 2)
GCR	1.06 Budget transparency	The World Bank Group. (see Note 2)
GCR	1.07 Judicial independence	WEF, Executive Opinion Survey. (see Note 2)
GCR	1.08 Efficiency of legal framework in challenging regulations	WEF, Executive Opinion Survey. (see Note 2)
GCR	1.13 Future orientation of government	WEF, Executive Opinion Survey. (see Note 2)
GCR	1.15 Property rights	WEF, Executive Opinion Survey. (see Note 2)
GCR	1.16 Intellectual property protection	WEF, Executive Opinion Survey. (see Note 2)
GCR	1.17 Quality of land administration	The World Bank Group.
GCR	1.18 Strength of auditing and reporting standards	WEF, Executive Opinion Survey. (see Note 2)
1.1.2.1	Entry and exit barriers	
GII	1.3.1 Ease of starting a business	World Bank, Ease of Doing Business Index 2017: Equal Opportunity for All (2014–16). (http://www.doingbusiness.org/reports/global-reports/doing-business-2017)
GII	1.3.2 Ease of resolving insolvency	World Bank, Ease of Doing Business Index 2017: Equal Opportunity for All (2014–16). (http://www.doingbusiness.org/reports/global-reports/doing-business-2017)
PMR	Barriers to domestic and foreign entry	OECD Product Market Regulation database.

PMR	Administrative burden on start-ups	OECD Product Market Regulation database.
AISR	Start-up procedures to register a business, count	World Bank (2017) World Development Indicators, 2017, URL: http://data.worldbank.org/;
AISR	Cost of business start-up procedures, % of GNI per capita	World Bank (2017) World Development Indicators, 2017, URL: http://data.worldbank.org/;
GCR	11.01 Cost of starting a business	The World Bank Group.
GCR	11.02 Time to start a business	The World Bank Group.
GCR	11.04 Insolvency regulatory framework	The World Bank Group.
1.1.3	Taxation environment	
GCR	8.12 Labour tax rate	The World Bank Group.
1.1.4	Financial environment	
GCR	9.06 Soundness of banks	WEF, Executive Opinion Survey. (see Note 2)
GCR	10.01 Gross domestic product	International Monetary Fund (IMF).
GCR	7.02 Extent of market dominance	WEF, Executive Opinion Survey. (see Note 2)
GII	4.3.3 Domestic market scale, billion PPP$	World Bank, International Monetary Fund, World Economic Outlook Database October 2016 (PPP$ GDP) (2016). (https://www.imf.org/external/pubs/ft/weo/2016/02/weodata/index.aspx)
HDI	Gross national income (GNI) per capita (2011 PPP $)	World Bank (2018b), IMF (2018) and United Nations Statistics Division (2018b).

HDI	Gross domestic product (GDP) per capita (2011 PPP $)	World Bank (2018a).
HDI	Gross domestic product (GDP), total (2011 PPP $ billions)	World Bank (2018a).
HDI	Gross fixed capital formation (% of GDP)	World Bank (2018a).
HDI	Gross capital formation (% of GDP)	World Bank (2018a).
S&P	Standard & Poor (S&P) Sovereign Rating	S&P
1.1.4.1	Credit	
GII	4.1.1 Ease of getting credit	World Bank, Ease of Doing Business Index 2017: Equal Opportunity for All (2016). (http://www.doingbusiness.org/reports/global-reports/doing-business-2017)
GII	4.1.2 Domestic credit to private sector, % GDP	International Monetary Fund, International Financial Statistics and data files; and World Bank and OECD GDP estimates; extracted from the World Bank's World Development Indicators database (2008–15). (http://data.worldbank.org/)
GII	4.1.3 Microfinance gross loans, % GDP	Microfinance Information Exchange, Mix Market database; International Monetary Fund, World Economic Outlook Database, October 2016 (current US$ GDP) (2007–15). (https://reports.themix.org/; https://www.imf.org/external/pubs/ft/weo/2016/02/weodata/index.aspx)
AISR	Ease of access to loans, score ranges from 1–7 (best)	WEF (2014–17) Global Competitiveness Index, 2014–15 to 2017–18, URL: http://www.weforum.org/
GCR, HDI	9.01 Domestic credit to private sector	The World Bank Group.
GCR	9.02 Financing of SMEs	WEF, Executive Opinion Survey. (see Note 2)
GCR	9.08 Credit gap	WEF; calculations based on The World Bank Group data.

1.1.4.2	Equity	
AISR	Financing through local equity market, score ranges from 1–7 (best)	WEF (2014–17) Global Competitiveness Index, 2014–15 to 2017–18, URL: http://www.weforum.org/
ABS	Barrier to innovation: Lack of access to additional funds, % of respondents	8158.0 – Innovation in Australian Business, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0
ABS	Proportion of businesses seeking debt or equity finance for innovation, % of respondents	8158.0 – Innovation in Australian Business, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0
GCR	9.09 Banks' regulatory capital ratio	The World Bank Group.
1.1.5	Policy and program environment	
HDI	Ratio of education and health expenditure to military expenditure	World Bank (2018a)
1.1.5.1	Innovation procurement	
ISA 2018	Percentage of contracts allocated to SMEs	Australian Government Department of Finance. https://data.gov.au/dataset/historical-australian-government-contract-data
AusTender	Government procurement including by supplier type and contract amount.	Australian Government Department of Finance. https://data.gov.au/dataset/historical-australian-government-contract-data
1.2	Infrastructure	
1.2.1	ICT and digital infrastructure	
EIS	1.3.1 Broadband penetration	Data source Eurostat, Community Survey of ICT Usage and E-commerce in Enterprises
GII	3.1.1 ICT access	International Telecommunication Union, Measuring the Information Society 2016, ICT Development Index 2016. (http://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2016.aspx)

GII	3.1.2 ICT use	International Telecommunication Union, Measuring the Information Society 2016, ICT Development Index 2016. (http://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2016.aspx)
GII	3.1.3 Government's online service	United Nations Public Administration Network, e-Government Survey 2016. (https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2016)
STIS	2. Mobile broadband penetration, Total subscriptions and per 100 inhabitants, 2016	OECD, Broadband Portal, http://oe.cd/broadband and ITU, World Telecommunication/ICT Indicators Database, July 2017
STIS	3. M2M SIM card penetration, Per 100 inhabitants	OECD calculations based on GSMA Intelligence, September 2017
STIS	4. Top M2M SIM card connections, Total connections and as a percentage of world total	OECD calculations based on GSMA Intelligence, September 2017
STIS	Diffusion of selected ICT tools and activities in enterprises, by technology, As percentage of enterprises with 10 or more persons employed	OECD, ICT Access and usage by Businesses Database, http://oe.cd/bus, July 2017.
STIS	Enterprises engaged in sales via e-commerce, by size, As a percentage of enterprises in each employment size class	OECD, ICT Access and usage by Businesses Database, http://oe.cd/bus, July 2017
STIS	Enterprises using cloud computing services, by size. As a percentage of enterprises in each employment size class	OECD, ICT Access and usage by Businesses Database, http://oe.cd/bus, July 2017
STIS	Mobile broadband penetration, by technology. Per 100 inhabitants	OECD, Broadband Portal, www.oecd.org/sti/broadband/oecdbroadbandportal.htm, July 2017
STIS	Households with broadband connections, urban and rural, 2010 and 2016	OECD, ICT Access and usage by Households and Individuals Database, http://oe.cd/hhind, June 2017.
STIS	Small and medium enterprises with broadband access, fixed or mobile, 2016	OECD, ICT Access and usage by Businesses Database, http://oe.cd/bus, July 2017

GCR	1.12 E-Participation Index	United Nations, Department of Economic and Social Affairs (UNDESA).
GCR	3.01 Mobile-cellular telephone subscriptions	International Telecommunications Union (ITU).
GCR	3.02 Mobile-broadband subscriptions	International Telecommunications Union (ITU).
GCR	3.03 Fixed-broadband internet subscriptions	International Telecommunications Union (ITU).
GCR	3.04 Fiber internet subscriptions	WEF calculations based on International Telecommunications Union (ITU).
GCR, HDI	3.05 Internet users	International Telecommunications Union (ITU).
HDI	Internet users, female (% of female population)	International Telecommunications Union (ITU).
HDI	Mobile phone subscriptions (per 100 people)	International Telecommunications Union (ITU).
World Bank	Fixed broadband Internet tariffs, PPP $/month	World Bank (https://tcdata360.worldbank.org/indicators/etrade.entrp.broadband.tar?country=AUS&indicator=3411&countries=KOR,USA&viz=line_chart&years=2012,2016)
1.2.2	Research infrastructure	
XXX	Nil at present	Nil
1.2.3	General infrastructure	
GCR	2.01 Quality of road network	WEF's calculations.
GCR	2.02 Quality of road infrastructure	WEF, Executive Opinion Survey. (see Note 2)

GCR	2.04 Efficiency of train services	WEF, Executive Opinion Survey. (see Note 2)
GCR	2.05 Airport connectivity	International Air Transport Association (IATA).
GCR	2.07 Liner Shipping Connectivity Index	United Nations Conference on Trade and Development (UNCTAD).
GCR	2.09 Electricity access	International Energy Agency (IEA).
GCR	2.10 Electricity quality	International Energy Agency (IEA).
GCR	2.11 Exposure to unsafe drinking water % pop.	Institute for Health Metrics and Evaluation (IHME).
GCR	2.12 Reliability of water supply	WEF, Executive Opinion Survey. (see Note 2)
1.3	Business environment	
GCR	7.03 Competition in services	WEF, Executive Opinion Survey. (see Note 2)
GCR	8.10 Pay and productivity	WEF, Executive Opinion Survey. (see Note 2)
GCR	11.07 Growth of innovative companies	WEF, Executive Opinion Survey. (see Note 2)
GCR	1.10 Burden of government regulation	WEF, Executive Opinion Survey. (see Note 2)
GCR	1.11 Efficiency of legal framework in settling disputes	WEF, Executive Opinion Survey. (see Note 2)
PMR	Barriers in Service & Network sectors	OECD Product Market Regulation database.
1.3.1	Business churn	

STIS	Entry and exit rates in ICT and other business sectors, 2013–15, Number of entering/exiting units as a percentage of number of entering/exiting and incumbent units	OECD calculations based on the DynEmp v.2 and v.3 Databases, preliminary data, http://oe.cd/dynemp, July 2017. StatLink contains more data.
AISR	Churn Rate	ABS 8165.0 Counts of Australian Businesses, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8165.0
AISR	Employer Enterprise Birth Rate %	ABS 8165.0 Counts of Australian Businesses, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8165.0
AISR	Employer Enterprise Death Rate	ABS 8165.0 Counts of Australian Businesses, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8165.0
AISR	1–year survival rate (employer enterprises)	ABS 8165.0 Counts of Australian Businesses, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8165.0
1.3.2	Diversity	
GII	1.2.3 Cost of redundancy dismissal, salary weeks	World Bank, Ease of Doing Business Index 2017: Equal Opportunity for All (2014–16). (http://www.doingbusiness.org/reports/global-reports/doing-business-2017)
STIS	Share of young micro and small existing firms in ICT and other sectors, 2013–15	OECD calculations based on the DynEmp v.2 and v.3 Databases, preliminary data, http://oe.cd/dynemp , July 2017
STIS	Differences in employment growth between young small and old small firms in ICT and other sectors, 2013–15	OECD calculations based on the DynEmp v.2 and v.3 Databases, preliminary data, http://oe.cd/dynemp , July 2017.
GCR	8.11 Female participation in labour force	International Labour Organization (ILO); WEF.
GCR	12.01 Diversity of workforce	WEF, Executive Opinion Survey. (see Note 2)
HDI	Income inequality, Gini coefficient	World Bank (2018a).

HDI	Income inequality, Palma ratio	World Bank (2018a).
HDI	Income inequality, quintile ratio	World Bank (2018a).
HDI	Inequality in education (%)	Calculated based on data from the Luxembourg Income Study database, Eurostat's European Union Statistics on Income and Living Conditions, the World Bank's International Income Distribution Database, the Center for Distributive, Labor and Social Studies and the World Bank's Socio-Economic Database for Latin America and the Caribbean, ICF Macro Demographic and Health Surveys and United Nations Children's Fund Multiple Indicator Cluster Surveys using the methodology in Technical [Note 2] (available at http://hdr.undp.org/sites/default/files/hdr2018_technical_notes.pdf).
HDI	Inequality in income (%)	Calculated based on data from the Luxembourg Income Study database, Eurostat's European Union Statistics on Income and Living Conditions, the World Bank's International Income Distribution Database, the Center for Distributive, Labor and Social Studies and the World Bank's Socio-Economic Database for Latin America and the Caribbean, ICF Macro Demographic and Health Surveys and United Nations Children's Fund Multiple Indicator Cluster Surveys using the methodology in Technical (see Note 2) (available at http://hdr.undp.org/sites/default/files/hdr2018_technical_notes.pdf).
HDI	Female share of employment in senior and middle management (%)	ILO (2018a).; https://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page27.jspx?subject=SDG&indicator=SDG_0552_OCU_RT&datasetCode=A&collectionCode=SDG; Labor Force Survey
HDI	Female share of graduates in science, mathematics, engineering, manufacturing and construction at tertiary level (%)	UNESCO Institute for Statistics (2018). ; http://data.uis.unesco.org/
HDI	Share of seats in parliament (% held by women)	Inter-Parliamentary Union (IPU); https://data.ipu.org/
1.3.3	Entrepreneurship environment	

EIS	1.3.2 Opportunity-driven entrepreneurship	Data source Global Entrepreneurship Monitor (GEM)
GII	4.2.3 Venture capital deals/billion PPP$ GDP	Thomson Reuters, Thomson One Banker Private Equity database; International Monetary Fund, World Economic Outlook Database October 2016 (PPP$ GDP) (2015–16). (https://www.thomsonone.com; https://www.imf.org/external/pubs/ft/weo/2016/02/weodata/index.aspx)
EIS	2.1.2 Venture capital expenditures	Data source VC data from Invest Europe. GDP data from Eurostat
GII	6.2.2 New businesses/thousand pop. aged 15–64	World Bank, Doing Business 2016, Entrepreneurship (2009–14). (http://www.doingbusiness.org/data/exploretopics/entrepreneurship)
STIS	73. Venture capital investment in selected countries, by sector, as a percentage of total venture capital investment	OECD, based on OECD Entrepreneurship Financing Database, September 2017
AISR	Venture Capital Investment, million A$	ABS (2016–2017) VC&LSPE, Australia, cat. No. 5678.0, 2014–15 to 2015–16, Ref: http://www.abs.gov.au/ausstats/abs@.nsf/mf/5678.0;
AISR	Entrepreneurial intentions, %	Global Entrepreneurship Research Association (GERA) (2017) Global Entrepreneurship Monitor (GEM), 2016–17, Adult Population Survey, URL: http://www.gemconsortium.org/;
AISR	Venture capital availability, score ranges from 1–7 (best)	WEF (2014–2017) Global Competitiveness Index, 2014–15 to 2017–18, URL: http://www.weforum.org/;
STIS, ISA 2016, AISR	Venture capital investments, % of GDP	OECD Entrepreneurship at a Glance, http://www.abs.gov.au/AUSSTATS/abs@.nsf/allprimarymainfeatures/BFFEF2819DF68CA2CA256B6B007AB94E?opendocument
AISR	Early stage venture capital investment, % of GDP	OECD Entrepreneurship at a Glance
AISR	Later Stage Private Equity investment, % of GDP	OECD Entrepreneurship at a Glance
AISR	Barriers to entrepreneurship	OECD Entrepreneurship at a Glance

ISA 2016, ISA 2018, AISR	Total early-stage entrepreneurship activity, %	Global Entrepreneurship Monitor (GEM), https://www.gemconsortium.org/data
GCR	9.03 Venture capital availability	WEF, Executive Opinion Survey. (see Note 2)
GCR	11.05 Attitudes toward entrepreneurial risk	WEF, Executive Opinion Survey. (see Note 2)
GCR	11.08 Companies embracing disruptive ideas	WEF, Executive Opinion Survey. (see Note 2)
GCR	12.02 State of clusters development	WEF, Executive Opinion Survey. (see Note 2)
1.4	International environment	
STIS	SMEs participating in international and public sector markets, by innovation status, 2012–14, as a percentage of businesses in the relevant category	OECD, based on the 2017 OECD survey of national innovation statistics and Eurostat Community Innovation Survey (CIS-2014), June 2017. http://oe.cd/inno-stats.
STIS	Jobs in the business sector sustained by foreign final demand, 2005 and 2014, as a percentage of total business sector employment	OECD calculations based on Inter-Country Input-Output (ICIO) Database, http://oe.cd/icio , Annual National Accounts Database, www.oecd.org/std/na , Structural Analysis (STAN) Database, http://oe.cd/stan ,Trade in Employment (TiM), http://oe.cd/io-empn ; World Input-Output Database (WIOD) and national sources, June 2017
STIS	Share of compensation of employees in the business sector sustained by domestic and foreign final demand, 2014	OECD calculations based on Inter-Country Input-Output (ICIO) Database, http://oe.cd/icio , Annual National Accounts Database, www.oecd.org/std/na, Structural Analysis (STAN) Database, http://oe.cd/stan , Trade in Employment (TiM), http://oe.cd/io-empn and national sources, June 2017.
1.4.1	Trade and competition	
GII	4.3.2 Intensity of local competition	WEF, Executive Opinion Survey 2016–2017. (see Note 2) (https://www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1)

GCR	7.08 Service trade openness	The World Bank Group.
GCR	10.02 Imports of goods and services	World Trade Organization (WTO); International Monetary Fund (IMF).
PMR	Barriers to trade and investment	OECD Product Market Regulation database.
1.4.1.1	Free trade agreements	
XXX	Nil at present	Nil
1.4.1.2	Tariff barriers	
GII	4.3.1 Applied tariff rate, weighted mean, %.	World Bank, based on data from United Nations Conference on Trade and Development's Trade Analysis and Information System (TRAINS) database and the WTO's Integrated Data Base (IDB) and Consolidated Tariff Schedules (CTS) database; extracted from World Bank World Development Indicators database (2011–15). (http://data.worldbank.org/)
GCR	7.05 Trade tariffs	Source: International Trade Centre (ITC).
GCR	7.06 Complexity of tariffs	Source: International Trade Centre (ITC).
1.4.1.3	Non-tariff barriers	
GCR	7.04 Prevalence of non-tariff barriers	WEF, Executive Opinion Survey. (see Note 2)
2	RESEARCH SYSTEM	
2.1	R&D Funders	

MSTI, ISA 2016, ISA 2018, AISR, GII, STIS	2.3.2 Gross Expenditure on R&D (GERD), % of GDP	GII: UNESCO Institute for Statistics, UIS online database (2007–16). (http://data.uis.unesco.org/); OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
ABS, MSTI, AISR	Gross Expenditure on R&D (GERD), billion A$	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Gross Domestic Expenditure on R&D -- GERD (million current PPP $)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	GERD per capita population (current PPP $)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Percentage of GERD financed by other national sources	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Percentage of BERD financed by other national sources	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
2.1.1	Government (funder)	
MSTI	Government-financed GERD as a percentage of GDP	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Percentage of GERD financed by government	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI, AISR	Percentage of BERD financed by government	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI, STIS	Government Budget Allocations for R&D (GBARD) by socio-economic objectives:	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI, STIS	Total Government Budget Allocations for R&D -- GBARD (million current PPP $)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Total GBARD (million national currency for euro area: pre-EMU euro or EUR)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)

SRIBT	Total Government investment in R&D (GBARD + GTARD)	SRI Budget Tables, https://www.industry.gov.au/data-and-publications/science-research-and-innovation-sri-budget-tables
AISR	Government Budget Appropriations or Outlays for R&D (GBAORD), % of GDP	OECD Main S&T Indicators
STIS	70. Direct funding and tax incentive support for business R&D by SMEs, as a percentage of government support for BERD in each category	OECD, R&D Tax Incentive Indicators, http://oe.cd/rdtax, July 2017
STIS	Direct government funding and tax support for business R&D, 2015, as a percentage of GDP	OECD, R&D Tax Incentive Indicators, http://oe.cd/rdtax, July 2017
STIS	Change in government support for business R&D through direct funding and tax incentives, as a percentage of total support	OECD, R&D Tax Incentive Indicators, http://oe.cd/rdtax, July 2017
STIS	Tax subsidy rates on R&D expenditures, 2017, 1-B-Index, by firm size and profit scenario	OECD, R&D Tax Incentive Indicators, http://oe.cd/rdtax, July 2017
AISR	University income from Cooperative Research Centre (CRC) Research, million A$	Australian Government (2013–2014) Higher Education Research Data Collection (HERDC), 2012–2013, URL: http://education.gov.au/; [5] Australian Government (2015–2017) Higher Education Research Data Collection (HERDC), 2014–2015–1, Research Block Grants, URL: http://education.gov.au/
AISR	Environmentally related government R&D budget, % of total government R&D	OECD (2016–2017) Green growth indicators, 2016–2 to 2017, URL: http://www.oecd.org/
2.1.2	Business (funder)	
EIS	3.2.3 Private co-funding of public R&D expenditures	Eurostat, https://ec.europa.eu/eurostat/data/database
GII	5.1.4 GERD financed by business, %	UNESCO Institute for Statistics, UIS online database (2007–16). (http://data.uis.unesco.org)

MSTI	Business-financed GERD as a percentage of GDP	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Percentage of GERD financed by the business enterprise sector	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI, AISR	Percentage of GOVERD financed by the business enterprise sector	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Business-financed BERD -- (million 2010 dollars -- constant prices and PPP)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Business-financed BERD as a percentage of value added in industry	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
STIS	Business R&D and government support for business R&D, by size, 2015, Share corresponding to SMEs, as a percentage of the relevant total	OECD, Research and Development Statistics Database, http://oe.cd/rds, June 2017
STIS	R&D investment per patent of top corporate R&D investors, by headquarters' location, 2012–14, Million USD per IP5 patent family	OECD calculations based on JRC-OECD, COR&DIP© Database v.1., June 2017
STIS	Businesses receiving public support for innovation, by size, 2012–14, a percentage of product and/or process-innovating businesses in each size category	OECD, based on the 2017 OECD survey of national innovation statistics and Eurostat Community Innovation Survey (CIS-2014), June 2017. http://oe.cd/inno-stats
AISR	University income from industry and other funding sources, million A$	Australian Government (2013–14) Higher Education Research Data Collection (HERDC), 2012–13, URL: http://education.gov.au/; [5] Australian Government (2015–17) Higher Education Research Data Collection (HERDC), 2014 – 2015–1, Research Block Grants, URL: http://education.gov.au/

ISA 2016, ISA 2018, AISR, MSTI	Percentage of HERD financed by industry	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm) ABS 8111.0 – Research and Experimental Development, Higher Education Organisations, Australia http://www.abs.gov.au/ausstats/abs@.nsf/mf/8111.0
2.1.3	Higher Education (funder)	
STIS	Funding of R&D in higher education, as a percentage of Higher Education R&D expenditure	OECD, Research and Development Statistics Database, http://oe.cd/rds, June 2017
2.1.4	Not-for-profit (funder)	
MSTI	Percentage of Gross Expenditure on R&D (GERD) performed by the Private Non-Profit sector, %	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
2.1.5	Overseas (funder)	
MSTI, AISR, GII	Percentage of GERD financed by the rest of the world	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm), UNESCO Institute for Statistics, UIS online database (2007–16). (http://data.uis.unesco.org)
MSTI, STIS, AISR	Business R&D funded from abroad, by source of funds, as a percentage of business enterprise expenditure on R&D	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm), OECD, Research and Development Statistics Database, http://oe.cd/rds, June 2017
2.2	R&D Performers	
MSTI	Gross Domestic Expenditure on R&D -- GERD (million current PPP $)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
AISR, MSTI, STIS, GCR, HDI	GERD as a percentage of GDP	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm) ABS 8104.0 –

		Research and Experimental Development, Businesses, Australia, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8104.0 ; World Bank (2018a)
MSTI	GERD per capita population (current PPP $)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	R&D expenditure of foreign affiliates (million current PPP $)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	R&D expenditure of foreign affiliates (million national currency – for euro area, pre-EMU euro or EUR)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	R&D expenditure of foreign affiliates as a percentage of R&D expenditure of enterprises	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
AISR	Gross Expenditure on R&D (GERD) per capita population, current PPP $	OECD (2017) Main Science and Technology Indicators, 2016–2 to 2017, URL: http://stats.oecd.org/;
AISR	Public spending in environment-related R&D, % total public spending on R&D	OECD (2014) Green growth indicators, 2014, DOI: 10.1787/data-00686-en;
AISR	Energy public research, development and demonstration (RD&D) budget, % of GDP	OECD (2016–2017) Green growth indicators, 2016–2 to 2017, URL: http://www.oecd.org/;
AISR	Renewable energy public research, development and demonstration (RD&D) budget, % of total energy public RD&D	OECD (2016–2017) Green growth indicators, 2016–2 to 2017, URL: http://www.oecd.org/;
2.2.1	Government (Performer)	
EIS	2.1.1 R&D expenditure in the public sector	Data source Eurostat
MSTI	Percentage of GERD performed by the Government sector	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)

MSTI	Government Intramural Expenditure on R&D -- GOVERD (million current PPP $)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	GOVERD (million national currency for euro area, pre-EMU euro or EUR)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	GOVERD (million 2010 dollars -- constant prices and PPP)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
ISA 2016, AISR, MSTI	Government expenditure on research and development (GOVERD), % of GDP	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm), 8109.0 – Research and Experimental Development, Government and Private Non-Profit Organisations, Australia, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8109.0
2.2.2	Business (Performer)	
RDTI	Business expenditure on R&D by ANZSIC	R&D Tax Incentive program
EIS	2.2.1 R&D expenditure in the business sector	Data source Eurostat

MSTI, ISA 2016, ISA 2018, AISR, STIS	Business expenditure on research and development (BERD), % of GDP	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm). ABS 8104.0
ABS	Business expenditure on research and development (BERD) by Field of Research, Socio-Economic Objective, Type of Activity	8104.0 – Research and Experimental Development, Businesses, Australia, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8104.0/
ABS, MSTI, AISR	Business expenditure on R&D (BERD), billion A$	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
GII	2.3.3 Global R&D companies, avg. expend. top 3, million $US	EU JRC Industrial R&D Investment Scoreboard 2016. (http://iri.jrc.ec.europa.eu/scoreboard16.html)
GII	5.1.3 GERD performed by business, % of GDP	UNESCO Institute for Statistics, UIS online database (2007–15). (http://data.uis.unesco.org)
MSTI	Percentage of GERD performed by the Business Enterprise sector	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Business Enterprise Expenditure on R&D -- BERD (million current PPP $)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	BERD (million national currency for euro area, pre-EMU euro or EUR)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	BERD -- (million 2010 dollars -- constant prices and PPP)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	BERD as a percentage of value added in industry	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	BERD performed in the pharmaceutical industry (million current PPP $)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Percentage of BERD performed in the pharmaceutical industry	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)

MSTI	BERD performed in the computer, electronic and optical industry (million current PPP $)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Percentage of BERD performed in the computer, electronic and optical industry	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	BERD performed in the aerospace industry (million current PPP $)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Percentage of BERD performed in the aerospace industry	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	BERD performed in service industries (million current PPP $)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Percentage of BERD performed in service industries	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
STIS	Concentration of business R&D, as a percentage of domestic business R&D expenditure and of total count of performers, : top 50 and top 100 performers	OECD, based on preliminary results from the OECD microBeRD project, http://oe.cd/microberd, July 2017
STIS	Business R&D performance by size and age, as a percentage of domestic business R&D expenditure	OECD, based on preliminary results from the OECD microBeRD project, http://oe.cd/microberd, July 2017.
STIS	R&D intensity by industry, 2015, as a percentage of gross value added, log scale	OECD calculations based on ANBERD, http://oe.cd/anberd, STAN, http://oe.cd/stan, National Accounts (SNA), and Research and Development Statistics (http://oe.cd/rds) Databases, June 2017.
STIS	New-to-market product innovators, by firm size, 2012–14, as a percentage of all businesses in each size category within the scope of national innovation surveys	OECD, based on the 2017 OECD survey of national innovation statistics and the Eurostat, Community Innovation Survey (CIS-2014), http://oe.cd/inno-stats, June 2017

STIS	Business R&D intensity adjusted for industrial structure, 2015, as a percentage of value added in industry	OECD calculations based on the ANBERD Database, http://oe.cd/anberd, the National Accounts (SNA) Database, the Structural Analysis (STAN) Database, http://oe.cd/stan, Main Science and Technology Indicators Database, http://oe.cd/msti, and Research and Development Statistics Database, http://oe.cd/rds, June 2017. See chapter notes.
STIS	Business R&D expenditures by foreign-controlled affiliates, selected countries, 2015 or latest available, as a percentage of business enterprise expenditure on R&D	OECD, Activity of Multinational Enterprises Database, http://oe.cd/amne; Eurostat Inward FATS Database and Research and Development Statistics Database, http://oe.cd/rds, June 2017
2.2.3	Higher Education (Performer)	
MSTI	Percentage of GERD performed by the Higher Education sector	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI, ISA 2016, AISR, STIS	Higher education expenditure on research and development (HERD), % of GDP	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm) 8111.0 – Research and Experimental Development, Higher Education Organisations, Australia, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8111.0
MSTI	Higher Education Expenditure on R&D -- HERD (million current PPP $)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	HERD (million 2010 dollars -- constant prices and PPP)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
NSRC	Research Expenditure	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
NSRC	Number of invention disclosures received	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
2.2.4	Not-for-profit (Performer)	

MSTI	Percentage of GERD performed by the Private Non-Profit sector	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
2.2.5	Overseas (Performer)	
MSTI	R&D expenditure of foreign affiliates (million current PPP $)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	R&D expenditure of foreign affiliates (million national currency for euro area, pre-EMU euro or EUR)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	R&D expenditure of foreign affiliates as a percentage of R&D expenditure of enterprises	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
3	NON-R&D BASED KNOWLEDGE AND IDEA CREATION	
EIS	2.2.2 Non-R&D innovation expenditures	Data source Eurostat (Community Innovation Survey)
GII	7.2.1 Cultural & creative services exports, % of total trade	WTO, Trade in Commercial Services database, based on the sixth (2009) edition of the International Monetary Fund's Balance of Payments Manual and Balance of Payments database; Bureau of Economic Analysis (BEA) released October 2016 (2007–15). (http://stat.wto.org/StatisticalProgram/WSDBStatProgramSeries.aspx; http://www.oecd.org/std/its/EBOPS-2010.pdf ; https://www.bea.gov/iTable/iTable.cfm)
GII	7.2.2 National feature films/million pop. aged 15–69	UNESCO Institute for Statistics, UIS online database; United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects: The 2015 Revision (population) (2008–15). (http://data.uis.unesco.org; http://esa.un.org/unpd/wpp/)
GII	7.2.3 Global ent. & media market/thousand pop. aged 15–69	The source of the data for the base of these calculations was derived from PwC's Global Entertainment and Media Outlook, 2016–2020; United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects: The 2015 Revision (population); World Economic Outlook Database, October 2016 (current US$GDP); Middle East & North Africa in World Bank's DataBank. (http://www.pwc.com/outlook;

		http://esa.un.org/unpd/wpp/; https://www.imf.org/external/pubs/ft/weo/2016/02/weodata/index.aspx; http://data.worldbank.org/region/middle-east-and-north-africa)
GII	7.2.4 Printing & publishing manufactures, %	United Nations Industrial Development Organization, Industrial Statistics Database; 2-digit level of International Standard Industrial Classification ISIC Revision 3 (INDSTAT2 2015) (2006–14). (http://www.unido.org/statistics.html; http://unstats.un.org/unsd/cr/registry/regcst.asp?cl=2)
GII	7.2.5 Creative goods exports, % total trade	United Nations, COMTRADE database; 2009 UNESCO Framework for Cultural Statistics, Table 3, International trade of cultural goods and services based on the 2007 Harmonised System (HS 2007); WTO, Trade in Commercial Services database, itself based on the sixth (2009) edition of the International Monetary Fund's Balance of Payments Manual and Balance of Payments database (2010–15). (http://comtrade.un.org/; http://www.uis.unesco.org/culture/Documents/framework-cultural-statistics-culture-2009-en.pdf; http://stat.wto.org/StatisticalProgram/WSDBStatProgramSeries.aspx ; http://www.oecd.org/std/its/EBOPS-2010.pdf)
GII	7.3.3 Wikipedia edits/million pop. aged 15–69	Wikimedia Foundation; United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects: The 2012 Revision (population). (https://wikimediafoundation.org; https://esa.un.org/unpd/wpp/)
GII	7.3.4 Video uploads on YouTube/pop. aged15–69	Google, parent company of YouTube; United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects: The 2012 Revision (population). (http://www.youtube.com; http://esa.un.org/unpd/wpp/Excel-Data/population.htm; http://www.comscore.com/Industries/Media)
3.1	Domestic	
3.1.1	Domestic Government	
XXX	Nil at present	Nil
3.1.2	Domestic Business	

XXX	Nil at present	Nil
3.2	Overseas	
3.2.1	Overseas Government	
XXX	Nil at present	Nil
3.2.2	Overseas Business	
XXX	Nil at present	Nil
4	HUMAN CAPITAL	
4.1	Education and training	
OECD	Total expenditure on educational institutions, % of GDP	OECD Education and Training Statistics, https://www.oecd.org/statistics/data-collection/educationandtraining.htm
GII, HDI	2.1.1 Expenditure on education, % GDP	UNESCO Institute for Statistics, UIS online database (2007–16). (http://data.uis.unesco.org/)
OECD	Public expenditure on education, % of GDP	OECD Education and Training Statistics, https://www.oecd.org/statistics/data-collection/educationandtraining.htm
NCVER	Percentage of employers recruiting international students, %	National Centre for Vocational Education Research (NCVER), https://www.ncver.edu.au/research-and-statistics/data/all-data
NCVER	Employer difficulty sourcing/recruiting graduates, %	National Centre for Vocational Education Research (NCVER), https://www.ncver.edu.au/research-and-statistics/data/all-data
NCVER	Businesses reporting some or a lot of difficulty in recruiting staff, % of all employers	National Centre for Vocational Education Research (NCVER), https://www.ncver.edu.au/research-and-statistics/data/all-data

ABS	Barrier to innovation: Lack of skilled persons in any location, % of respondents	ABS 8158.0 – Innovation in Australian Business, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0
ISA 2018	Percentage of population aged 25–64 with STEM at tertiary level, %	OECD Statistics: Education and training, Education at a glance: Educational attainment and labour-force status table http://stats.oecd.org/; Education at a Glance 2017: OECD indicators https://www.hm.ee/sites/default/ files/eag2017_eng.pdf; ABS – Labour Force statistics
AISR, EIS	Proportion of population aged 25–34 with tertiary education, %	OECD Education and Training Statistics, https://www.oecd.org/statistics/data-collection/educationandtraining.htm; Eurostat, https://ec.europa.eu/eurostat/data/database
ISA 2016	Population aged 25–64 with tertiary education, %	OECD Statistics: Education and Training, Education at a glance: *Table Educational attainment and labour-force status* http://stats.oecd.org/; Education at a Glance2017: OECD INDICATORS https://www.hm.ee/sites/default/files/eag2017_eng.pdf ABS 6202.0 – Labour Force, Australia http://www.abs.gov.au/ausstats/abs@.nsf/mf/6202.0
GII	2.2.2 Graduates in science & engineering, %	UNESCO Institute for Statistics, UIS online database (2007–16). (http://data.uis.unesco.org/)
ABS	% all graduates with a post-graduate degree	6227.0 – Education and Work, Australia http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/6227.0
STIS	59. Women tertiary graduates in natural sciences, engineering and ICTs (NSE & ICT), As a percentage of all tertiary graduates in NSE & ICT	OECD calculations based on OECD, Education Database, September 2017.
AISR	Number of students completing higher degree by research in Australia[5] [6]	National Centre for Vocational Education Research (NCVER), https://www.ncver.edu.au/research-and-statistics/data/all-data
AISR	Number of domestic students completing higher degree by research in Australia[5] [6]	National Centre for Vocational Education Research (NCVER), https://www.ncver.edu.au/research-and-statistics/data/all-data
AISR	Number of international students completing higher degree by research in Australia[5] [6]	National Centre for Vocational Education Research (NCVER), https://www.ncver.edu.au/research-and-statistics/data/all-data

STIS	Tertiary graduates in the natural sciences, engineering and ICTs (NSE & ICT), As a percentage of all tertiary graduates	OECD, based on OECD (2017), Education at a Glance 2017: OECD Indicators and OECD (2007), Education at a Glance 2007: OECD Indicators, OECD Publishing, Paris.
STIS	Tertiary graduates in Information and communication technologies, by gender, As a percentage of all tertiary graduates	OECD calculations based on OECD Education Database, September 2017.
STIS, ISA 2016	Doctorate holders in the working age population, Per thousand population aged 25–64	OECD calculations based on OECD data collection on Careers of Doctorate Holders 2017, http://oe.cd/cdh, OECD (2017), Education at a Glance 2017: OECD Indicators and OECD (2009), Education at a Glance 2009: OECD Indicators, OECD Publishing, Paris.
ISA 2016	Population aged 25–64 with a doctorate per thousand population	OECD (2015) OECD Science, Technology and Industry Scoreboard 2015: Innovation for growth and society. OECD Publishing. Paris. pg. 102 OECD (2013) OECD Science, Technology and Industry Scoreboard 2013: Innovation for growth. OECD Publishing. Paris. pg. 96 ABS 6202.0 – Labour Force, Australia http://www.abs.gov.au/ausstats/abs@.nsf/mf/6202.0
STIS	R&D personnel, Per thousand employment	OECD, Main Science and Technology Indicators Database, http://oe.cd/msti, July 2017.
STIS	Researchers, by sector of employment, As a percentage of total researchers, full-time equivalents	OECD, Research and Development Statistics Database, http://oe.cd/rds, June 2017.
GII	2.3.1 Researchers, FTE/million pop	UNESCO Institute for Statistics, UIS online database (2007–16). (http://data.uis.unesco.org/)
GII	5.1.1 Knowledge-intensive employment, %	International Labour Organization ILOSTAT Database of Labour Statistics (2007–15). (http://www.ilo.org/ilostat/)
GII	5.1.5 Females employed w/advanced degrees, % total	International Labour Organization, ILOSTAT Annual Indicators (2009–16); and Statistics Canada, Table 282-0004; Labour Force Survey estimates (LFS) by educational attainment, sex and age group, annual, CANSIM, accessed 9 February 2017. (http://www.ilo.org/ilostat/; http://laborsta.ilo.org/ ; http://www.statcan.gc.ca/)
MSTI	Total researchers (FTE)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)

MSTI	Total researchers (FTE) per thousand total employment	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Total researchers (FTE) per thousand labour force	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Total R&D personnel (FTE)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Total R&D personnel (FTE) per thousand total employment	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Total R&D personnel (FTE) per thousand labour force	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Total researchers (headcount)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Women researchers (headcount)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Women researchers as a percentage of total researchers (based on headcount)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Government Sector: Total researchers (headcount)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Government Sector: Women researchers (headcount)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Government Sector: Women researchers as a percentage of total researchers (based on headcount)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Government researchers (FTE)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Government researchers (FTE) as a percentage of national total	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Government Total R&D personnel (FTE)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)

MSTI	Higher Education sector: Total researchers (headcount)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Higher Education sector: Women researchers (headcount)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Higher Education sector: Women researchers as a percentage of total researchers (based on headcount)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Higher Education researchers (FTE)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Higher Education researchers (FTE) as a percentage of national total	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Higher Education Total R&D personnel (FTE)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
STIS	10.Researchers, per thousand employment by Gross domestic expenditures on R&D as a percentage of GDP	OECD, Main Science and Technology Indicators Database, http://oe.cd/msti and UNESCO Institute for Statistics, Research and experimental development (full dataset), July 2017.
STIS	International and domestic doctoral students in natural sciences, engineering and ICT (NSE & ICTs), 2015.	OECD calculations based on OECD Education Database, September 2017
AISR	R&D personnel, % of total employment	OECD (2017) Main Science and Technology Indicators, 2016–2 to 2017, URL: http://stats.oecd.org/;
AISR	Researchers, % of total labour force	OECD (2017) Main Science and Technology Indicators, 2016–2 to 2017, URL: http://stats.oecd.org/;
AISR	Proportion of population aged 25–64 attaining upper secondary or post-secondary non-tertiary education, %	OECD Education and Training Statistics, https://www.oecd.org/statistics/data-collection/educationandtraining.htm
AISR	Proportion of population aged 25–64 attaining below upper secondary school education, %	OECD Education and Training Statistics, https://www.oecd.org/statistics/data-collection/educationandtraining.htm

AISR	PhD graduation rate	OECD Education and Training Statistics, https://www.oecd.org/statistics/data-collection/educationandtraining.htm
AISR	Lack of access to knowledge or technology, % of respondents (Barriers to innovation)	ABS 8158.0 – Innovation in Australian Business, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0
AISR	Lack of skilled persons in any location, % of respondents (Barriers to innovation)	ABS 8158.0 – Innovation in Australian Business, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0
AISR	Lack of skilled persons within the business, % of respondents (Barriers to innovation)	ABS 8158.0 – Innovation in Australian Business, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0
AISR	Lack of skilled persons within the labour market, % of respondents	ABS 8158.0 – Innovation in Australian Business, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0
NSRC	Number of academic researchers	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
NSRC	Number of research students	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
GCR	6.05 Digital skills among active population	WEF, Executive Opinion Survey. (see Note 2)
GCR	6.06 Ease of finding skilled employees	WEF, Executive Opinion Survey. (see Note 2)
GCR	6.07 School life expectancy	UNESCO
OECD	Percentage of graduates in Science, Technology, Engineering and Mathematics programmes in tertiary education who are female	Education at a glance: OECD.stat
4.1.1	Early childhood development	

HDI	Gross enrolment ratio, pre-primary (% of preschool-age children)	UNESCO Institute for Statistics (2018), ICF Macro Demographic and Health Surveys, UNICEF Multiple Indicator Cluster Surveys and OECD (2017a).; http://data.uis.unesco.org/
4.1.2	Schools	
ISA 2018	Programme for International Student Assessment (PISA) scores in science, reading, mathematics	OECD: PISA http://www.oecd.org/Pisa/
GII	2.1.2 Gov't expenditure/pupil, secondary, % GDP/cap	UNESCO Institute for Statistics, UIS online database (2007–16). (http://data.uis.unesco.org/)
GII	2.1.3 School life expectancy, years	UNESCO Institute for Statistics, UIS online database (2007–16). (http://data.uis.unesco.org/)
GII	2.1.4 PISA scales in reading, maths, & science	OECD Programme for International Student Assessment (PISA) (2010–15). (www.pisa.oecd.org/)
GII	2.1.5 Pupil-teacher ratio, secondary	UNESCO Institute for Statistics, UIS online database (2007–16). (http://data.uis.unesco.org/)
STIS	Top and low PISA performers in science and mathematics, As a percentage of 15 year-old students	OECD calculations based on OECD PISA 2015 Database, July 2017
AISR	Expenditure on primary, secondary and post-secondary (non-tertiary educational) institutions, % of GDP	OECD Education and Training Statistics, https://www.oecd.org/statistics/data-collection/educationandtraining.htm
GCR, HDI	6.01 Mean years of schooling	UNESCO; Wittgenstein Centre for Demography and Global Human Capital.
GCR	6.09 Pupil-to-teacher ratio in primary education	The World Bank Group.
HDI	Gross enrolment ratio, secondary (% of secondary school-age population)	UNESCO Institute for Statistics (2018), ICF Macro Demographic and Health Surveys, UNICEF Multiple Indicator Cluster Surveys and OECD (2017a).; http://data.uis.unesco.org/

HDI	Gross enrolment ratio, primary (% of primary school-age population)	UNESCO Institute for Statistics (2018), ICF Macro Demographic and Health Surveys, UNICEF Multiple Indicator Cluster Surveys and OECD (2017a).; http://data.uis.unesco.org/
HDI	Expected years of schooling (years)	UNESCO Institute for Statistics (2018), ICF Macro Demographic and Health Surveys, UNICEF Multiple Indicator Cluster Surveys and OECD (2017a).; http://data.uis.unesco.org/
HDI	Expected years of schooling, female (years)	UNESCO Institute for Statistics (2018), ICF Macro Demographic and Health Surveys, UNICEF Multiple Indicator Cluster Surveys and OECD (2017a).; http://data.uis.unesco.org/
HDI	Expected years of schooling, male (years)	UNESCO Institute for Statistics (2018), ICF Macro Demographic and Health Surveys, UNICEF Multiple Indicator Cluster Surveys and OECD (2017a).; http://data.uis.unesco.org/
HDI	Mean years of schooling, female (years)	UNESCO Institute for Statistics (2018), ICF Macro Demographic and Health Surveys, UNICEF Multiple Indicator Cluster Surveys and OECD (2017a).; http://data.uis.unesco.org/
HDI	Mean years of schooling, male (years)	UNESCO Institute for Statistics (2018), ICF Macro Demographic and Health Surveys, UNICEF Multiple Indicator Cluster Surveys and OECD (2017a).; http://data.uis.unesco.org/
HDI	Population with at least some secondary education (% ages 25 and older)	UNESCO Institute for Statistics (2018), ICF Macro Demographic and Health Surveys, UNICEF Multiple Indicator Cluster Surveys and OECD (2017a).; http://data.uis.unesco.org/
HDI	Population with at least some secondary education, female (% ages 25 and older)	UNESCO Institute for Statistics (2018), ICF Macro Demographic and Health Surveys, UNICEF Multiple Indicator Cluster Surveys and OECD (2017a).; http://data.uis.unesco.org/
HDI	Population with at least some secondary education, male (% ages 25 and older)	UNESCO Institute for Statistics (2018), ICF Macro Demographic and Health Surveys, UNICEF Multiple Indicator Cluster Surveys and OECD (2017a).; http://data.uis.unesco.org/
HDI	Programme for International Student Assessment (PISA) score in mathematics	OECD (2017b).; http://www.oecd.org/pisa/

HDI	Programme for International Student Assessment (PISA) score in reading	OECD (2017b).; http://www.oecd.org/pisa/
HDI	Programme for International Student Assessment (PISA) score in science	OECD (2017b).; http://www.oecd.org/pisa/
4.1.3	VET	
STIS	Expenditure on tertiary education and vocational programmes, As a percentage of GDP	OECD based on OECD (2017), Education at a Glance 2017: OECD Indicators, OECD Publishing, Paris
AISR	% of employers satisfied that vocational qualifications provide employees with the skills they require for the job.	National Centre for Vocational Education Research (NCVER), https://www.ncver.edu.au/research-and-statistics/data/all-data
AISR	% of employers satisfied that apprentices and trainees are obtaining skills they require from training	National Centre for Vocational Education Research (NCVER), https://www.ncver.edu.au/research-and-statistics/data/all-data
AISR	% of employers satisfied that nationally recognised training (which is not part of an apprenticeship or traineeship) provides employees with the skills they require for the job	National Centre for Vocational Education Research (NCVER), https://www.ncver.edu.au/research-and-statistics/data/all-data
AISR	Participation rate of Australians aged 15 years and older in VET, %	National Centre for Vocational Education Research (NCVER), https://www.ncver.edu.au/research-and-statistics/data/all-data
AISR	Number of qualifications completed by students in VET, '000s	National Centre for Vocational Education Research (NCVER), https://www.ncver.edu.au/research-and-statistics/data/all-data
AISR	Percentage of government-funded graduates employed in labour force after completing VET, % of respondents	National Centre for Vocational Education Research (NCVER), https://www.ncver.edu.au/research-and-statistics/data/all-data

AISR	Percentage of government-funded VET graduates satisfied with overall quality of training, % of respondents	National Centre for Vocational Education Research (NCVER), https://www.ncver.edu.au/research-and-statistics/data/all-data
AISR	Employer overall satisfaction with VET system, %	National Centre for Vocational Education Research (NCVER), https://www.ncver.edu.au/research-and-statistics/data/all-data
ISA 2018	Vocational education and training completion rates	National Centre for Vocational Education Research (NCVER), https://www.ncver.edu.au/research-and-statistics/data/all-data
4.1.4	Higher Education (flow – production grads)	
EIS	1.1.1 New doctorate graduates	Eurostat, https://ec.europa.eu/eurostat/data/database
EIS	1.1.3 Lifelong learning	Eurostat, https://ec.europa.eu/eurostat/data/database
EIS	1.2.3 Foreign doctorate students	Eurostat, https://ec.europa.eu/eurostat/data/database
GII	2.2.1 Tertiary enrolment, % gross	UNESCO Institute for Statistics, UIS online database (2007–16). (http://data.uis.unesco.org/)
GII	2.3.4 QS university ranking, average score top 3	QS Quacquarelli Symonds Ltd, QS World University Ranking 2016/2017, Top Universities. (https://www.topuniversities.com/university-rankings/world-university-rankings/2016)
QILT	Measures of teaching quality	Quality Indicators of Learning and Teaching, Department of Education and Training/Social Research Centre, https://www.qilt.edu.au/for-institutions/data-request
QILT	Measures of learner engagement	Quality Indicators of Learning and Teaching, Department of Education and Training/Social Research Centre, https://www.qilt.edu.au/for-institutions/data-request
QILT	Measures of learning resources	Quality Indicators of Learning and Teaching, Department of Education and Training/Social Research Centre, https://www.qilt.edu.au/for-institutions/data-request
QILT	Measures of student support	Quality Indicators of Learning and Teaching, Department of Education and Training/Social Research Centre, https://www.qilt.edu.au/for-institutions/data-request
QILT	Measures of skills development	Quality Indicators of Learning and Teaching, Department of Education and Training/Social Research Centre, https://www.qilt.edu.au/for-institutions/data-request

QILT	Measures of employer satisfaction with graduate attributes	Quality Indicators of Learning and Teaching, Department of Education and Training/Social Research Centre, https://www.qilt.edu.au/for-institutions/data-request
AISR	Public expenditure on tertiary education, % of GDP	OECD Education and Training Statistics, https://www.oecd.org/statistics/data-collection/educationandtraining.htm
AISR	Proportion of international students enrolled in advanced research programs, %	OECD Education and Training Statistics, https://www.oecd.org/statistics/data-collection/educationandtraining.htm
ISA 2016, ISA 2018	Academic Ranking of World Universities top 200 universities, per million population	ShanghaiRanking Consultancy (2016) Academic Ranking of World Universities 2016. Accessed at http://www.shanghairanking.com/ARWU2016.html OECD (2016) Main Science and Technology Indicators, 2016-1. Accessed at https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB
ISA 2016	Government and higher education researchers (full time equivalent) per thousand total employment	ABS 8111.0 – Research and Experimental Development, Higher Education Organisations, Australia http://www.abs.gov.au/ausstats/abs@.nsf/mf/8111.0 8109.0 – Research and Experimental Development, Government and Private Non-Profit Organisations, Australia http://www.abs.gov.au/ausstats/abs@.nsf/mf/8109.0
ISA 2016	Universitas 21 national higher education systems ranking	Universitas 21 (2016) Data Comparison of the U21 Rankings. Accessed at http://www.universitas21.com/rankingcomparison
GCR	12.08 Research institutions prominence index	SCImago; WEF.
HDI	Gross enrolment ratio, tertiary (% of tertiary school-age population)	UNESCO Institute for Statistics (2018), ICF Macro Demographic and Health Surveys, UNICEF Multiple Indicator Cluster Surveys and OECD (2017a).; http://data.uis.unesco.org/
4.1.5	Non-accredited education and training	
XXX	Nil at present	Nil
4.1.6	On the job training and professional development)	

EIS	2.2.3 Enterprises providing training to develop or upgrade ICT skills of their personnel	Data source Eurostat, Community Survey of ICT Usage and E-commerce in Enterprises
GII	5.1.2 Firms offering formal training, % firms	World Bank, Enterprise Surveys (2006–16). (http://www.enterprisesurveys.org/).
AusTender	Income from education and training services provided by universities to government	Australian Government Department of Finance. https://data.gov.au/dataset/historical-australian-government-contract-data
STIS	40. Workers receiving firm-based training, by skill level, As a percentage of total employed persons	OECD calculations based on the OECD Programme for International Assessment of Adult Competencies (PIAAC) Database, June 2017.
STIS	43. Employees participating in on-the-job training, by gender, As a percentage of total employees of a given gender in the economy	OECD calculations based on the OECD Programme for International Assessment of Adult Competencies (PIAAC) Database, September 2017
STIS	Workers receiving training, by type of training, As a percentage of total employed persons	OECD calculations based on the OECD Programme for International Assessment of Adult Competencies (PIAAC) Database, June 2017
NSRC	Offering industry skills training to academic researchers or research students	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
NSRC	Total Number of partcipants that completed training in industry skills	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
4.2	Labour and skills mobility	
STIS	69. International net flows of scientific authors, Difference between annual	OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017

	fractional inflows and outflows, as a percentage of total flows	
LinkedIn	Mobility of personnel between PFROs and industry	LinkedIn, https://www.linkedin.com/feed/
GCR	8.08 Internal labour mobility	WEF, Executive Opinion Survey. (see Note 2)
4.2.1	Internships	
XXX	Nil at present	Nil
4.2.2	Cross-sectoral staff placements and exchanges	
XXX	Nil at present	Nil
4.2.3	Skilled migration	
GII	2.2.3 Tertiary inbound mobility, %	UNESCO Institute for Statistics, UIS online database (2007–16). (http://data.uis.unesco.org/)
ABS	Skilled migration as a proportion of total (non-humanitarian) migration	ABS 3412.0 – Migration, Australia, http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/3412.0
STIS	Internationally mobile students enrolled in tertiary education, 2015, Total and breakdown by field of education	OECD, based on OECD (2017), Education at a Glance 2017: OECD Indicators, OECD Publishing, Paris.
STIS	International mobility of scientific authors, 2016., As a percentage of authors, by last main recorded affiliation in 2016	OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017.
HDI	International student mobility (% of total tertiary enrolment)	UNESCO Institute for Statistics (2018).
4.3	• Entrepreneurship skills	

Startup Muster	When Startup Was Founded Which Skills Were Strongly Represented In The Founding Team	Startup Muster survey, https://www.startupmuster.com/reports
5	DISTRIBUTION OF KNOWLEDGE	
5.1	Publications	
EIS	3.2.2 Public-private co-publications	Data source Data provided by CWTS (Leiden University) as part of a contract to the European Commission (DG Research and Innovation)
EIS	1.2.1 International scientific co-publications	Data source Data provided by CWTS (Leiden University) as part of a contract to the European Commission (DG Research and Innovation)
EIS	1.2.2 Top 10% most cited publications as a percentage of total scientific publications of the country (field weighted)	Data source Data provided by CWTS (Leiden University) as part of a contract to the European Commission (DG Research and Innovation), OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017
GII	6.1.4 Scientific & technical articles/billion PPP$ GDP	Clarivate Analytics, special tabulations from Thomson Reuters, Web of Science, Science Citation Index (SCI) and Social Sciences Citation Index (SSCI); International Monetary Fund, World Economic Outlook Database, October 2016 (PPP$ GDP) (2016). (https://apps.webofknowledge.com ; https://www.imf.org/external/pubs/ft/weo/2016/02/weodata/index.aspx)
GII	6.1.5 Citable documents H index	SCImago (2017) SJR–SCImago Journal & Country Rank. Retrieved February 2017. (http://www.scimagojr.com)
STIS	11. Percentage of the world's top 10% most-cited publications	OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017
Leiden	Median number and proportion of university publications co-authored with one or more other organizations.	Leiden University Centre for Science and Technology Studies (CWTS), http://www.journalindicators.com/indicators
Leiden	Median number and proportion of university publications that have been co-authored by two or more countries.	Leiden University Centre for Science and Technology Studies (CWTS), http://www.journalindicators.com/indicators

Leiden	Median number and the proportion of university publications that have been co-authored with one or more industrial organizations.	Leiden University Centre for Science and Technology Studies (CWTS), http://www.journalindicators.com/indicators
STIS	66. Open access of scientific documents, As a percentage of a random sample of 100 000 documents published in 2016	OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017; and roaDOI "wrapper" routine for the oaDOI API, https://oaDOI.org, July 2017
STIS	67. Highly cited scientific documents, by open-access status, Percentage within the 10% most-cited published in 2016	OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017; and roaDOI wrapper for the oaDOI API, https://oaDOI.org, July 2017
STIS	68. International collaboration in science and innovation, Co-authorship and co-invention as a percentage of scientific publications and IP5 patent families	OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017 and OECD, STI Micro-data Lab: IP Database, http://oe.cd/ipstats, July 2017.
STIS	Quantity and quality of scientific production, 2005 and 2015., Number of documents and percentage among the world's 10% most cited publications, fractional counts	OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017; and 2015 Scimago Journal Rank from the Scopus journal title list (accessed June 2017), July 2017
STIS	Specialisation and citation impact in science, selected fields, 2015, Percentage of documents in the top 10% ranked documents and relative specialisation, by field, fractional counts	OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017; and 2015 Scimago Journal Rank from the Scopus journal title list (accessed June 2017), July 2017
STIS	International scientific collaboration, 2015, As a percentage of domestically authored documents, fractional counts	OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017
STIS	The citation impact of scientific production and the extent of international collaboration, 2012–16, Domestic and foreign-led top	OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017.

	cited, as a percentage of all documents, fractional counts	
STIS	Top 10% most-cited documents and patterns of international collaboration, 2015	OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017; and 2015 Scimago Journal Rank from the Scopus journal title list (accessed June 2017), July 2017
AISR	Share of world publications, %	InCites (2016–17) InCites, 2016 – 2017, Ref: Thomson Reuters subscription database
ISA 2016, ISA 2018	Highly cited publications (top 1% or 10% in the world, all disciplines) per million population)	Thomson Reuters (2016) InCites. Accessed at https://incites.thomsonreuters.com OECD (2016) Main Science and Technology Indicators, 2016-1. Accessed at https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB
GCR	12.05 Scientific publications	SCImago.
5.2	• IP, licensing (out and in) and trade secrets	
EIS	3.3.1 PCT patent applications	Data source Patent data from the OECD. GDP data from Eurostat
EIS	3.3.2 Trademark applications	Data source Trademark data from European Union Intellectual Property Office (EUIPO) and WIPO. GDP data from Eurostat
EIS	3.3.3 Design applications	Data source Design data from European Union Intellectual Property Office (EUIPO). GDP data from Eurostat
GII	5.2.5 Patent families 2+ offices/billion PPP$ GDP	WIPO, IP Statistics; International Monetary Fund, World Economic Outlook Database, October 2016 (PPP$ GDP) (2008–13). (http://www.wipo.int//ipstats/ ; https://www.imf.org/external/pubs/ft/weo/2016/02/weodata/index.aspx)
GII	6.1.1 Patents by origin/billion PPP$ GDP	WIPO, IP Statistics; International Monetary Fund, World Economic Outlook Database, October 2016 (PPP$ GDP)(2010–15). (http://www.wipo.int/ipstats/ ; https://www.imf.org/external/pubs/ft/weo/2016/02/weodata/index.aspx)
GII	6.1.2 PCT patent applications/billion PPP$ GDP	WIPO, IP Statistics; International Monetary Fund, World Economic Outlook Database, October 2016 (PPP$ GDP) (2010–15). (http://www.wipo.int/ipstats/ ; https://www.imf.org/external/pubs/ft/weo/2016/02/weodata/index.aspx)

GII	7.1.1 Trademarks by origin/billion PPP$ GDP	WIPO, IP Statistics; International Monetary Fund, World Economic Outlook Database, October 2016 (PPP$ GDP) (2010–15). (https://www.wipo.int/ipstats/en/; https://www.imf.org/external/pubs/ft/weo/2016/02/weodata/index.aspx)
GII	7.1.2 Industrial designs by origin/billion PPP$ GDP	WIPO, IP Statistics; International Monetary Fund, World Economic Outlook Database, October 2016 (PPP$ GDP) (2010–15). (http://www.wipo.int//ipstats/ ; https://www.imf.org/external/pubs/ft/weo/2016/02/weodata/index.aspx)
MSTI	Number of triadic patent families (priority year)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Number of patent applications to the PCT (priority year)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Share of countries in triadic patent families (priority year)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Number of patent applications to the PCT in the ICT sector – (priority year)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Number of patent applications to the PCT in the biotechnology sector – (priority year)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
HEFP	Income to universities from royalties, trademarks and licenses	Department of Education and Training, Higher Education Finance Publication, https://www.education.gov.au/finance-publication
NSRC	Number of active LOA's yielding income	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
NSRC	Total value of income yielded from active LOAs	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
NSRC	New PCT applications by universities as % of all patent applications by universities	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc

STIS	61. Patenting activity by women inventors, As a percentage of IP5 patent families by technology and inventors' country	OECD, STI Micro-data Lab: IP Database, http://oe.cd/ipstats, June 2017
STIS	International co-inventions in ICT, 2012–15., As a percentage of economies' IP5 patent families	OECD, STI Micro-data Lab: IP Database, http://oe.cd/ipstats, June 2017
STIS	Number of economies in which inventors are located, by technology, 2012–15	OECD, STI Micro-data Lab: IP Database, http://oe.cd/ipstats, June 2017
STIS	Domestic ownership of ICT inventions from abroad, 2012–15	OECD, STI Micro-data Lab: IP Database, http://oe.cd/ipstats, June 2017
AISR	Patent applications filed under PCT per million population	OECD (2017) Main Science and Technology Indicators, 2016–2 to 2017, URL: http://stats.oecd.org/;
AISR	Share of world triadic patent families	OECD (2017) Main Science and Technology Indicators, 2016–2 to 2017, URL: http://stats.oecd.org/;
AISR	Triadic patent families per million population	OECD (2017) Main Science and Technology Indicators, 2016–2 to 2017, URL: http://stats.oecd.org/;
AISR	Madrid system trademark registrations by country of origin	Cornell University, INSEAD, WIPO (2011–16) Global Innovation Index, GII 2011–16, URL: http://www.globalinnovationindex.org
AISR	Development of environment-related technologies, inventions per capita	OECD (2016–17) Green growth indicators, 2016-2 to 2017, URL: http://www.oecd.org/;
AISR	National office resident trademark registrations, per billion PPP$ GDP	Cornell University, INSEAD, WIPO (2011–16) Global Innovation Index, GII 201116, URL: http://www.globalinnovationindex.org
AISR	Patent Cooperation Treaty resident applications, per billion PPP$ GDP	Cornell University, INSEAD, WIPO (2011–16) Global Innovation Index, GII 2011–16, URL: http://www.globalinnovationindex.org
ISA 2016,ISA 2018	Number of international patent applications filed by residents at the PCT per billion GDP (PPP)	Cornell, INSEAD and WIPO (2016) Global Innovation Index Analysis: 6.1.2 PCT international applications by origin. Accessed at https://www.globalinnovationindex.org/analysis-indicator
GCR	12.06 Patent applications	Organisation for Economic Co-operation and Development (OECD).

GCR	12.10 Trademark applications	WIPO.
5.3	Collaborations, contracts and consultancies between businesses and between businesses and research institutions	
CRC	Investments made and income received by PFRO for mission-directed research	Cooperative Research Centre (CRC) program https://www.business.gov.au/assistance/cooperative-research-centres-programme
IC	Number of contracts and income received by PFROs for undertaking industry-focused research	Innovation Connections (IC) program (and precursors) https://www.business.gov.au/assistance/entrepreneurs-programme/innovation-connections
ARC	Investments made and income received by university for mission-directed research	ARC Linkage and Industrial Transformation Research Program https://www.arc.gov.au/grants-and-funding/apply-funding/grants-dataset
RRDC	Number of contracts, and income received by PFROs for undertaking agriculture-related research, by research focus	Rural R&D Corporations program data http://www.agriculture.gov.au/ag-farm-food/innovation/research_and_development_corporations_and_companies
SME Connect	Number of contracts and income received by PFROs for undertaking industry-focused research	CSIRO SME Connect https://www.csiro.au/en/Do-business/Solutions-for-SMEs/About-SME-Connect
GII	5.2.1 University/industry research collaboration	WEF, Executive Opinion Survey 2016–17. (see Note 2) (https://www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1)
GII	5.2.4 JV–strategic alliance deals/billion PPP$ GDP	Thomson Reuters, Thomson One Banker Private Equity, SDC Platinum database; International Monetary Fund World Economic Outlook Database, October 2016 (PPP$GDP) (2015–16). (http://banker.thomsonib.com ; https://www.imf.org/external/pubs/ft/weo/2016/02/weodata/index.aspx)
NSRC	Gross contracted value of contracts, collaborations and consultancies for PFROs	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
HERDC	Research income to universities from contracts and consultancies	Department of Education and Training, Higher Education Research Data Collection, https://www.education.gov.au/higher-education-research-data-collection

STIS	Businesses collaborating on innovation with higher education or research institutions, by size, 2012–14	OECD, based on the 2017 OECD survey of national innovation statistics and the Eurostat, Community Innovation Survey (CIS-2014), http://oe.cd/inno-stats, June 2017
STIS	Businesses collaborating on innovation with suppliers and clients, by size, 2012–14, As percentage of product and/or process-innovating businesses in each size category	OECD, based on the 2017 OECD survey of national innovation statistics and the Eurostat, Community Innovation Survey (CIS-2014), http://oe.cd/inno-stats, June 2017
STIS	Businesses engaged in international collaboration for innovation, by size, 2012–14, As a percentage of product and/or process-innovating businesses in each size category	OECD, based on the 2017 OECD survey of national innovation statistics and the Eurostat, Community Innovation Survey (CIS-2014), http://oe.cd/inno-stats, June 2017.
AISR	International collaboration in development of environment-related technologies, % collaboration in all technologies	OECD (2016) Green growth indicators, 2016–2, URL: http://www.oecd.org/
AISR	Percentage of innovation-active large firms collaborating with universities or other research institutions (excluding commercial), %	ABS (2012–15) Special request, 12-Oct-2012 to 2015–2; OECD (2013) Science, Technology and Industry Scoreboard, 2013, DOI: 10.1787/sti_scoreboard-2013-en; OECD (2015) Science, Technology and Industry Scoreboard, 2015, DOI: 10.1787/20725345;
AISR	Percentage of innovation-active total businesses with international collaboration on innovation, %	ABS (2012–15) Special request, 12-Oct-2012 to 2015–2; OECD (2013) Science, Technology and Industry Scoreboard, 2013, DOI: 10.1787/sti_scoreboard-2013-en;
AISR	Percentage of innovation-active total businesses collaborating with universities or other research institutions excluding commercial, as a percentage of collaborative innovation-active businesses, %	ABS (2012–15) Special request, 12-Oct-2012 to 2015–2;

AISR, STIS	Percentage of innovation-active total businesses collaborating on innovation, %	ABS Selected Characteristics of Australian Business, cat. no. 8167.0, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8167.0
AISR, STIS	Proportion of non-innovation active businesses collaborating for any reason, % of respondents	ABS Selected Characteristics of Australian Business, cat. no. 8167.0, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8167.0
AISR, STIS	Proportion of innovation-active businesses collaborating for any reason, % of respondents	ABS Selected Characteristics of Australian Business, cat. no. 8167.0, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8167.0
AISR, STIS	Percentage of innovation-active SMEs collaborating on innovation, %	ABS 8158.0 – Innovation in Australian Business, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0, Special request
AISR, STIS	Percentage of innovation-active large firms collaborating on innovation, %	ABS 8158.0 – Innovation in Australian Business, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0, Special request
AISR	Percentage of innovation-active SMEs that collaborate with non-commercial research institutions, as a percentage of collaborative innovation-active businesses, %	ABS 8158.0 – Innovation in Australian Business, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0, Special request
AISR	Percentage of innovation-active SMEs collaborating with universities or other research institutions (excluding commercial)	ABS 8158.0 – Innovation in Australian Business, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0, Special request
AISR	Percentage of innovation-active large firms that collaborate with non-commercial research institutions, as a percentage of collaborative innovation-active businesses, %	ABS 8158.0 – Innovation in Australian Business, http://www.abs.gov.au/ausstats/abs@.nsf/mf/8158.0, Special request
ISA 2016	Proportion of publications with industry affiliated co-authors, %	Thomson Reuters (2016) InCites. Accessed at https://incites.thomsonreuters.com/#/analytics
ISA 2016, ISA 2018	Proportion of Patent Cooperation Treaty (PCT) Australian patents with foreign co-inventors, %	OECD (2016) International co-operation in patents: patent applications filed under the PCT with foreign co inventors. Accessed at http://stats.oecd.org/Index.aspx?DatasetCode=PATS_COOP

GCR	12.03 International co-inventions	Organisation for Economic Co-operation and Development (OECD).
GCR	12.04 Multistakeholder collaboration	WEF, Executive Opinion Survey. (see Note 2)
5.4	PFRO facilities, technology, materials, processes	
NSRC	Material Transfer Agreements, number and value of	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
NSRC	Expenditure on research commercialisation staff and FTE staff numbers	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
AISR	Diffusion of environment-related technologies, % all technologies	OECD (2016–17) Green growth indicators, 2016-2 to 2017, URL: http://www.oecd.org/;
5.5	Networks	
GII	5.2.2 State of cluster development	WEF, Executive Opinion Survey 2016–17. (https://www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1)
6	APPLICATION CAPABILITIES	
EP	Number of firms, by ANZSIC, receiving various kinds of business support	Entrepreneurs' Programme
EIS	3.1.1 SMEs with product or process innovations	Data source Eurostat (Community Innovation Survey)
EIS	3.1.2 SMEs with marketing or organisational innovations	Data source Eurostat (Community Innovation Survey)
EIS	3.1.3 SMEs innovating in-house	Data source Eurostat (Community Innovation Survey)

EIS	3.2.1 Innovative SMEs collaborating with others	Data source Eurostat (Community Innovation Survey)
AISR, STIS	Percentage of innovation-active firms, %	ABS 8166.0 Summary of IT use and Innovation, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8166.0
AISR, STIS	Percentage of innovation-active large firms, %	ABS 8166.0 Summary of IT use and Innovation, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8166.0
AISR, STIS	Proportion of businesses introducing goods or services innovation, %	ABS 8166.0 Summary of IT use and Innovation, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8166.0
AISR, STIS	Proportion of businesses introducing operational/ process innovation, %	ABS 8166.0 Summary of IT use and Innovation, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8166.0
AISR, STIS	Proportion of businesses introducing organisational/managerial process innovation, %	ABS 8166.0 Summary of IT use and Innovation, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8166.0
AISR, STIS	Proportion of businesses introducing marketing innovation, %	ABS 8166.0 Summary of IT use and Innovation, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/8166.0
AISR	Development of environment-related technologies, % all technologies	OECD (2016–17) Green growth indicators, 2016–2 to 2017, URL: http://www.oecd.org/;
ISA 2016	Percentage of firms that introduced new-to-market product innovation	OECD (2015) OECD Innovation Indicators 2015: June 2015. Accessed from http://www.oecd.org/sti/inno-stats.htm OECD (2013) OECD Innovation Indicators 2013: June 2013, Accessed from http://www.oecd.org/sti/inno-stats.htm
ABS	Written strategic plan or policy in place, all businesses, %	ABS Cat. 8172.0
6.1	Absorptive capacity	
XXX	Nil at present	Nil
6.2	Management capability	

GCR	11.06 Willingness to delegate authority	WEF, Executive Opinion Survey. (see Note 2)
6.3	Innovation capability	
6.3.1	R&D capacity	
XXX	Nil at present	Nil
6.3.2	Design capability	
XXX	Nil at present	Nil
6.3.3	Workforce skills and HR	
SEEK	Demand for PhD skills by industry sector and location	SEEK dataset, interpreted using methodology developed by the ANU and Data61
GII	5.3.5 Research talent, % in business enterprise	UNESCO Institute for Statistics, UIS online database (2007–16). (http://data.uis.unesco.org)
ISA 2016, MSTI	Business researchers, per thousand employed in industry	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Business Enterprise Sector: Total researchers (headcount)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Business Enterprise Sector: Women researchers (headcount)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Business Enterprise Sector: Women researchers as a percentage of total researchers (based on headcount)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Business Enterprise researchers (FTE)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)

MSTI	Business Enterprise researchers (FTE) as a percentage of national total	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Business Enterprise researchers (FTE) per thousand employment in industry	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Total Business Enterprise R&D personnel (FTE)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Total Business Enterprise R&D personnel (FTE) as a percentage of national total	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Total Business Enterprise R&D personnel (FTE) per thousand employment in industry	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
STIS	Business investment in fixed and knowledge-based capital, As a percentage of business sector gross value added	OECD calculations based on the OECD System of National Accounts (SNA) Database, INTAN-Invest data (http://www.intan-invest.net); and U.S. Bureau of Economic Analysis data, May 2017.
STIS	Market and non-market sector KBC investment, selected economies, As a percentage of gross value added in the sector	OECD calculations based on the OECD System of National Accounts (SNA) Database, INTAN-Invest data, (http://www.intan-invest.net), and SPINTAN data (http://www.spintan.net), May 2017
HDI	Skilled labour force (% of labour force)	ILO (2018a).; https://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page27.jspx?subject=SDG&indicator=SDG_0552_OCU_RT&datasetCode=A&collectionCode=SDG; Labor Force Survey
6.3.4	Digital capability	
GII	6.2.3 Computer software spending, % GDP	IHS Global Insight, Information and Communication Technology Database. (https://www.ihs.com/index.html)
STIS	28. Industrial robot stock over manufacturing value added, millions USD, current values	OECD calculations based on International Federation of Robotics data, and the World Bank, Word Development Indicators Database, September 2017. StatLink contains more data

STIS	29. Robot intensity and ICT task intensity of manufacturing jobs, Correlation of robots per worker and average ICT task intensity	OECD calculations based on OECD Programme for International Assessment of Adult Competencies (PIAAC) Database and International Federation of Robotics, September 2017
AISR	Firm-level technology absorption, score ranges from 1–7 (best)	WEF (2014–17) Global Competitiveness Index, 2014–15 to 2017–18, URL: http://www.weforum.org/;
6.3.5	IP management and appropriation	
NSRC	IPR protection external fees and legal costs	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
6.3.6	Supply-chain integration	
XXX	Nil at present	Nil
6.4	Financial capability	
XXX	Nil at present	Nil
6.4.1	Investment (debt or equity)	
XXX	Nil at present	Nil
7	APPLICATION PERFORMANCE	
ARTG	Proportion of Australian sponsors or manufacturers of registered therapeutic goods	Australian Register of Therapeutic Goods (ARTG), https://www.tga.gov.au/artg
AISR	Adjusted gross income from Licenses, Options and Assignments by major publicly	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc

	funded research agencies, universities and medical research institutes million A$	
AISR	Number of Licenses, Options and Assignments yielding income from major publicly funded research agencies, universities and medical research institutes	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
AISR	Number of patents granted worldwide from publicly funded research agencies, universities, and medical research institutes (MRIs)	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
AISR	Value of equity holdings by major publicly funded research agencies, universities and medical research institutes, million A$	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
AISR	Number of start-up companies in which major publicly funded research agencies, universities and medical research institutes have an equity holding	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
7.1	New products and processes	
STIS	Innovation types, by business size, 2012–14, as a percentage of all businesses in each size category within the scope of national innovation surveys	OECD, based on the 2017 OECD survey of national innovation statistics and the Eurostat, Community Innovation Survey (CIS-2014), http://oe.cd/inno-stats, June 2017
7.2	Start-ups and spinouts	
NSRC	Median value of research commercialisation equity holdings	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc

NSRC	No start-ups dependent upon licensing/ assignment for initiation	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
NSRC	No of start-ups dependent upon licensing/ assignment for initiation institution held equity	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
NSRC	Number of start-up companies created	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
NSRC	Number of patent families represented in new patent applications worldwide (NUM_FAMS) in PFRO start-ups/spinouts	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
NSRC	Number of patents granted to an institution elsewhere (NUM_GRANTS_ELSE) in PFRO start-ups/spinouts	National Survey of Research Commercialisation (NSRC), https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation-nsrc
8	IMPACTS	
8.1	Economic	
AISR	Rate of high-growth enterprises, measured by employment growth, %	ABS (special request)
AISR	Rate of high-growth enterprises in the construction sector, measured by employment growth	ABS (special request)
AISR	Rate of high-growth enterprises in the industry sector, measured by employment growth, %	ABS (special request)

AISR	Rate of high-growth enterprises in the services sector, measured by employment growth, %	ABS (special request)
AISR	Rate of high-growth enterprises, measured by turnover growth, %	ABS (special request)
AISR	Rate of high-growth enterprises in the construction sector, measured by turnover growth, %	ABS (special request)
AISR	Rate of high-growth enterprises in the industry sector, measured by turnover growth, %	ABS (special request)
AISR	Rate of high-growth enterprises in the services sector, measured by turnover growth, %	ABS (special request)
ISA 2016, ISA 2018	High growth enterprise rate, measured by employment growth, industry, %	OECD Statistics, SDBS Business Demography Indicators (ISIC REV.4): Rate of high-growth enterprise. Data on HE_R-Rate of high-growth enterprises (20% growth based on employment: <https://stats.oecd.org/> ABS 2017: Business longitudinal analysis data environment (BLADE); Customised data analysis commissioned by the Department of Industry, Innovation and Science.
ABS	Percentage of income from sales due to innovation in goods or services	ABS 8158.0 – Innovation in Australian Business http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8158.0
ABS	Percentage of innovation-active businesses that have increased revenue as result of innovation	ABS 8158.0 – Innovation in Australian Business http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8158.0
ABS	Percentage of innovation-active businesses that have reduced costs as result of innovation	ABS 8158.0 – Innovation in Australian Business http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8158.0

ABS	Percentage of innovation-active businesses that have gained a competitive edge as a result of innovation	ABS 8158.0 – Innovation in Australian Business http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8158.0
ABS	Percentage of innovation-active businesses that have improved customer service as a result of innovation	ABS 8158.0 – Innovation in Australian Business http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8158.0
8.1.1	National economic performance	
EIS	4.2.3 Sales of new-to-market and new-to-firm product innovations	Data source Eurostat (Community Innovation Survey)
GII, GCR	4.2.2 Market capitalization, % GDP. 9.04 Market capitalization	World Federation of Exchanges database; extracted from the World Bank's World Development Indicators database (2008–15). (http://data.worldbank.org/)
AISR	Market capitalization of listed companies, % of GDP	World Bank Statistics – WB_WDI https://data.worldbank.org/
AISR	Contribution to employment, income, exports and VA, of business by degree of novelty (time series) as per Fig 2.1 AISR 2016.	ABS (special request)
AISR	Proportion of high-growth firms (by turnover, by employment) that are innovation-active, definitions to be confirmed.	ABS (special request)
AISR	Percentage of innovation-active SME firms, %	OECD STI Scoreboard (pre-2017)
HDI	Income quintile ratio, average annual change (%)	World Bank (2018a)

HDI	Total debt service (% of exports of goods, services and primary income)	World Bank (2018a)
OECD	Household net adjusted disposable income	OECD Better Life Index 2017
8.1.1.1	Employment	
EIS	4.1.1 Employment in knowledge-intensive activities	Data source Eurostat
EIS	4.1.2 Employment fast-growing enterprises of innovative sectors	Data source Eurostat
HDI	Unemployment, total (% of labour force)	ILO (2018a).; https://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page27.jspx?subject=SDG&indicator=SDG_0552_OCU_RT&datasetCode=A&collectionCode=SDG; Labor Force Survey
HDI	Unemployment, youth (% ages 15–24)	ILO (2018a).; https://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page27.jspx?subject=SDG&indicator=SDG_0552_OCU_RT&datasetCode=A&collectionCode=SDG; Labor Force Survey
HDI	Vulnerable employment (% of total employment)	ILO (2018a).; https://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page27.jspx?subject=SDG&indicator=SDG_0552_OCU_RT&datasetCode=A&collectionCode=SDG; Labor Force Survey
HDI	Youth not in school or employment (% ages 15–24)	
8.1.1.2	Workforce composition	
STIS	34.Relative contribution to change in total employment by major sectors of economic activity	OECD calculations based on Annual National Accounts Database, www.oecd.org/std/na, Structural Analysis (STAN) Database, http://oe.cd/stan and national sources, September 2017

ABS	Contribution to employment (% of employment and numbers of FTE) of innovation-active start-ups (0–2 years), ABS Special request, build time series and provide sectoral disaggregation.	ABS Special request, BLADE
STIS	Highly educated individuals in the working-age population, by place of birth, 2015., As a percentage of relevant group, 15–64 year-old population	OECD calculations based on Eurostat Labour Force Survey and national sources, July 2017.
AISR	Share of professionals and technicians in total employment, %	OECD STI Scoreboard 2007, 2009, 2011, 2013
HDI	Employment to population ratio (% ages 15 and older)	ILO (2018a).; https://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page27.jspx?subject=SDG&indicator=SDG_0552_OCU_RT&datasetCode=A&collectionCode=SDG; Labor Force Survey
HDI	Employment in agriculture (% of total employment)	ILO (2018a).; https://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page27.jspx?subject=SDG&indicator=SDG_0552_OCU_RT&datasetCode=A&collectionCode=SDG; Labor Force Survey
HDI	Employment in services (% of total employment)	ILO (2018a).; https://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page27.jspx?subject=SDG&indicator=SDG_0552_OCU_RT&datasetCode=A&collectionCode=SDG; Labor Force Survey
HDI	Labour force participation rate (% ages 15 and older)	ILO (2018a).; https://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page27.jspx?subject=SDG&indicator=SDG_0552_OCU_RT&datasetCode=A&collectionCode=SDG; Labor Force Survey
HDI	Labour force participation rate (% ages 15 and older), female	ILO (2018a).; https://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page27.jspx?s

		ubject=SDG&indicator=SDG_0552_OCU_RT&datasetCode=A&collectionCode=SDG; Labor Force Survey
HDI	Labour force participation rate (% ages 15 and older), male	ILO (2018a).; https://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page27.jspx?subject=SDG&indicator=SDG_0552_OCU_RT&datasetCode=A&collectionCode=SDG; Labor Force Survey
8.1.1.3	Productivity & efficiency	
GII	6.2.1 Growth rate of PPP$ GDP/worker, %	The Conference Board Total Economy Database™ Output, Labor and Labor Productivity, 1950–2016, May 2016. (https://www.conference-board.org/data/economydatabase/)
STIS	46. Multifactor productivity growth, Total economy, percentage change at an annual rate	OECD calculations based on OECD Productivity Database, http://www.oecd.org/sdd/productivity-stats/, September 2017.
AISR	Multifactor productivity annual growth/change, %	OECD Productivity Statistics, http://www.oecd.org/sdd/productivity-stats/
ISA 2016, ISA 2018	Multifactor productivity change, five year compound annual growth rate, %	OECD Productivity Statistics, http://www.oecd.org/sdd/productivity-stats/
8.1.2	International performance	
HDI	Exports and imports (% of GDP)	World Bank (2018a).
World Bank	Export of goods and services (% of GDP)	World Bank
8.1.2.1	Exports	
EIS	4.2.1 Medium and high-tech product exports	Data source Eurostat (ComExt) for Member States, UN ComTrade for non-EU countries

EIS	4.2.2 Knowledge-intensive services exports	Data source Eurostat
GII	6.3.1 Intellectual property receipts, % total trade	WTO, Trade in Commercial Services database, based on the sixth (2009) edition of the International Monetary Fund's Balance of Payments Manual and Balance of Payments database (2007–15). (http://stat.wto.org/StatisticalProgram/WSDBStatProgramSeries.aspx ; http://www.oecd.org/std/its/EBOPS-2010.pdf)
MSTI	Export market share: Pharmaceutical industry	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Total imports: Pharmaceutical industry (million current dollars)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Total exports: Pharmaceutical industry (million current dollars)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Trade Balance: Pharmaceutical industry (million current dollars)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Export market share: Computer, electronic and optical industry	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Total imports: Computer, electronic and optical industry (million current dollars)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Total exports: Computer, electronic and optical industry (million current dollars)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Trade Balance: Computer, electronic and optical industry (million current dollars)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Export market share: Aerospace industry	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Total imports: Aerospace industry (million current dollars)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Total exports: Aerospace industry (million current dollars)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)

MSTI	Trade Balance: Aerospace industry (million current dollars)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Export market share: Pharmaceutical industry	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Technology balance of payments: Receipts (million current dollars)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Technology balance of payments: Receipts (million national currency for euro area, pre-EMU euro or EUR)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Technology balance of payments: Payments (million current dollars)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Technology balance of payments: Payments (million national currency for euro area, pre-EMU euro or EUR)	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
MSTI	Technology balance of payments: Payments as a percentage of GERD	OECD Main Science and Technology Indicators. (http://www.oecd.org/sti/msti.htm; http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm)
GII	6.3.2 High-tech exports less re-exports, % total trade	United Nations, COMTRADE database; Eurostat, Annex 5: High-tech aggregation by SITC Rev. 4, April 2009 (2010–15). (http://comtrade.un.org/; http://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an5.pdf)
GII	6.3.3 ICT services exports, % total trade	WTO, Trade in Commercial Services database, based on the sixth (2009) edition of the International Monetary Fund's Balance of Payments Manual and Balance of Payments database (2009–15).
GII	6.3.4 FDI net outflows, % GDP	International Monetary Fund, Balance of Payments database, supplemented by data from the United Nations Conference on Trade and Development and official national sources; extracted from the World Bank's World Development Indicators database (2013–15). (http://data.worldbank.org/)

STIS	47. Extended ICT domestic value added footprint, USD billions and world share, percent	OECD, Inter-Country Input-Output (ICIO) Database, http://oe.cd/icio, and Trade in Value Added (TiVA) database, http://oe.cd/tiva, July 2017
STIS	48. ICT-related domestic value added, As a percentage of GDP	OECD, Inter-Country Input-Output (ICIO) Database, http://oe.cd/icio, and Trade in Value Added (TiVA) database, http://oe.cd/tiva, July 2017.
STIS	Regional origin of foreign value added embodied in gross exports, 2014, As a percentage of domestic gross export	OECD estimates based on Trade in Value Added (TiVA) Database, http://oe.cd/tiva, Inter-Country Input-Output (ICIO) Database, http://oe.cd/icio, Bilateral Trade Database by Industry and End-use (BTDIxE), http://oe.cd/btd, Annual National Accounts Database, www.oecd.org/std/na, and most recent national Supply and use Tables and Input Output Tables, April 2017.
STIS	Domestic value added embodied in partner countries' exports, 2014, As a percentage of domestic gross exports	OECD estimates based on Trade in Value Added (TiVA) Database, http://oe.cd/tiva, Inter-Country Input-Output (ICIO) Database, http://oe.cd/icio, Bilateral Trade Database by Industry and End-use (BTDIxE), http://oe.cd/btd, Annual National Accounts Database, www.oecd.org/std/na, and most recent national Supply and use Tables and Input Output Tables, April 2017
AISR	Exports of goods, % of GDP	OECD National Accounts
AISR	Exports of services, % of GDP	OECD National Accounts
AISR	Exports in raw commodities, % of GDP	OECD National Accounts
AISR	Trade, % of GDP	World Bank statistics
STIS	Sectoral origin of the domestic value added created by gross exports, 2014	OECD estimates based on Trade in Value Added (TiVA) Database, http://oe.cd/tiva, Inter-Country Input-Output (ICIO) Database, http://oe.cd/icio, Bilateral Trade Database by Industry and End-use (BTDIxE), http://oe.cd/btd, Annual National Accounts Database, www.oecd.org/std/na, and most recent national Supply and use Tables and Input Output Tables, April 2017

AISR	Intellectual property balance of payments, million A$	ABS (2014) International Trade in Services by Country, by state and by Detailed Services Category, Calendar Year, cat. no. 5368.0.55.004, 2013, International Trade in Services, Debits, Calendar Year by Country & Service, URL: http://www.abs.gov.au/; ABS (2014–15) International Trade in Services by Country, by state and by Detailed Services Category, Calendar Year, cat. no. 5368.0.55.004, 2013–14, International Trade in Services, Credits, Calendar Year by Country & Service, URL: http://www.abs.gov.au/; ABS (2017) International Trade in Services by Country, by state and by Detailed Services Category, Calendar Year, cat. no. 5368.0.55.004, 2016, Table 5.8 International Trade in Services, Credits, Calendar Year by Country & Service, $m – Charges for the use of IP, URL: http://www.abs.gov.au/; ABS (2017) International Trade in Services by Country, by state and by Detailed Services Category, Calendar Year, cat. no. 5368.0.55.004, 2016, Table 6.8 International Trade in Services, Debits, Calendar Year by Country & Service, URL: http://www.abs.gov.au/;
AISR, MSTI	Technology balance of payments (receipts minus payments), % of GDP	OECD (2017) Main Science and Technology Indicators, 2016–2 to 2017, URL: http://stats.oecd.org/;
AISR	Share of international tertiary education market, %	OECD Education at a glance (pre2018)
HDI	Concentration index (exports) (value)	UNCTAD (2018).
8.1.2.2	Competitiveness	
UN	Number of exported goods where Australia has a Revealed Comparative Advantage (RCA) more than 2	UN Comtrade Database, https://comtrade.un.org/ EASD calculation
8.1.3	Economic diversity	
XXX	Nil at present	Nil
8.1.4	Economic complexity	

GII	6.2.5 High- & medium-high-tech manufactures, %	United Nations Industrial Development Organization (UNIDO), Industrial Statistics Database, 3- and 4-digit level of International Standard Industrial Classification ISIC Revision 3 (INDSTAT4 2016); OECD, Directorate for Science, Technology and Industry, Economic Analysis and Statistics Division, 'ISIC REV. 3 Technology Intensity Definition: Classification of Manufacturing Industries into Categories Based on R&D Intensities', 7 July 2011 (2006–14). (http://www.unido.org/statistics.html ; http://unstats.un.org/unsd/cr/registry/regcst.asp?cl=27 ; http://www.oecd.org/sti/ind/48350231.pdf)
AISR	Economic Complexity Index[7]	Center for International Development at Harvard University (2016) Atlas of Economic Complexity, 2016, URL: http://atlas.cid.harvard.edu/;
8.1.5	Investment	
HDI	Net official development assistance received (% of GNI)	World Bank (2018a).
HDI	Private capital flows (% of GDP)	World Bank (2018a).
HDI	Remittances, inflows (% of GDP)	World Bank (2018a).
8.1.5.1	Foreign investment	
GII	5.3.1 Intellectual property payments, % total trade	WTO, Trade in Commercial Services database, based on the sixth (2009) edition of the International Monetary Fund's Balance of Payments Manual and Balance of Payments database (2009–15). (http://stat.wto.org/StatisticalProgram/WSDBStatProgramSeries.aspx ; http://www.oecd.org/std/its/EBOPS-2010.pdf)
GII	5.3.2 High-tech imports less re-imports, % total trade	United Nations, COMTRADE database; Eurostat, Annex 5: High-tech aggregation by SITC Rev. 4, April 2009 (2010–15). (http://comtrade.un.org/ ; http://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an5.pdf)
GII	5.3.3 ICT services imports, % total trade	WTO, Trade in Commercial Services database, based on the sixth (2009) edition of the International Monetary Fund's Balance of Payments Manual and Balance of Payments

		database (2009–15). (http://stat.wto.org/StatisticalProgram/WSDBStatProgramSeries.aspx; http://www.oecd.org/std/its/EBOPS-2010.pdf)
GII, HDI	5.3.4 FDI net inflows, % GDP	International Monetary Fund, International Financial Statistics and Balance of Payments databases, World Bank, International Debt Statistics, and World Bank and OECD GDP estimates; extracted from the World Bank's World Development Indicators database (2013–15). (http://data.worldbank.org/)
8.2	ENVIRONMENTAL	
AISR, HDI	Renewable electricity, % total electricity generation	OECD (2016–17) Green growth indicators, 2016–2 to 2017, URL: http://www.oecd.org/; World Bank (2018a)
GII	Environmental performance	Yale University and Columbia University Environmental Performance Index 2016. (http://epi.yale.edu/)
HDI	Carbon dioxide emissions, per capita (tonnes)	World Bank (2018a)
HDI	Carbon dioxide emissions (kg per 2011 PPP $ of GDP)	World Bank (2018a)
HDI	Forest area (% of total land area)	World Bank (2018a)
HDI	Forest area, change (%)	World Bank (2018a)
HDI	Fossil fuel energy consumption (% of total energy consumption)	World Bank (2018a)
HDI	Fresh water withdrawals (% of total renewable water resources)	World Bank (2018a)
8.3	SOCIAL	
HDI	Human Development Index	Human Development Reports

8.4	GOVERNANCE RELATED	
XXX	Nil at present	Nil

Appendix G: Governance of the Review

The positions given below were the positions that contributors to the Innovation Metrics Review held at the time of their contribution.

Innovation Metrics Review Steering Committee

- Dr Alan Finkel, Australia's Chief Scientist, Co-Chair
- Mr Mark Cully, Chief Economist, Co-Chair, Australian Department of Industry, Innovation and Science
- Dr Charles Day, Chief Executive Officer, Office of Innovation and Science Australia
- Ms Luise McCulloch, Deputy Australian Statistician, Statistical Services Group, Australian Bureau of Statistics
- Professor Hugh Bradlow FTSE, President, Australian Academy of Technology and Engineering
- Dr Alan Bye, Former Vice President, Technology (Strategy & Innovation), BHP
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- Dr Francis Gurry, Director General, World Intellectual Property Organisation
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- Mr Dominic Banfield, Policy Analyst, Australian Academy of Technology & Engineering
- Ms Alix Ziebell, Principal Policy Analyst, Australian Academy of Technology & Engineering
- Ms Bianca Le, STEM Policy Graduate Intern, Australian Academy of Technology & Engineering
- Dr Fern Beavis, Policy Analyst, Australian Academy of Technology & Engineering

Appendix H: Scorecard metrics descriptions and data coverage

Table H.1: Scorecard metrics descriptions

		Innovation metrics	Definition	Source
Business activities	Inputs	[1] Total expenditure on innovation by businesses, % of GDP (this measure is a proxy for business investment in knowledge-based capital and physical capital as an input)	Total innovation expenditure incurred by Australian businesses includes both research and development (R&D) and non-R&D innovation. This is a calculation based on the total innovation expenditure incurred by Australian businesses, published by the ABS. It is sourced from the BCS. For the purposes of this scorecard, this value was then converted to a percentage of GDP. An estimated total for innovation expenditure was derived by assigning a random value to each innovation-active business that reported expenditure within the bounded ranges. These data, and the values of those businesses that reported actual dollar values, were then weighted to derive an innovation expenditure total. This simulation was run multiple times and an average of these simulations provides an approximate value of innovation expenditure. Australian data are presented as the median value of the upper and lower ranges for the innovation expenditure value published by the ABS.	ABS BCS – Cat. No. 8158.0 – Innovation in Australian Business (further ABS calculation); Gross Domestic Product: Current prices; ABS Cat No. 5206.0 – Australian System of National Accounts. International comparison data are available via Eurostat: Innovation activities and expenditures, Community Innovation Survey (CIS), Eurostat: Gross domestic product at current market prices.
		[2] Business expenditure on research and development (BERD), % of GDP (this measure is a proxy for business investment in knowledge-based capital as an input)	Business expenditure on R&D (BERD) includes all expenditure on R&D performed by business enterprises, irrespective of funding sources.	ABS Cat. No. 8104.0 – Research and Experimental Development, Businesses, Australia. International comparison data are available via OECD MSTI.
		[3] Investment in knowledge-based capital (ICT, R&D and other intellectual property products), % of GDP (this measure is a proxy for business investment in knowledge-based capital as an input)	ICT investment in the System of National Accounts includes the following key areas: investment in computer hardware, telecommunication equipment, computer software and databases, R&D and other IP products.	ABS Cat. No. 5204.0 – National Accounts. International comparison data are available from the Measuring the Digital Transformation (OECD 2019).

	Innovation metrics	Definition	Source
	[4] Diffusion of selected ICT tools and activities in enterprises (cloud computing), % of all businesses with 10+ employees (this measure is a proxy for the diffusion of digital technologies in business as an input)	Diffusion of selected ICT tools and activities in enterprises provides the percentage of businesses that reported using selected ICT tools, in this case, the metric specifies the use of paid cloud computing. Data on cloud computing services are gathered through direct surveys of ICT usage by businesses through the BCS. The reported data specifies the percentage of businesses that reported they used paid cloud computing. This is being used as a proxy for the diffusion of ICT tools. Cloud computing is the only advanced metric that Australia currently has a time series available to measure ICT diffusion. However, it is expected this indicator will be revised after mid 2022 if improvements are made to capture the diffusion of other ICT tools, such as Big Data, the Internet of Things, and other items in accordance with international practices, as recommended in Chapter 4. This metric looks at businesses with 10 or more employees, as do a number of others below, because the Community Innovation Surveys used internationally collect data on businesses with 10 or more employees. International comparison data on businesses with 9 or fewer employees are generally not available.	ABS BCS – Cat. No. 8129.0 – Business Use of Information Technology and 8167.0 – Selected Characteristics of Australian Businesses. Australian data are sourced from ABS customised data and are for businesses with 10+ employees. International comparison data are available via the OECD, ICT Access and Usage by Businesses Database, 2018.
	[5] Businesses collaborating on innovation, % of all businesses with 10+ employees (this measure is a proxy for inputs into business investment in management practices and business organisation)	This reports on the proportion of businesses with 10 or more employees that collaborated for the purposes of innovation as a percentage of all businesses. This annual figure on the Scorecard is calculated based on the proportion of all businesses that are innovative (55.9% – OECD table 1). This proportion is multiplied with the proportion of innovative businesses that have collaborated for the purposes of innovation (22.5% – OECD table 15) = (12.6% of all businesses with 10+ employees).	ABS Cat. No.8158.0 (superceded by 8167.0) – Australian data are sourced from ABS customised data and are for businesses with 10+ employees. International comparison data are available via OECD innovation indicators (http://www.oecd.org/sti/inno-stats.htm).
Outputs	[6] Proportion of businesses with more than 25% of income from sales due to innovation, % of all businesses with 10+ employees (this measure is a proxy for multiple productivity drivers including physical, human and knowledge-based capital as outputs)	This reports the proportion of businesses with 10 or more employees that have reported more than 25% income from sales from innovative products introduced by the company in the previous year. While the data is based on self-assessment, it is the best that is currently available. The OECD will be investigating similar intensity-based metrics in their forthcoming release (Q4 2019) and this may provide an internationally comparable data source for future scorecards. The metric will be reviewed when further international data is available.	ABS Cat. No.8158.0 (superceded by 8167.0) – Australian data are sourced from ABS customised data and are for businesses with 10+ employees. (Goods and Services Innovation Cube, table 6, further ABS calculation)
	[7] High-growth enterprise rate based on sales growth, % of all businesses with 10+ employees (this measure is a proxy for economies of scale and scope)	High-growth enterprises have an average annualised sales revenue growth of over 20% per year over a 3-year period, and had 10 or more employees at the beginning of the observation period.	Australian data are sourced from ABS BLADE customised data. A summary of these data is available on the AIS Monitor. International comparison data are available at the OECD Structural and Demographic Business Statistics (SDBS) database on high growth enterprise rates.

Innovation metrics			Definition	Source
		[8] Intellectual property rights filed overseas per billion GDP (constant 2010 US$) (this measure is a proxy for business investment in knowledge-based capital as an output)	The sum of the number of patent, trade mark (by class), industrial design (by class) and plant breeders' rights applications filed at another country's IP office by a country's residents in a given year, divided by the country's GDP (constant 2010 US$). The filing of IP rights abroad signals export intentions, which in turn suggests the production of globally competitive products and services. Counting all IP rights includes innovative ideas across the economy, enabling comparison of a country's performance in generating innovation. For trade mark and industrial design applications, some offices allow single-class filing only, meaning that applicants have to file a separate application for each class. Others permit multi-class filings, enabling applicants to file a single application in which a number of classes can be specified. To improve international comparisons of the numbers of applications received, each trade mark and industrial design application will be counted for each class they relate to. Applicants that file IP rights into the corresponding European IP office are counted once, despite the right being applicable for each member country signatory to that IP arrangement.	WIPO IP Statistics Data Center. Total foreign oriented patent applications (direct and PCT) by applicant origin. Total foreign oriented trade mark applications by class (direct and Madrid) by applicant origin. Total foreign oriented industrial design applications by class (direct and the Hague) by applicant origin. Total foreign oriented plant breeders rights applications (UPOV). GDP (constant 2010 US$) from the World Bank.

Innovation metrics			Definition	Source
Business environment	Inputs	[9] Level of regulatory barriers to firm entry and competition – OECD Product Market Regulation (this measure is a proxy for the inputs into regulation and competition of businesses)	The OECD Product Market Regulation (PMR) measures the degree to which policies promote or inhibit competition in areas of the product market where competition is viable. The PMR score is constructed from 18 base indicators that are grouped into two main components; Distortions induced by state involvement, and Barriers to domestic and Foreign Entry. A lower value indicates a better Product Market Regulation environment.	OECD Product Market Regulation database
		[10] Venture capital investment (funds invested in businesses), % of GDP (this measure is a proxy for inputs into trade and investment for business)	The ABS defines VC as investment at the pre-seed, seed, start-up, and early expansion stages of business development. This is a measure of new investment by funds into businesses during the financial year. Capital investment is vital to help innovative start-ups and young businesses commercialise technologies and turn research into new products. This measures the annual amount of equity investments made to support the pre-seed, seed, start-up and early expansion stages of business development, measured as a percentage of national GDP.	ABS Cat. No, 5678.0 – VC&LSPE. International comparison data are from OECD Entrepreneurship at a Glance.

	[11] Permanent migrants and non-student temporary entrants with higher education qualifications, % of the labour force (this measure is a proxy for inputs into demand and supply conditions for labour resources)	The proportion of entrants into Australia, either non-student temporary or permanent, with higher education qualifications. Higher education attainment includes bachelors, masters, doctorates, or equivalent (does not include short-cycle tertiary). Relates to temporary entrants who were present in Australia on 9 August, 2016 (Census night) and held a temporary visa that was not a student visa. Relates to migrants who have migrated to Australia under a permanent Skilled, Family, Humanitarian or Other Permanent visa stream and arrived in Australia between 1 January, 2000 and 9 August 2016.	ABS: Cat. No. 3419.0 – Insights from the Australian Census and Temporary Entrants Integrated Dataset, 2016 & ABS Cat. No. 3417.0 – Understanding Migrant Outcomes – Insights from the Australian Census and Migrants Integrated Dataset, Australia, 2016.
Outputs	[12] Birth rate of employing enterprises, % of business economy (this measure is a proxy for outputs of competition and regulation)	The OECD's definition of an employing enterprise birth is the establishment of an enterprise with at least one employee (headcount). This population consists of new enterprises that have at least one employee in the birth year. Enterprises that existed before the year in consideration that did not have one employee but then subsequently established themselves as an employee enterprise are included in the population for the year that they became an employee enterprise (the birth year). Employment excludes non-salaried directors, volunteers, persons paid by commission only, and self-employed persons, such as consultants and contractors. OECD's Entrepreneurship at a Glance 2017 indicates that for Australia and the Republic of Korea, enterprise births do not take into account the transition of enterprises from zero employees to one or more employees. For Australian data, employing enterprise entries into the population do not include entries due to: mergers, break-ups, split-offs or restructuring of a set of enterprises. The scope is limited to only include businesses that are actively trading in the market sector. Business entities with a turnover below $75,000 do not have to register for GST and hence those who have not registered will not be included in these counts. Businesses that have not submitted a Business Activity Statement or have reported zero dollar amounts over five consecutive quarters (or three consecutive years for annual remitters) are treated as 'long-term non-remitters'. These businesses are not considered to be actively trading and are excluded from the counts, as they are not remitting GST (see ABS explanatory notes for more information). The employing enterprise birth rate corresponds to the number of births of employing enterprises as a percentage of the population of active enterprises with at least one employee (see OECD Manual on Business Demography Statistics). The SDBS category is the total industry, construction and market services, except holding companies.	ABS Cat No. 8165.0 – Counts of Australian Businesses, International comparison data are from OECD Structural and Demographic Business Statistics (SDBS). OECD Entrepreneurship at a Glance (2017).

Innovation metrics			Definition	Source
National environment	Inputs	[13] Total expenditure on educational institutions (primary to tertiary), % of GDP (this measure is a proxy for economy level investment inputs into education)	Financial resources invested in education includes primary, secondary, post-secondary non-tertiary and tertiary sectors. This data includes both general government and private sector expenditure.	Data are sourced from national statistics and harmonised by the OECD for international comparison. OECD Education at a Glance.
		[14] Gross expenditure on research and development (GERD), % of GDP (this measure is a proxy for economy level investment inputs into education and infrastructure)	Gross expenditure on R&D (GERD) represents the total expenditure devoted to R&D by the Business, Government, Higher Education and Private Non-Profit sectors.	ABS Cat. No. 8104.0 – Research and Experimental Development, Businesses, Australia. International comparison data at OECD MSTI.
		[15] Fixed broadband subscriptions per 100 inhabitants, by speed faster than 100 Mbps (this measure is a proxy for inputs into the development of innovation infrastructure)	The data cover quality of broadband infrastructure as measured by the number of subscriptions for fixed broadband service based on speed of connection expressed in megabits per second (Mbps). This measure is a proxy for network capability but it does not provide the actual performance of broadband connections experienced by subscribers. This metric uses fixed broadband because a technology neutral broadband infrastructure is unavailable at present. This metric will require reviewing to reflect technology neutral infrastructure beyond fixed broadband (e.g. mobile or 5G technology that is used to provide broadband infrastructure).	ABS Cat. No. 8153.0 Internet Activity; Table 2 – Internet Subscribers by advertised download speed; ABS Cat. No. 3101.0 – Australian Demographic Statistics: Table 1 – Population Change summary: ERP Change Over Previous Year. International comparison data are sourced from the OECD broadband portal, 'Fixed broadband subscriptions per 100 inhabitants, per speed tiers' with historical time series data obtained from the OECD publications, the *Digital Economy Outlook 2015, 2017* and *Measuring the Digital Transformation*. International comparison data are for fixed broadband speeds greater than 100 Mbps. Australian data from ABS Cat. No. 8153.0 are for mobile and fixed broadband with speeds greater than or equal to 100 Mbps. This data source has been used as a proxy for fixed broadband with speeds greater than 100 Mbps because of the negligible number of subscribers with Mobile speeds greater than 100 Mbps and the negligible difference in the reported subscription speeds.
	Outputs	[16] Scores of students in mathematics – OECD PISA (this measure is a proxy for the output of investment into education at an economy level)	PISA is a triennial international survey that aims to evaluate education systems worldwide by testing the skills and knowledge of 15-year-old students in the subjects of reading, mathematics and science. The results for science and mathematics at country level are highly correlated. Mathematics has been tracked as Australia's current educational challenges with regard to mathematics were deemed to be more acute than those for science.	OECD PISA database

		[17] Quality-adjusted labour input (qualifications and experience), five-year compound annual growth rate, % of total economy (this measure is a proxy for the output of investment into education and skills at an economy level)	Quality-adjusted labour input is a measure of the skill composition of workers, usually based on the level of educational attainment and labour market experience. Changes in the quality of labour are calculated using data on employment (number of hours actually worked) and compensation of workers (hourly income) by educational attainment, to determine the annual growth rate. Changes in labour quality (the quality-adjusted labour input) therefore reflects the changing labour market conditions, which impacts labour input contribution to productivity and growth. For example, an increase in the share of workers with tertiary education and those in their prime age – typically defined as those aged 25 to 54 years (which reflect experience of workers) would result in increased labour productivity.	Conference Board Total Economy Database showing the growth rate of labour input, adjusted for quality (labour quality). The data can be accessed from the Growth Accounting and Total Factor Productivity, 1990–2018, series. The data source provides the level of growth in labour quality in the total economy only, not by sector.
		[18] Proportion of population aged 25–34 with higher education, % (this measure is a proxy for investment outputs into education at an economy level)	Higher education attainment includes bachelors, masters, doctorates, or equivalent (not short-cycle tertiary)	ABS Cat. No. 6227.0 – Education and Work, Australia, May 2018, Table 14. International comparison data at OECD Education at a Glance.

		Innovation metrics	Definition	Source
Impacts		[19] Multifactor productivity change, five year compound annual growth rate, %	MFP measures the changes in output per unit of combined inputs of labour and capital. The change or growth in MFP is measured as a 5-year compound annual growth rate.	OECD Multifactor Productivity.

Table H.2: Scorecard data coverage

Innovation metrics
- ■ (grey) = Country present in series
- † = Break in data series
- □ (white) = Data not available or considered
- ■ (teal) = Top 5 country

		Innovation metrics	Australia	Austria	Belgium	Brazil	Bulgaria	Canada	Chile	China	Croatia	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	India	Ireland	Israel	Italy	Japan	Korea Republic	Latvia	Lithuania	Luxembourg	Malta	Mexico	Netherlands	New Zealand	Norway	Poland	Portugal	Romania	Russia	Slovak Republic	Slovenia	South Africa	Spain	Sweden	Switzerland	Turkey	United Kingdom	United States
Business activities	Inputs	[1] Total expenditure on innovation by businesses, % of GDP														†			†				†																		†					†	†	
Business activities	Inputs	[2] Business expenditure on research and development (BERD), % of GDP	†	†					†					†							†									†		†		†										†	†			
Business activities	Inputs	[3] Investment in knowledge-based capital (ICT, R&D and other intellectual property products), % of GDP						†	†																	†		†						†	†	†												
Business activities	Inputs	[4] Diffusion of selected ICT tools and activities in enterprises (cloud computing), % of all businesses with 10+ employees	†	†		†		†							†		†	†			†				†	†	†			†														†	†	†	†	
Business activities	Inputs	[5] Businesses collaborating on innovation, % of all businesses with 10+ employees								†									†		†			†					†	†		†		†					†			†						†
Business activities	Outputs	[6] Proportion of businesses with more than 25% of income from sales due to innovation, % of all businesses with 10+ employees																																														
Business activities	Outputs	[7] High-growth enterprise rate based on sales growth, % of all businesses with 10+ employees						†						†																†			†		†			†			†			†			†	
Business activities	Outputs	[8] Intellectual property rights filed overseas per billion GDP (constant 2010 US$)																																														

Innovation metrics

- (grey) = Country present in series
- † = Break in data series
- (white) = Data not available or considered
- (teal) = Top 5 country

		Metric	Australia	Austria	Belgium	Brazil	Bulgaria	Canada	Chile	China	Croatia	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	India	Ireland	Israel	Italy
Business environment	Inputs	[9] Level of regulatory barriers to firm entry and competition – OECD Product Market Regulation				†	†		†	†	†				†							†		†	
Business environment	Outputs	[10] Venture capital investment (funds invested in businesses), % of GDP			†			†					†	†	†	†	†	†	†	†			†	†	†
Business environment	Outputs	[11] Permanent migrants and non-student temporary entrants with higher education qualifications, % of the labour force																							
Business environment	Outputs	[12] Birth rate of employing enterprises, % of business economy			†			†						†		†		†	†				†		
National environment	Inputs	[13] Total expenditure on educational institutions (primary to tertiary), % of GDP		†	†									†	†	†		†	†	†					
National environment	Inputs	[14] Gross expenditure on research and development (GERD), % of GDP	†						†					†							†		†		
National environment	Inputs	[15] Fixed broadband subscriptions per 100 inhabitants, by speed faster than 100 Mbps							†															†	
National environment	Outputs	[16] Scores of students in mathematics – OECD PISA		†					†						†									†	
National environment	Outputs	[17] Quality-adjusted labour input (qualifications and experience), five year compound annual growth rate, % of total economy																							
National environment	Outputs	[18] Proportion of population aged 25–34 with higher education, %							†														†	†	
Impacts		[19] Multifactor productivity change, five year compound annual growth rate, %		†																			†		

		Metric	Japan	Korea Republic	Latvia	Lithuania	Luxembourg	Malta	Mexico	Netherlands	New Zealand	Norway	Poland	Portugal	Romania	Russia	Slovak Republic	Slovenia	South Africa	Spain	Sweden	Switzerland	Turkey	United Kingdom	United States
Business environment	Inputs	[9] Level of regulatory barriers to firm entry and competition – OECD Product Market Regulation			†	†	†	†							†	†	†	†	†						
Business environment	Outputs	[10] Venture capital investment (funds invested in businesses), % of GDP	†		†	†	†			†	†	†	†	†			†	†		†	†	†		†	
Business environment	Outputs	[11] Permanent migrants and non-student temporary entrants with higher education qualifications, % of the labour force																							
Business environment	Outputs	[12] Birth rate of employing enterprises, % of business economy				†						†	†				†				†	†		†	
National environment	Inputs	[13] Total expenditure on educational institutions (primary to tertiary), % of GDP	†	†		†	†		†		†	†						†				†	†	†	†
National environment	Inputs	[14] Gross expenditure on research and development (GERD), % of GDP					†		†		†	†									†	†			
National environment	Inputs	[15] Fixed broadband subscriptions per 100 inhabitants, by speed faster than 100 Mbps	†	†	†	†	†		†				†												
National environment	Outputs	[16] Scores of students in mathematics – OECD PISA																†						†	
National environment	Outputs	[17] Quality-adjusted labour input (qualifications and experience), five year compound annual growth rate, % of total economy																							
National environment	Outputs	[18] Proportion of population aged 25–34 with higher education, %																							
Impacts		[19] Multifactor productivity change, five year compound annual growth rate, %					†					†		†						†					

Appendix I: Sources of data and metrics currently available

This is a summary of the key innovation-related sources of data and metrics currently being used by the Australian Government, highlighting where there are opportunities to make changes to increase existing utility.

Survey data

Survey of Research and Experimental Development (R&D Survey)	
Type	Suite of surveys
Agency	Australian Bureau of Statistics (ABS)
Description	The Survey of Research and Experimental Development is the collective name of a suite of ABS surveys on R&D. The surveys cover R&D expenditure by businesses[221], higher education[222], the Australian, state and territory governments[223], and by the private non-profit sector[224]. R&D, as collected by the ABS, is defined in accordance with the OECD's Frascati Manual, as: *'Creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge'.* [225] This definition allows a broader range of R&D to be reported to the ABS than may be reported for the Research and Development Tax Incentive (RDTI).
Scope and coverage	Business: ▪ all businesses with intramural expenditure on R&D greater than $100,000 in the reference period are in scope of the survey ▪ collection of data is undertaken based on a stratified random sample of businesses in scope. Higher Education: ▪ Survey is a complete enumeration of the higher education institutions ▪ The OECD definition of the higher education sector encompasses universities and other institutions of post-secondary education regardless of their source of finance or legal status. The scope of the ABS R&D survey is based on the OECD definition, but excludes Technical and Further Education colleges.

[221] Australian Bureau of Statistics 2019, Research and Experimental Development, Businesses, Australia, cat. no. 8104.0.

[222] Australian Bureau of Statistics 2019, Research and Experimental Development, Higher Education Organisations, Australia, cat. no. 8111.0.

[223] Australian Bureau of Statistics 2019, Research and Experimental Development, Government, Australia, cat. no. 8109.0.

[224] Australian Bureau of Statistics 2019, Research and Experimental Development, Private Non-Profit Organisations, cat. no. 8109.0.

[225] OECD 2015, Frascati Manual 2015: Guidelines for collecting and reporting data on research and experimental development, OECD Publishing, Paris.

	Government and Private Non-Profit: ▪ Survey is a complete enumeration of Australian government (Australian and state and territory) and private non-profit organisations with intramural expenditure on R&D during the reference period.
Frequency	Australian data on R&D expenditure is collected and published two-yearly on asynchronous collection between sectors (business, higher education, government and private-NPIs).
Key innovation-related outputs	Expenditure and human resources devoted to research and experimental development (R&D) carried out by business, higher education, government and private non-profit organisations in Australia, classified by employment size, type of expenditure, type of resource, location of expenditure, source of funds, type of activity, fields of research and socio-economic objective. The ABS R&D surveys provide key headline metrics such as: ▪ Gross Expenditure on R&D (GERD) [ABS Cat. No. 8104.0] ▪ Business Expenditure on R&D (BERD) [ABS Cat. No. 8104.0] ▪ Higher Education Expenditure on R&D (HERD) [ABS Cat. No. 8111.0] ▪ Government Expenditure on R&D (GOVERD) [ABS Cat. No. 8109.0] ▪ Private Non-Profit Expenditure on R&D (PNPERD) [ABS Cat. No. 8109.0].
Current use	▪ Measures of business expenditure on R&D allow the Government to assess the effectiveness of policies and programs, such as the RDTI ▪ International benchmarking through the OECD MSTI publication
Current limitations and future opportunities	▪ Access to annual indicators of GERD and BERD would allow policymakers to adjust policies and programs related to R&D in a timelier manner ▪ Current sample sizes limit the scope for analysis at the 4-digit ANZSIC, Field of Research (FOR) and Socioeconomic Objective (SEO) level ▪ More granular information on the ANZSIC, Field of Research (FOR) and Socioeconomic Objective (SEO) would enable policy analysts to align the strategic research priorities of the publicly funded research sector with business direction and track research and innovation in sectors that are considered strategic priorities for Australia. Additionally, there is strong policy interest in assessing expenditure on R&D in Australia by foreign-owned businesses.

Business Characteristics Survey (BCS)	
Type	Survey
Agency	Australian Bureau of Statistics (ABS)
Description	The key national survey used for innovation measurement is the BCS[226]. It goes beyond R&D to collect information about the use of information technology[227], types of innovation and the innovation expenditure by Australian businesses. The BCS collects information from businesses about the broad types and status of innovation undertaken by Australian business in a one-year reference period. The BCS draws on the conceptual definitions and guidelines included in the Oslo Manual[228] This manual provides a framework for the collection of innovation statistics and specifies the definitions of innovating businesses and innovation-active businesses that are used by the ABS. The BCS draws on this manual for the questions used in the BCS and in the presentation of outputs from the survey.
Scope and coverage	All employing business entities in the Australian economy are in scope of the survey, except for: SISCA 3000 General government SISCA 6000 Rest of the world ANZSIC06 Division O Public administration and safety ANZSIC06 Division P Education and training ANZSIC06 Groups 624 (Financial asset investing) and 633 (Superannuation funds) ANZSIC06 Groups 954 (Religious services) and 955 (Civic, professional and other interest group services) ANZSIC06 Subdivision 96 Private households employing staff Collection of data is undertaken based on a random sample of in scope businesses.
Frequency	The BCS is an annual survey and produces point in time estimates for: use of information technology; innovation; and a broad range of other non-financial business characteristics[229]. The survey produces core annual use of IT and innovation indicators, with a more detailed set of items for each of these topics collected every second year (i.e. in alternating years).
Key innovation-related outputs	ABS Cat. No. 8167.0 – Characteristics of Australian Businesses ABS Cat. No. 8158.0 – Innovation in Australian Businesses ABS Cat. No. 8129.0 – Business Use of Information Technology ABS Cat. No. 8168.0.55.001 0 Microdata: Business Characteristics, Australia Key indicators of innovation include: ▪ measures of business innovation (innovating, innovation-active)

[226] Australian Bureau of Statistics 2019, Characteristics of Australian Businesses, cat. no. 8167.0.

[227] Australian Bureau of Statistics 2019, Business Use of Information Technology, cat. no. 8129.0.

[228] OECD/Eurostat, Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition.

[229] Australian Bureau of Statistics 2019, Microdata: Business Characteristics, Australia, cat. no. 8168.0.55.001.

	▪ types of innovation (goods or services, operational processes, organisational/managerial processes, marketing methods) ▪ status of innovation (introduced, still in development, abandoned) ▪ innovation expenditure ▪ collaboration on innovation. Key indicators of IT use include: ▪ main type of internet connection ▪ importance of digital technologies ▪ web presence and social media presence and use ▪ IT support ▪ extent of IT use in business processes ▪ cloud computing use ▪ incidence and impact of internet security incidents or breaches ▪ internet commerce. Key indicators of business characteristics include: ▪ business structure and operations ▪ business finance ▪ markets and competition ▪ skills used, skills shortages and deficiencies.
Current use	▪ Indicators of innovation in Australian businesses are important to researchers and policymakers in building an understanding of the drivers and impacts of innovation ▪ Indicators of IT use in Australian businesses inform researchers and policymakers of the extent of technology diffusion, adoption, use and impacts of digital technologies in businesses ▪ International benchmarking through the OECD STI scoreboard publication.
Current limitations and future opportunities	▪ Differences in business innovation survey methodology used in Australia versus other countries in the OECD limit the ability to compare data internationally. For example, Australia uses a single financial year reference period while innovation surveys in most other countries use a two or three-year reference period ▪ An improved evidence base is needed to understand business expenditure on non-R&D innovation-related activities. In Australia, estimates (in expenditure ranges) of innovation expenditure are collected through the BCS. The utility of this data is limited and collecting data that would support the production of a value estimate instead of a range would meet user needs better ▪ Current measures of business collaboration may exclude significant business collaboration arrangements in some sectors of the economy (for example, information on fee-for service arrangements should be collected and published separately) ▪ Opportunities have been identified to present existing business innovation data in new ways; complementing existing measures and providing a more complete picture of the relative impacts of innovation activities occurring in Australian businesses ▪ Current Australian Bureau of Statistics survey content related to digital technology usage covers a limited scope of new technologies. There is opportunity to Review and update the

content to reflect technological advancements and their impact on business performance

- The BCS sample is designed to produce efficient estimates for industry and employment size at the national level and thus it does not provide quality estimates for states/territories. There is demand from state and territory governments for indicators to evaluate innovation policies and programs implemented at state or territory level.

Management Capabilities Module (MCM)	
Type	Survey collected as a module of the BCS
Agency	Australian Bureau of Statistics (ABS)
Description	The ABS was funded by DIIS to conduct the MCM.[230] The survey instrument was developed in collaboration with the UTS. The survey module was designed to support international comparisons of management practices and the analysis of the impact of different levels of management sophistication on business productivity and performance. Similar international surveys have collected information about the manufacturing industry. The MCM is the first to collect this data for the whole economy.
Scope and coverage	All employing business entities in the Australian economy are in scope of the survey, except for: SISCA 3000 General government SISCA 6000 Rest of the world ANZSIC06 Division O Public administration and safety ANZSIC06 Division P Education and training ANZSIC06 Groups 624 (Financial asset investing) and 633 (Superannuation funds) ANZSIC06 Groups 954 (Religious services) and 955 (Civic, professional and other interest group services) ANZSIC06 Subdivision 96 Private households employing staff Collection of data is undertaken based on a random sample of in scope businesses
Frequency	One-off user-funded collection run in the 2015–16 reference period
Key innovation-related outputs	ABS Cat. No. 8172.0 – Management and Organisational Capabilities of Australian Business The MCM provides baseline data on management and organisational capabilities of Australian businesses. It presents statistics on a selection of topics, including: key performance indicators; use of data in decision making; strategic plans; skills; supply chain; environmental management; and demographic information related to the Principal Manager. Data was also released as a Confidentialised Unit Record File (CURF)
Current use	The survey is a resource to help researchers: ▪ examine management practices in Australian businesses

[230] Australian Bureau of Statistics 2019, Management and Organisational Capabilities of Australian Business, cat. no. 8172.0.

	▪ analyse management capability and its impact on productivity and economic growth ▪ evaluate industry programs that focus on management capability ▪ benchmark Australian management capability against the USA and other countries. The data provided by this survey has been used in business analysis.[231]
Current limitations and future opportunities	▪ Currently, the international comparability of this data is limited. A similar survey was run in the US in the manufacturing sector (2011 and 2016), but the MCM was the first national survey to collect this type of information across a whole economy ▪ Users have indicated that minor changes could be made to the survey content of the MCM. The MCM provides meaningful measures that would support policy development in this space. They have also indicated that some questions are much more valuable than others in generating policy-relevant information.

National Survey of Research Commercialisation (NSRC)	
Type	Survey
Agency	Department of Industry, Innovation and Science (DIIS)
Description	The NSRC[232] is a national survey on the research engagement and commercialisation activities of publicly funded research organisations (PFROs) in Australia. It is the primary source of information on the publicly funded research sector's efforts to collaborate with industry to transfer knowledge and commercialise research. The NSRC collects data on the commercialisation activities of PFROs and measures the extent to which public researchers have successfully translated their ideas into valuable technologies, services, business models and other IP. The current suite of questions draws on some concepts collected in international surveys run by the AUTM (the leading association of technology transfer professionals) in the US and Canada that measure trends and share research commercialisation insights about the technology transfer industry and those who work in it. However, there is currently no international framework for the measurement of research commercialisation activities.
Scope and coverage	The target population for the NSRC primarily consists of research organisations which: ▪ undertake their own research rather than commissioning it from other organisations

[231] I Moran, A Balaguer, O Majeed, R Agarwal, C Bajada & PJ Brown 2018, Strategic management in Australian firms, Department of Industry, Innovation and Science, viewed 22 November 2019.

[232] Department of Industry, Innovation and Science 2019, National Survey of Research Commercialisation, Canberra, viewed 22 November 2019, < https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation>.

	▪ receive public funding for research (this excludes research service providers that are funded entirely through contracts with research users) ▪ are not-for-profit (this excludes businesses that receive public funding through the R&D Tax Incentive) ▪ have an Australian Business Number (ABN) or Australian Company Number (ACN) (this excludes sub-units within universities).
Frequency	Since its inception in 2001, the NSRC has been undertaken either biennially or annually. It is not currently funded for any future cycles.
Key innovation-related outputs	The data collected covers: ▪ investment in R&D, commercialisation staff and training ▪ commercialisation pathways: licenses, start-ups, patents and disclosures, consultancies, contracts and collaborations. The data are released in both aggregate and at the unit-record level
Current use	The 2016 NSRC Snapshot states that the dataset is widely used to understand trends, priorities and gaps by a range of stakeholders, including Australian and state governments, international bodies, universities, medical research institutes, publicly funded research agencies and peak bodies. It is used for policy, planning and benchmarking by research organisations, industry and government' A key use of the data is by the PFROs to compete publicly in terms of their research commercialisation outcomes. However, user consultation has determined that the NSRC currently meets few of the needs of policymakers to progress research commercialisation for public good reasons. It collects some innovation data, modelled on internationally comparable data, that would be deemed important by stakeholders if the data quality was higher.
Current limitations and future opportunities	Two issues need to be resolved to provide fit for purpose research commercialisation data for policy making: ▪ determining what should be measured to determine the success of PFRO in terms of translation and commercialisation of ideas, and agreeing definitions that support this ▪ addressing the data quality issues of a subset of PFRO, to ensure the statistics generated are fit for use. The latter will require investment by these organisations.

Survey of Venture Capital and Later Stage Private Equity (VC&LSPE)	
Type	Survey
Agency	Australian Bureau of Statistics (ABS)
Description	The survey provides details of VC&LSPE activity from VC&LSPE fund managers. The survey is fully funded by the Department of Industry, Innovation and Science.

Scope and coverage	The VC&LSPE survey[233] aims to have full coverage of all resident VC&LSPE funds (vehicles) in enterprises that meet the following definitions of VC&LSPE: ▪ VC is defined as high risk private equity capital for typically new, innovative or fast growing unlisted companies in the pre-seed, seed, start-up, or early expansion stage. A VC 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 (LSPE) is defined as investment in companies in the late stage of expansion, turnaround and buy-out or sale stage of investment. 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).
Frequency	Annual
Key innovation-related outputs	ABS Cat. No. 5678.0 VC&LSPE, Australia. Information includes: commitments and drawdowns by source of funds, assets and liabilities of the VC&LSPE investment vehicles; capital flows between the vehicles, investors and investee companies; and characteristics of VC investee companies.
Current use	VC investment, % of GDP is a key indicator of the annual amount of equity investments made to support the pre-seed, seed, start-up and early expansion stages of business development. Measures of VC investment allow the Government to assess the effectiveness of policies and programs to improve access to capital for innovation
Current limitations and future opportunities	Policymakers are interested in understanding business access to finance and other forms of investment (including VC; but also angel investors, crowd-sourced equity funding, grants, accelerators and venture debts) for start-ups. These types of investment are not currently in scope due to the difficulty in identifying businesses engaged in this activity. There is a strong preference for internationally comparable data. Policymakers are unclear if Australian businesses have more difficulty obtaining access to finance than their international counterparts. However, there are currently no internationally agreed upon definitions of the stages of VC.

Counts of Australian Businesses, including Entries and Exits (CABEE)	
Type	Administrative
Agency	Australian Bureau of Statistics (ABS)
Description	This publication presents counts of businesses based on snapshots of actively trading businesses from the Australian Bureau of Statistics Business Register (ABSBR). This publication contains counts and rates of business entries and exits from the Australian economy as well as counts and rates pertaining to the survival of businesses.

[233] Australian Bureau of Statistics 2019, Venture Capital and Later Stage Private Equity, Australia, cat. no. 5678.0.

Scope and coverage	All actively trading businesses from the ABSBR.
Frequency	Annual
Key innovation-related outputs	ABS Cat. No. 8165.0 – Counts of Australian Businesses including Entries and Exits.[234] Business birth, death and survival rates.
Current use	Birth and death rates provide an indication of the rate at which businesses are created and existing businesses close down. This supports analysis of business dynamism and its contribution to productivity growth. The rate of business entries (or births) is seen as a key determinant of employment and output growth and increasing competitiveness.
Current limitations and future opportunities	The quality of birth rates is higher than that of death rates due to the difficulty of separating mergers and acquisitions from deaths. There is interest from stakeholders in more reliable information about net births.

Programme for International Student Assessment (PISA) and Programme for the International Assessment of Adult Competencies (PIACC)	
Type	Surveys
Agency	Organisation for Economic Co-operation and Development (OECD)
Description	PISA is an international survey that aims to evaluate education systems worldwide by testing the skills and knowledge of 15-year-old students in the subjects of reading, mathematics and science.[235] PIACC[236] is an international survey of adults' proficiency in literacy, numeracy and problem solving and gathers information and data on how adults use their skills at home, at work and in the wider community.
Scope and coverage	The desired base PISA target population in each country consists of 15-year-old students attending educational institutions in grades 7 and higher. The target population for PIACC is adults aged 16 to 65. The survey samples 5000 individuals in each participating country.
Frequency	PISA is run every three years PIACC is run every 10 years

[234] Australian Bureau of Statistics 2019, Counts of Australian Businesses, including Entries and Exits, cat. no. 8165.0

[235] Programme for International Student Assessment (PISA) database, OECD Publishing, Paris, three-yearly updating, viewed 22 November 2019.

[236] Programme for the International Assessment of Adult Competencies (PIACC) database, OECD Publishing, Paris, viewed 22 November 2019, <https://www.oecd.org/skills/piaac/>.

Key innovation-related outputs	PISA's headline indicator is the average performance for the three subject areas: science, mathematics and reading. PIACC provides measures of adults' performance in literacy, numeracy, and problem solving in technology-rich environments.
Current use	Assessing the performance of the Australian education and training systems relative to other OECD countries. Educational outcomes are linked to productivity growth.
Current limitations and future opportunities	N/A

Population Surveys	
Type	Surveys and integrated datasets
Agency	ABS
Description	There are a number of population surveys that produce key demographic information relevant to innovation policy For example, the Census of Population and Housing[237] collects information on topics such as education, participation in the labour force, occupations and industries. This data has also been linked to Temporary Visa Holder data[238] from the Department of Home Affairs to provide insights into the characteristics of temporary residents in Australia that was previously not available, including employment and skills. More frequent collections, such as the ABS Labour Force Survey,[239] also provide key insights into the occupations and qualifications of the workforce.
Scope and coverage	Australian population
Frequency	The Census is run every five years Labour Force data are produced quarterly
Key innovation-related outputs	Population surveys provide key measures of human capital, such as level of education, occupations and qualifications of the working population. They also provide measures of the temporary or permanent migration of labour and skills within and in and out of Australia These measures are found in: ▪ various Census products ▪ ABS Cat. No. 6291.0.55.003 – Labour Force, Australia

[237] Australian Bureau of Statistics 2019, Insights from the Australian Census and Temporary Entrants, cat. no. 3419.0.

[238] Australian Bureau of Statistics 2019, Understanding Migrant Outcomes – Insights from the Australian Census and Migrants Integrated Dataset, Australia, Australian Bureau of Statistics, viewed 21 November 2019, <https://www.abs.gov.au/ausstats/abs@.nsf/PrimaryMainFeatures/3417.0?OpenDocument.

[239] Australian Bureau of Statistics 2019, Labour Force, Australia, cat. no. 6291.0.55.003.

	▪ ABS Cat. No. 3417.0 – Understanding Migrant Outcomes – Insights from the Australian Census and Migrants Integrated Dataset ▪ ABS Cat. No. 3419.0 – Insights from the Australian Census and Temporary Entrants.
Current use	The stock (and flows) of human capital (e.g. skills and qualifications of the population) can affect productivity and growth by facilitating innovation. These measures enable the Government to evaluate the effectiveness of policies and programs designed to support skills development and improve education outcomes. Measures of skilled migration provide insight into how effective Government migration programs are in improving access to skills.
Current limitations and future opportunities	There is increasing demand from users to understand the skills, rather than qualifications, of the workforce better.

Internet Activity	
Type	Survey
Agency	Australian Competition and Consumer Commission (ACCC) (Previously conducted by the ABS)
Description	The Internet Activity Report[240] provides information on the number of retail services in operation (SIOs) in terms of connection type and download speed, as well as the volume of data downloaded within Australia. These data are collected due to the ACCC's Internet Activity Record Keeping Rule (RKR). Previously information on internet activity data was collected by the Australian Bureau of Statistics (ABS) under the now discontinued Internet Activity Survey (IAS).
Scope and coverage	The current carriage service providers required to report include Aussie Broadband, Australian Private Networks, Dodo, Harbour ISP, iiNet, IPStar Australia, MyRepublic, Primus, Singtel Optus, SkyMesh, Telstra, TPG and Vodafone Hutchison Australia.
Frequency	6 monthly
Key innovation-related outputs	The collected data includes wired broadband, wireless broadband and mobile handset services information regarding retail services in operation (SIOs) and volume of data downloaded by access technology and estimated download speeds.
Current use	Provides proxy measures for inputs into the development of innovation infrastructure. This enables the Australian Government to assess the deployment of communications infrastructure, which contributes to productivity-enhancing capabilities.
Current limitations and future opportunities	Provides proxy measures for network capability but it does not provide the actual performance of broadband connections experienced by subscribers.

[240] Australian Competition and Consumer Commission 2019, Internet activity report, Australian Competition and Consumer Commission, viewed 21 November 2019.

Australian National Accounts	
Type	Publication – The majority of the estimates in the quarterly national accounts are based on the results of sample surveys.
Agency	ABS
Description	This publication contains estimates of gross domestic product (GDP) and its components, components of state final demand, the national income account, the national capital account and supporting series. Australia's national accounts statistics[241] are compiled in accordance with international standards contained in the System of National Accounts (SNA).
Scope and coverage	In accordance with international standards contained in the System of National Accounts.[242]
Frequency	Quarterly
Key innovation-related outputs	The SNA includes some measures of intangible capital (such as R&D, mineral and petroleum exploration, computer software and artistic originals). This is included in the IMR Scorecard as Investment in knowledge-based capital (ICT, R&D and other intellectual property products), % of GDP. Whilst not all intangible investment necessarily represents innovation, it is an increasing feature of the innovation ecosystem and potentially a key source of underlying economic growth. These measures are found in: ▪ ABS Cat. No. 5206.0 – Australian National Accounts: National Income, Expenditure and Product ▪ Investment in knowledge-based capital (ICT, R&D and other intellectual property products), % of GDP
Current use	Current use of the measures of intangible capital is limited because not all types of intangible investment are in the scope of the SNA and are therefore not being measured. At present, policymakers do not have a solid evidence base to understand whether the right policy levers are in place to foster accumulation of intangibles and encourage this potential growth.
Current limitations and future opportunities	All intangibles in the scope of the SNA are currently measured in the Australian national accounts. However, the data sources and underlying assumptions covering new investment data, price deflators and capital stock have not been reviewed for some time. At present, the Australian Bureau of Statistics is not measuring all the kinds of intangibles that are outside the current scope of the SNA.

[241] Australian Bureau of Statistics 2019, Australian National Accounts: National Income, Expenditure and Product, cat. no. 5206.0.

[242] United Nations Statistics Division 2019, System of National Accounts 2008, viewed 21 November 2019

Global Entrepreneurship Monitor (GEM)	
Type	Survey
Agency	Global Entrepreneurship Research Association
Description	The Global Entrepreneurship Monitor (GEM)[243] is currently the primary source of entrepreneurship data. The innovation data are collected through two streams: the Adult Population Survey (APS) and the NES. Data are reported at both the national and international levels, with around 54 countries participating.
Scope and coverage	The APS tracks the entrepreneurial attitudes, activity and aspirations of individuals. It is administered to a minimum of 2000 adults in each country. The NES monitors nine factors that are believed to have a significant impact on entrepreneurship, known as the Entrepreneurial Framework Conditions (EFCs). It is administered to a minimum of 36 carefully chosen 'experts'.
Frequency	Annual
Key innovation-related outputs	Total early-stage entrepreneurship activity, %
Current use	The OECD publication, Entrepreneurship at a Glance, cites the GEM as being a key data source for metrics in Entrepreneurial capabilities and entrepreneurship culture. Australian governments invest significant resources into programs designed to support entrepreneurship activity so there is demand for measures that support both domestic analysis of policy and program effectiveness, interjurisdictional comparison across Australian states and territories, and international comparison. GEM is generally used because there is no alternative that provides a similar level of coverage and claimed comparability. However, the IMR notes the limitations of GEM data due to its small sample size and limited coverage.
Current limitations and future opportunities	Consultation with stakeholders highlighted the need for better quality data on entrepreneurship, start-ups and spin-outs and considerable common ground with regard to stakeholder priorities. Confidentialised output from the consultation process run by the Innovation Metrics Review has been provided to the Commercialisation Policy Branch of DIIS, which has engaged a consultant, Colmar Brunton, to see if there is sufficient common ground to agree on concepts, a set of definitions, and a basis for measurement in Australia going forward.

[243] Global Entrepreneurship Research Association 2019, Global Entrepreneurship Monitor, viewed 21 November 2019, < https://www.gemconsortium.org/>.

Key government administrative and transactional data

Government Administrative and Transactional data	
Type	Administrative
Agency	Various Australian and state and territory Government agencies
Description	Administration and transaction data are collected by the Government primarily for the purposes of program management and service provision. However, data of this kind is also frequently used as part of evaluations and may also be made publicly available. Examples that may provide innovation-related data include: ▪ Data collected through delivery of Australian Government programs (e.g. R&D Tax Incentive, Rural R&D Corporations, Cooperative Research Centres Program and the Entrepreneurs' Program), and state and territory Government programs (e.g. the NSW Government's Boosting Business Innovation Program and the Innovate Queensland Program ▪ Data collected through delivery of Australian Government grants and funding (e.g. National Health and Medical Research Council (NHMRC) research grants, ARC grants) ▪ Data collected through service delivery of Australian Government agencies (e.g. ATO, IP Australia, Customs)
Scope and coverage	Varies
Frequency	Varies
Key innovation-related outputs	▪ The Science, Research and Innovation Budget Tables[244] ▪ The NHMRC's Research Funding Data[245] ▪ The ARC's Grants Dataset[246] ▪ The Department of Education's Research Block Grant Allocations[247] ▪ IP Australia patent databases[248] ▪ ATO data (e.g. Business Activity Statements, Pay As You Go, Business Income Tax Statements)

[244] Department of Industry, Innovation and Science 2019, Science, Research and Innovation (SRI) Budget Tables, Department of Industry, Innovation and Science, Canberra, viewed 21 November 2019, < https://www.industry.gov.au/data-and-publications/science-research-and-innovation-sri-budget-tables>.

[245] National Health and Medical Research Council 2019, Research Funding Data, National Health and Medical Research Council, Canberra, viewed 21 November 2019, < https://www.nhmrc.gov.au/funding/data-research/research-funding-statistics-and-data.

[246] Australian Research Council 2019, Grants Dataset, Australian Research Council, Canberra, viewed 21 November 2019, < https://www.arc.gov.au/grants-and-funding/apply-funding/grants-dataset.

[247] Department of Education and Training, Research Block Grant Allocations, Department of Education and Training, Canberra, viewed 21 November 2019, < https://docs.education.gov.au/node/51901>.

[248] IP Australia 2019, IP Government Open Data, IP Australia, Canberra, viewed 21 November 2019, <https://www.ipaustralia.gov.au/about-us/data-and-research/ip-government-open-data>.

	▪ Customs information on exports and imports
Current use	Government administrative and transaction data are frequently used in policy and program evaluation. A number of Government administrative datasets, such as ATO and IP Australia data, have been linked into BLADE, enhancing their analytical value
Current limitations and future opportunities	There may be opportunities to leverage statistical assets and enhance the utility of existing data by making additional datasets available for integration using BLADE

Key private sector data sources

As already highlighted, increased digitalisation is providing unprecedented opportunities to source science, technology and innovation data.

Over the course of the Review, a broad range of emerging opportunities were identified to understand the Australian innovation landscape and innovation performance better by making use of non-government transactional data sources and unstructured data sources through Big Data analytic techniques.

Examples of some private sector data sources with potential utility for innovation measurement are summarised in Table I.2. In the short term, the Review identified LinkedIn, Burning Glass, Seek, and Xero to be potentially useful to Australian governments.

Table I.2: Private sector data collections relevant to innovation measurement

Organisation	Brief description of business model	Data collected and potential utility for innovation measurement
LinkedIn	LinkedIn is the world's largest professional network. Members use LinkedIn to advance their careers, connect with professionals and stay informed. LinkedIn offers services that can be used by customers to change the way they hire, market, sell and learn.	LinkedIn is keen to work with the Australian Government, and is currently collaborating with DIIS on projects related to entrepreneurialism, management capability and digital skills.
Burning Glass	Burning Glass is an analytics software company that uses AI technology to provide its clients with custom, real-time data analysis on jobs, skills, and the labour market.	Burning Glass collects data on skills (as opposed to qualifications) and labour market data. Burning Glass Technologies has developed a dynamic, global skills taxonomy based on its analysis of job postings, resumes, and social profiles.[249]

[249] Burning Glass 2019, Mapping the Genome of Jobs, the Burning Glass skills taxonomy, Burning Glass, Boston, viewed 14 October 2019, <https://www.burning-glass.com/research-project/skills-taxonomy/>.

		The US Bureau of Labor Statistics uses Burning Glass data to supplement its 'Occupational Requirements Survey', reducing research costs and improving the timeliness and granularity of survey questions.
Xero	Xero provides cloud-based accounting software that connects small businesses to their advisors and other services. Its products are based on the Software as a Service (SaaS) model and sold by subscription, based on the type and number of company entities managed by the subscriber. It currently has accounting information from over 1.8 million subscribers.	Xero data can indicate the financial health of a business in close to real time. It includes items such as profitability, payment terms and cash flow. For example, AlphaBeta has used Xero data to investigate how businesses respond to company tax cuts.
SEEK	SEEK has a portfolio of employment, education and volunteer businesses. SEEK provides: · a matching service between job seekers and employers · online education · a marketplace for volunteering opportunities.	SEEK collects supply and demand data.
JobGetter	JobGetter provides services to job seekers. The company is supported by a grant from the NSW Department of Trade and Investment, and has been named as one of the world's top HR technology companies.[250]	JobGetter collects supply and demand data.
MYOB	MYOB provides a suite of business management products. These include: accounting, payroll, payments, retail point of sale, CRM and professional tax solutions.	MYOB has a large amount of data about customers and suppliers.
Facebook	Facebook's business model is built on harvesting platform data about its users.	Facebook crunches data to generate behavioural inferences that it on-sells, usually to advertisers.

[250] JobGetter 2017, JobGetter, JobGetter, Sydney, viewed 21 November 2019, < https://my.jobgetter.com/about/?_ga=2.266925390.1317499673.1505182548-1421747512.1494913624>.

		Algorithms functionalise Facebook's vast body of user data. Facebook does not sell identifiable data or allow developers access to it.[251]
Techboard	Techboard is a directory of Australian start-ups and young tech companies.	Techboard provides data on Australian start-ups and young tech companies. Techboard tracks the companies in its directory and uses this to provide its data reports, including data on funding.
League of Scholars	League of Scholars provides bibliometrics data from a range of open public data sources including Google Scholar, Microsoft Academic and Webometrics.	League of Scholars collects data on publications from the global top 5,000 universities and research institutions. The 2018 and 2019 NSW Innovation and Productivity Scorecard utilised this dataset to produce the metric 'Percentage of researchers who are in the top 10 of their field'.
Crunchbase	Crunchbase holds a database on innovative companies which includes data on funding, exits, and locations of start-ups and investors.	Crunchbase provides free access for academic research. Crunchbase's data are partially crowd-sourced, i.e. users can add to and revise contents. Crunchbase has cross-linked information on companies, their funders, and their staff.
Pitchbook	Pitchbook is a private capital market data provider.	Pitchbook collects data via internet scans, i.e. web crawlers that capture financial information from news articles, regulatory filings, websites, and press releases. Language processing and machine learning technology organises and filters out irrelevant data. Data are analysed and verified by specialised data teams, to validate information and gather hard-to-find details.
Glassdoor	Glassdoor is an international job and recruiting site.	Glassdoor has a growing database of company reviews, CEO approval ratings, salary reports, interview review and questions, and so on.
Preqin	Preqin is a private capital and hedge fund data provider.	Preqin Pro provides access to industry private capital and hedge fund data sets and tools.

Box I.2: Use of LinkedIn data for innovation measurement

LinkedIn working with governments

LinkedIn has expressed interest in working with the Australian Government on a pro-bono basis under a Memorandum of Understanding to provide innovation relevant

[251] B Barnet , 'Facebook is now cleaner, faster and group-focused, but still all about your data', The Conversation, 4 June, 2019, viewed 30 September, 2019.

data and analysis. In mid-2018, LinkedIn presented analyses to DIIS on industry, education and skills. LinkedIn is also currently collaborating with DIIS on research projects about Entrepreneurial Landscapes, Management Capability and Digital Skills.

In partnership with the World Bank, LinkedIn, produces Industry Reports to investigate the geographic spread and growth rate of industries and uncover insights. The Industry Reports provide quarterly updates on countries and regions, enabling the monitoring of small changes over time.

LinkedIn is also currently developing a real-time self-service tool and is testing the value proposition of such a tool. The intention is to enable use of LinkedIn data while protecting the privacy of individuals. LinkedIn's vision is 'to create economic opportunity for every member of the global workforce through ongoing development of the world's first Economic Graph'.[252]

Policy utility

LinkedIn's coverage of different occupations is variable. For example, it has near saturation coverage of digital technology-related occupations but low coverage of agricultural workers. Notwithstanding this, its data could be useful to address data gaps identified by the Review, including the following:

- Labour and skills mobility
- Networks and clusters
- Technology transfer capability
- Entrepreneurialism
- Management capability.

[252] G Filicori, 'LinkedIn Unveils 2019 Top Companies List Revealing Where Job Seekers Want to Work Now', Business Wire, 3 April 2019,<https://www.businesswire.com/news/home/20190403005499/en/>.

Appendix J: Priority ordering of the recommendations

Priority	Recommendation
NECESSARY PRECONDITION	RECOMMENDATION 4.1: ASSIGN RESPONSIBILITY FOR LEADERSHIP OF INNOVATION MEASUREMENT
	RECOMMENDATION 1.1: INTRODUCE ANNUAL INNOVATION SYSTEM REPORTING
VERY HIGH	RECOMMENDATION 2.3 IMPROVE MEASURES OF BUSINESS INNOVATION ACTIVITIES
	RECOMMENDATION 2.7: INTRODUCE AND IMPROVE MEASURES OF INTANGIBLE CAPITAL
	RECOMMENDATION 2.1: IMPROVE MEASURES OF EXPENDITURE ON R&D
	RECOMMENDATION 2.2: IMPROVE MEASURES OF BUSINESS DIGITAL TECHNOLOGIES USE
	RECOMMENDATION 2.8: INTRODUCE AND IMPROVE MEASURES OF DIGITAL ACTIVITIES IN THE ECONOMY
	RECOMMENDATION 3.1: TAKE A WHOLE-OF-GOVERNMENT APPROACH TO INNOVATION RESEARCH
	RECOMMENDATION 2.4: CONDUCT AN ANNUAL SECTORAL ANALYSIS
	RECOMMENDATION 2.9: MEASURE GOVERNMENT INNOVATION ACQUISITION
HIGH	RECOMMENDATION 2.5: UPDATE OCCUPATION CLASSIFICATION SYSTEM
	RECOMMENDATION 2.6: UPDATE INDUSTRY CLASSIFICATION SYSTEM
MEDIUM	RECOMMENDATION 2.10: INTRODUCE AND IMPROVE MEASURES OF ENTREPRENEURSHIP; START-UPS AND SPIN OUTS
	RECOMMENDATION 2.11: IMPROVE MEASURES OF ACCESS TO FINANCE FOR START-UPS
	RECOMMENDATION 2.12: MEASURE LOCATION-BASED INNOVATION
	RECOMMENDATION 2.13: IMPROVE MEASURES OF RESEARCH COMMERCIALISATION

Glossary

Phrase	Meaning
Accessibility and clarity	Accessibility may be understood as the ease with which the metric (or its underlying components) can be obtained from it underlying data source. This includes the ease with which the existence of information can be ascertained, as well as the suitability of the form or medium though which the information can be accessed. The cost of the information may also be an aspect of accessibility.
Accuracy and validity	Accuracy relates to the degree to which the metric correctly describes the phenomena it was designed to measure (how close it is to the 'true value'). It is usually characterised in terms of error in statistical elements and is traditionally decomposed into bias (systematic error) and variance (random error) components. It may also be described in terms of the major sources of error that potentially cause inaccuracy. Validity is the extent to which a score represents the variable it is intended to measure. Validity may be affected by the collection method or respondent characteristics.
Actors in the innovation system	Actors in the innovation system include government, business, higher education institutions, and not-for-profit organisations.
Administrative data	Administrative data is the set of units and data derived from an administrative source, such as business registers or tax files.
Artificial intelligence (AI)	Artificial intelligence is a term used to describe the activity and outcome of developing computer systems that mimic human thought processes, reasoning and behaviour.
Asset	An asset is a store of value that represents a benefit or series of benefits accruing to the economic owner by holding or using the asset over a period of time. Both financial and non-financial assets are relevant to innovation. Fixed assets are the result of production activities and are used repeatedly or continuously in production processes for more than one year.
AUTM	AUTM (formerly known as the Association of University Technology Managers) is the leading association of technology transfer professionals.

Phrase	Meaning
Big data	Big data has two meanings. In common use it refers to extremely large data sets that may be analysed computationally to reveal patterns, trends and associations. These may be structured, semi-structured, or unstructured. When used by data scientists, it refers to extremely large unstructured data sets. This report uses it to mean unstructured data sets.
Brand equity	The commercial value that derives from consumer perception of the brand name of a particular product or service, rather than from the product or service itself. This may positive or negative.
Business capabilities	Business capabilities include the knowledge, competencies and resources that a business accumulates over time and draws upon in the pursuit of its objectives. The skills and abilities of a business's workforce are a particularly critical part of innovation-relevant business capabilities.
Business expenditure on R&D (BERD)	Business expenditure on R&D (BERD) is the measure of intramural R&D expenditures within the Business enterprise sector during a specific reference period.
Business sector	The Business sector comprises: ▪ All resident corporations, including not only legally incorporated enterprises, regardless of the residence of their shareholders. This group includes all other types of quasi-corporations, i.e. units capable of generating a profit or other financial gain for their owners, recognised by law as separate legal entities from their owners, and set up for purposes of engaging in market production at prices that are economically significant ▪ The unincorporated branches of non-resident enterprises are deemed to be resident because they are engaged in production on the economic territory on a long-term basis ▪ All resident non-profit institutions (NPIs) that are market producers of goods or services or serve business. This sector comprises both private and public enterprises

Phrase	Meaning
Business innovation	A business innovation is a new or improved product or business process (or combination thereof) that differs significantly from the business's previous products or business processes and that has been introduced on the market or brought into use by the business.
Business innovation activities	Business innovation activities include all developmental, financial and commercial activities undertaken by a business that are intended to result in an innovation for the business. They include: ▪ research and experimental development (R&D) activities ▪ engineering, design and other creative work activities ▪ marketing and brand equity activities ▪ IP related activities ▪ employee training activities ▪ software development and database activities ▪ activities related to the acquisition or lease of tangible assets ▪ innovation management activities. Innovation activities can result in an innovation, be ongoing, postponed or abandoned.
Business model innovation	Business model innovation relates to changes in a business's core business processes as well as in the main products that it sells, currently or in the future.

Phrase	Meaning
Business process innovation	A business process innovation is a new or improved business process for one or more business functions that differs significantly from the business's previous business processes and that has been brought into use by the business. The characteristics of an improved business function include greater efficacy, resource efficiency, reliability and resilience, affordability, and convenience and usability for those involved in the business process, either external or internal to the business. Business process innovations are implemented when they are brought into use by the business in its internal or outward-facing operations. Business process innovations include the following functional categories: ▪ production of goods and services ▪ distribution and logistics ▪ marketing and sales ▪ information and communication systems ▪ administration and management ▪ product and business process development.
Capital deepening	Growth in capital equipment. Capital deepening is a situation where the capital per worker is increasing in the economy. This is also referred to as capital intensity. Capital deepening is often measured by the rate of change in capital stock per labour hour.
Capital expenditures	Capital expenditures are the annual gross amount paid for the acquisition of fixed assets and the costs of internally developing fixed assets. These include gross expenditures on land and buildings, machinery, instruments, transport equipment and other equipment, as well as intellectual property products.
Capital shallowing	Capital shallowing is a situation where the capital per worker is decreasing in the economy. This is also referred to as capital intensity Capital shallowing is often measured by the rate of change in capital stock her labour hour.
Chain linking	Chain linking means joining together two time series that overlap in one period by rescaling one of them to make its value equal to that of the other in the same period, thus combining them into a single time series. More complex methods may be used to link together time series that overlap by more than one period.

Phrase	Meaning
Cloud computing	Cloud computing is the on-demand availability of computer system resources, especially data storage and computing power, without direct active management by the user. The term is generally used to describe data centres available to many users over the Internet. Large clouds, predominant today, often have functions distributed over multiple locations from central servers.
Cognitive testing	Cognitive testing is a methodology developed by psychologists and survey researchers which collects verbal information on survey responses. It is used to evaluate the ability of a question (or group of questions) to measure constructs as intended by the researcher and if respondents can provide reasonably accurate responses.
Coherence	Coherence related to the degree to which a metrics can be successfully integrated with other statistical information within a broad analytic framework and over time. The use of standard concepts, classifications and target populations promotes coherence, as does the use of common methodology across surveys.
Collaboration	Collaboration requires co-ordinated activity across different parties to address a jointly defined problem, with all partners contributing. Collaboration requires the explicit definition of common objectives and it may include agreement over the distribution of inputs, risks and potential benefits. Collaboration can create new knowledge, but it does not need to result in an innovation.
Commercialisation	Commercialisation is the process of introducing a new product or production method into commerce – making it available on the market. The term often connotes especially entry into the mass market (as opposed to entry into earlier niche markets), but it also includes move from the laboratory into (even limited) commerce.
Community innovation survey (CIS)	The CIS is a harmonised survey of innovation in enterprises co-ordinated by Eurostat and currently carried out every one, two or three years in EU Member States and several European Statistical System (ESS) Member Countries.

Phrase	Meaning
Comparability	The comparability of a metric will be against one or more international benchmarks. Metrics calculated for Australia only are less useful than those measured by a significant number of other countries, such as the OECD members and reporting partners in the Main Science and Technology Indicators. In addition, metrics may be more or less readily compared. For example, six factors determine the international comparability of Australian innovation indicators obtained from innovation surveys: ▪ The reference period ▪ Differences in the distribution of businesses by size ▪ Differences in industry structure ▪ Service sector coverage ▪ The design of response categories ▪ Question wording.
Composite indicator	A composite indicator compiles multiple indicators into a single index based on an underlying conceptual model in a manner which reflects the dimensions or structure of the phenomena being measured. See also Indicator.
Conceptual framework (measurement)	A conceptual framework is an analytical tools with several variations and contexts. It can be applied in different categories of work where an overall picture is needed. It is used to make conceptual distinctions and organise ideas. Strong conceptual frameworks capture something real and do this in a way that is easy to remember and apply.
Co-operation	Co-operation occurs when two or more participants agree to take responsibility for a task or series of tasks and information is shared between the parties to facilitate the agreement. See also Collaboration.
Corporations	The SNA Corporations sector consists of corporations that are principally engaged in the production of market goods and services. This manual adopts the convention of referring to this sector as the Business enterprise sector, in line with the terminology adopted in the OECD Frascati Manual.
Database	A database is an organised collection of data, generally stored and accessed electronically from a computer system.

Phrase	Meaning
Design	Design is defined as an innovation activity aimed at planning and designing procedures, technical specifications and other user and functional characteristics for new products and business processes. Design includes a wide range of activities to develop a new or modified function, form or appearance for goods, services or processes, including business processes to be used by the business itself. Most design (and other creative work) activities are innovation activities, with the exception of minor design changes that do not meet the requirements for an innovation, such as producing an existing product in a new colour. Design capabilities include the following: (i) engineering design; (ii) product design; and (iii) design thinking.
Design right	A registered design protects the visual appearance of a product or item and gives you exclusive rights for that appearance to the extent that, if necessary, there is a legal right to stop an unauthorised party from producing or using your design.
Diffusion (innovation)	Innovation diffusion encompasses both the process by which ideas underpinning product and business process innovations spread (innovation knowledge diffusion), and the adoption of such products, or business processes by other businesses (innovation output diffusion).
Digital platforms	Digital platforms are ICT-enabled mechanisms that connect and integrate producers and users in online environments. They often form an ecosystem in which goods and services are requested, developed and sold, and data generated and exchanged. Digital platforms capture, transmit and monetise data over the Internet through competitive and collaborative transactions between different users, buyers, or suppliers.
Digitalisation	Digitalisation entails the application of digital technologies to a wide range of existing tasks and also enables new tasks to be performed. See also Digitisation.
Digitisation	Digitisation is the conversion of an analogue signal conveying information (e.g. sound, image, printed text) to binary bits. Digitisation entails the application of digital technologies to existing tasks. See also Digitalisation.

Phrase	Meaning
Doctoral Students	Doctoral students attend "tertiary programmes which lead to the award of an advanced research qualification [and which] are therefore devoted to advanced study and original research and are not based on course work only". Such students are usually required to submit a thesis or dissertation of publishable quality, i.e. the product of original research that represents a significant contribution to knowledge. See also *International Standard Classification of Education*.
Early expansion stages of business development	Business development can be summarised as the ideas, initiatives and activities aimed towards making a business better. This includes increasing revenues, growth in terms of business expansion, increasing profitability by building strategic partnerships, and making strategic business decisions.
Employees	Employees include all persons who work in or for the statistical unit, who have a contract of employment with the unit and who receive compensation in cash or in kind at regular intervals of time. Employees engaged in activity ancillary to the main activity of the unit are also included, as well as the following groups: persons on short-term leave (sick leave, annual leave or vacation); persons on special paid leave (educational or training leave, maternity or parental leave); persons on strike; and part-time workers, seasonal workers and apprentices when on the payroll. Employees also include persons working physically outside the statistical unit's premises, when paid by and under the control of the unit (outworkers); for example, outside service engineers and repair and maintenance personnel are employees.
Employing enterprises	An enterprise with at least one employee. An Enterprise being the smallest combination of legal units that is an organisational unit producing goods or services, which benefits from a certain degree of autonomy in decision-making, especially for the allocation of its current resources. An enterprise carries out one or more activities at one or more locations. An enterprise may be a sole legal unit.
Employment	Employment – See *persons employed.*

Phrase	Meaning
Enterprise	An enterprise is the smallest combination of legal units with autonomy in respect of financial and investment decision-making, as well as authority and responsibility for allocating resources for the production of goods and services. The term enterprise may refer to a corporation, a quasi-corporation, an NPI or an unincorporated enterprise. It is used throughout this manual to refer specifically to business enterprises. See also Business enterprise sector.
Experimental Development	Experimental development is systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes.
Fields of Research	The OECD fields of research and development (FoR) classification has been developed in the framework of the Frascati Manual and is used to classify R&D units and resources by fields of enquiry, namely, broad knowledge domains based primarily on the content of the R&D subject matter.
Framework conditions	Broader set of contextual factors related to the external environment that facilitate or hinder business activities in a given country. These usually include the regulatory environment, taxation, competition, product and labour markets, institutions, human capital, infrastructure, standards, etc.
Full-Time Equivalent (FTE)	FTE is the ratio of working hours actually spent on an activity during a specific reference period (usually a calendar year) divided by the total number of hours conventionally worked in the same period.
Global value chains	Pattern of organisation of production involving international trade and investment flows whereby the different stages of the production process are located across different countries.
Globalisation	In broad terms, globalisation refers to the international integration of financing, factor supply, R&D, production, and trade of goods and services.
Goods	Goods are physical, produced objects for which a demand exists, over which ownership rights can be established and whose ownership can be transferred from one institutional unit to another by engaging in transactions on markets. See also Products.

Phrase	Meaning
Government Budget Allocations for R&D (GBARD)	Government budget allocations for R&D (GBARD) encompass all spending allocations met from sources of government revenue foreseen within the budget, such as taxation. Spending allocations by extra-budgetary government entities are only within the scope to the extent that their funds are allocated through the budgetary process. Likewise, R&D financing by public corporations is outside the scope of GBARD statistics, as it is based on funds raised within the market and outside the budgetary process. Only in the exceptional case of budgetary provisions for R&D to be carried out or distributed from public corporations should this be counted as part of GBARD. See also *Socio-economic (SEO) objectives classification.*
Government expenditure on R&D (GOVERD)	Government expenditure on R&D (GOVERD) represents the component of GERD incurred by units belonging to the Government sector. It is the measure of expenditures on intramural R&D within the Government sector during a specific reference period. See also *Gross domestic expenditure on R&D (GERD)* and *intramural R&D expenditures*.
Government Sector	The Government sector consists of the following groups of resident institutional units: ▪ All units of central (federal), regional (state) or local (municipal) government, including social security funds, except those units that provide higher education services or fit the description of higher education institutions provided in this manual ▪ All non-market NPIs that are controlled by government units that are not part of the Higher education sector. The sector does not include public corporations, even when all the equity of such corporations is owned by government units. Public enterprises are included in the Business enterprise sector.
Green economy	Economy that aims at reducing environmental risks and ecological scarcities, and that aims for sustainable development without degrading the environment.
Gross Domestic Expenditure on R&D (GERD)	Gross domestic expenditure on R&D (GERD) is total intramural expenditure on R&D performed in the national territory during a specific reference period.

Phrase	Meaning
Headcount (HC)	The headcount (HC) of R&D personnel is defined as the total number of individuals contributing to intramural R&D, at the level of a statistical unit or at an aggregate level, during a specific reference period (usually a calendar year).
Hidden Innovation	Hidden innovation is innovation activity that is not captured in current innovation indicators.
High growth enterprise	A growth enterprise is a company growing faster than its peers or the broader economy. Although there is no hard-and-fast rules of defining growth, these enterprises generally have increased annual revenues by more than the industry average over a sustained period. A enterprise is not classified as a growth enterprise if revenues or other financial metrics surge for one quarter and relax in subsequent periods. This progress must be demonstrated over several years to legitimise the quality of growth.
Higher Education Expenditure on R&D (HERD)	Higher education expenditure on R&D (HERD) represents the component of GERD incurred by units belonging to the Higher education sector. It is the measure of intramural R&D expenditures within the Higher education sector during a specific period. See also *Gross domestic expenditure are R&D (GERD)* and *intramural R&D expenditures*.
Higher Education Sector	The higher education sector comprises all universities, colleges of technology and other institutions providing formal tertiary education programmes, whatever their source of finance or legal status, and all research institutes, centres, experimental stations and clinics that have their R&D activities under the direct control of, or are administered by, tertiary education institutions.
Households	Households are institutional units consisting of one or more individuals. In the SNA, individuals must belong to only one household. The principal functions of households are to supply labour, to undertake final consumption and, as entrepreneurs, to produce market goods and services.
Human capital	The skills, knowledge, and experience possessed by an individual or population, viewed in terms of value or cost to an organisation or country.

Phrase	Meaning
Implementation	Implementation refers to the point in time when a significantly different new or improved product or business process is first made available for use. In the case of product innovation, this refers to its market introduction, while for business process innovations it relates to their first use within the business.
Indicator	An indicator is a variable that purports to represent the performance of different units along some dimension. Its value is generated through a process that simplifies raw data about complex phenomena in order to compare similar units of analysis across time or location. See also Innovation indicator.
Industry	An economic activity or industry consists of a group of establishments engaged in the same, or similar, kinds of activity. The International Standard Industrial Classification (ISIC) is the reference classification for economic activities. See also 'International Standard Industrial Classification (ISIC').
Innovation	An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).
Innovation activities	Institutional units can undertake a series of actions with the intention to develop innovations. This can require dedicated resources and engagement in specific activities, including policies, processes and procedures. See also Innovation activities (business).
Innovation barriers	Internal or external factors that hamper business innovation efforts.
Innovation drivers	Internal or external factors that incentivise business innovation efforts.
Innovation indicator	An innovation indicator is a statistical summary measure of an innovation phenomenon (activity, output, expenditure, etc.) observed in a population or a sample thereof for a specified time or place. Indicators are usually corrected (or standardised) to permit comparisons across units that differ in size or other characteristics. See also indicator.

Phrase	Meaning
Innovation outcomes	Innovation outcomes are the observed effects of innovations, including the extent to which a business's objectives are met and the broader effects of innovation on other organisations, the economy, society, and the environment. These can also include unexpected effects that were not identified among the business's initial objectives (e.g. spill overs and other externalities).
Innovation project	An innovation project is a set of activities that are organised and managed for a specific purpose and with their own objectives, resources and expected outcomes. Information on innovation projects can complement other qualitative and quantitative data on innovation activities.
Innovation status	The innovation status of a business is defined on the basis of its engagement in innovation activities and its introduction of one or more innovations over the reference period of a data collection exercise. See also Innovation-active business and non-innovation-active business
Innovation-active business	An innovation-active business is engaged at some time during the reference period in one or more activities to develop or implement new or improved products or business processes for an intended use. Both innovative and non-innovative businesses can be innovation-active during a reference period. See also Innovation status.
Internet of things	The interconnection via the Internet of computing devices embedded in everyday objects, enabling them to send and receive data.
Intangible assets	See Knowledge-based capital. Intangible assets consists of assets that lack physical substance in contrast to physical assets (such as machinery, land and buildings) and financial assets (such as government securities). IP, goodwill, and brand recognition are all examples of intellectual assets.

Phrase	Meaning
Intellectual property products	Intellectual property products are the result of research, development, investigation or innovation leading to knowledge that the developers can market or use to their own benefit in production because use of the knowledge is restricted by means of legal or other protection. Examples include: ▪ research and experimental development (R&D) ▪ mineral exploration and evaluation ▪ computer software and databases ▪ entertainment, literary and artistic originals.
Intellectual property rights (IPRs)	Intellectual property rights (IPRs) are legal rights over intellectual property. See also Intellectual property products.
International Organisations	International organisations have as members either national states or other international organisations whose members are national states. They are established by formal political agreements between their members that have the status of international treaties; their existence is recognised by law in their member countries, and they are not subject to the laws or regulations of the country, or countries, in which they are located. For example, they cannot be compelled by national authorities to provide statistical information on their R&D performance or funding activities. For the purposes of the SNA and also for R&D statistics, international organisations are treated as units that are resident abroad (part of Rest of the world), regardless of the physical location of their premises or operations.
International Standard Classification of Occupations (ISCO)	The ISCO is used to classify jobs. For the purpose of ISCO, a job is defined as a set of tasks and duties performed, or meant to be performed, by one person, including for an employer or in self-employment. An occupation is defined as a set of jobs whose main tasks and duties are characterised by a high degree of similarity. A person may be associated with an occupation through the main job currently held, a second job or a job previously held. Jobs are classified by occupation with respect to the type of work performed, or to be performed. The basic criteria used to define the system of major, sub-major, minor and unit groups are the “skill level” and “skill specialisation” required to perform the tasks and duties of the occupations competently.

Phrase	Meaning
International Standard Industrial Classification of All Economic Activities (ISIC)	The International Standard Industrial Classification of All Economic Activities (ISIC) consists of a coherent and consistent classification structure of economic activities based on a set of internationally agreed concepts, definitions, principles and classification rules. It provides a comprehensive framework within which economic data can be collected and reported in a format that is designed for purposes of economic analysis, decision-taking and policy-making. The classification structure represents a standard format to organise detailed information about the state of an economy according to economic principles and perceptions. The scope of ISIC in general covers productive activities, i.e. economic activities within the production boundary of the System of National Accounts (SNA). The classification is used to classify statistical units, such as establishments or enterprises, according to the economic activity in which they mainly engage. The most recent version is ISIC Revision 4.
Knowledge flows	Knowledge flows refer to inbound and outbound exchanges of knowledge, through market transactions as well as non-market means. Knowledge flows encompass both deliberate and accidental transmission of knowledge.
Knowledge-based capital (KBC)	Knowledge-based capital comprises intangible assets that create future benefits. It comprises software and databases, Intellectual property products, and economic competencies (including brand equity, business-specific human capital, organisational capital). Software, databases and Intellectual property products are currently recognised by the SNA as produced assets. See also Intellectual property products.
Labour productivity	Labour productivity is the rate of output per worker (or group of workers) per unit of time as compared with an established standard of expected rate of output.
Labour utilisation	Labour utilisation is the measure of the labour hours recorded against production activities vs. the hours available or scheduled for a given period.

Phrase	Meaning
Land and buildings	Land and buildings include land acquired for R&D use (e.g. testing grounds, sites for laboratories and pilot plants) and buildings constructed or purchased for R&D use, including major improvements, modifications and repairs. Since buildings are produced assets and land is a non-produced asset in National Accounts, R&D expenditures for land and for buildings should be separately identified.
Managerial capability	Managerial capability include all of a business's internal abilities, capacities, and competences that can be used to mobilise, command and exploit resources in order to meet the business's strategic goals. These capabilities typically relate to managing people; intangible, physical and financial capital; and knowledge. Capabilities concern both internal processes and external relations. Managerial capabilities are a specific subset of organisational capabilities that relate to the ability of managers to organise change.
Marketing innovation	Type of innovations used in the previous edition of this Manual, currently these are mostly subsumed under business process innovation, except for innovations in product design which are included under product innovation.
Metadata	Metadata are data that define and describe other data. This includes including information on the procedure used to collect data, sampling methods, procedures for dealing with non-response, and quality indicators.
Migrants	A person who moves from one place to another, especially in order to find work or better living conditions
Multifactor productivity	Multifactor productivity (MFP) reflects the overall efficiency with which labour and capital inputs are used together in the production process. Changes in MFP reflect the effects of changes in management practices, brand names, organizational change, general knowledge, network effects, spillovers from production factors, adjustment costs, economies of scale, the effects of imperfect competition and measurement errors. Growth in MFP is measured as a residual, i.e. that part of GDP growth that cannot be explained by changes in labour and capital inputs. In simple terms therefore, if labour and capital inputs remained unchanged between two periods, any changes in output would reflect changes in MFP. This indicator is measured as an index and in annual growth rates.

Phrase	Meaning
New-to-business innovation	Lowest threshold for innovation in terms of novelty referring to a first time use or implementation by a business. A new-to-business innovation can also be new-to-market (or world), but not vice versa. If an innovation is new-to-business but not new-to-market (e.g. when adopting existing products or business processes – as long as they differ significantly from what the business offered or used previously – with little or no modification), it is referred to as "new-to-business only". See also New-to-market innovation.
New-to-market innovation	An innovation by a business that has not been available in the market(s) served by the business. New-to-market innovation represent a higher threshold for innovation than a new-to-business innovation in terms of novelty. See also New-to-business innovation.
Non-innovation active business	A non-innovation active business is one that does not report an innovation within the reference period. A non-innovative active business can still be innovation-active if it had one or more ongoing, suspended, abandoned or completed innovation activities that did not result in an innovation during the reference period. See also Innovation-active business and innovation status.
Non-profit entity	Non-profit entity are legal or social entities created for the purpose of producing goods and services, whose status does not permit them to be a source of income, profit or other financial gain for the units that establish, control or finance them. They can be engaged in market or non-market production.
Novelty	Novelty is a dimension used to assess whether a product or business process is "significantly different" from previous ones and if so, it could be considered an innovation. The first and most widely used approach to determine the novelty of a business's innovations is to compare these with the state of the art in the market or industry in which the business operates. The second option is to assess the potential for an innovation to transform (or create) a market, which can provide a possible indicator for the incidence of radical or disruptive innovation. A final option for product innovations is to measure the observed change in sales over the reference period or by asking directly about future expectations of the effect of these innovations on competitiveness.
Organisational innovation	Type of innovation used in the previous edition of this Manual, currently subsumed under business process innovation.

Phrase	Meaning
Patent	A government authority or licence conferring a right or title for a set period, especially the sole right to exclude others from making, using or selling an invention.
Persons Employed	Persons employed include both employees and unpaid family workers and working proprietors (i.e. active business partners). Silent or inactive partners whose principal activity is conducted outside of the statistical unit should be excluded. See also *internal R&D personnel.*
PhD	A Doctor of Philosophy (PhD, Ph.D., or DPhil; Latin philosophiae doctor or doctor philosophiae) is the highest university degree that is conferred after a course of study by universities in most countries. PhDs are awarded for programs across the whole breadth of academic fields. As an earned research degree, those studying for a PhD are usually required to produce original research that expands the boundaries of knowledge, normally in the form of a thesis or dissertation, and defend their work against experts in the field. The completion of a PhD is often a requirement for employment as a university professor, researcher, or scientist in many fields.
Physical capital	Physical capital is one of what economists call the three main factors or production. It consists of tangible, man-made goods that assist in the process of creating a product or service. The machinery, buildings, office or warehouse supplies, vehicles, and computers that a company owns are all considered part of its physical capital.
Plant breeders' rights	Plant breeder's rights (PBR) are used to protect new varieties of plants that are distinct, uniform and stable. PBR are exclusive commercial rights for a registered variety of plant. The rights are form of IP, like patents, trademarks and designs. If you develop a new plant variety, you may want to protect your IP with plant breeders' rights. The PBR scheme protects plant breeders and gives them a commercial monopoly for a period of time. This encourages plant breeding and innovation, and means that a large and growing pool of new plant varieties is freely available to anybody when the protection periods lapse.
Policy relevance	Policy relevance refers to how effectively research findings inform decisions made by decision-makers. In other words, policy relevance is determined by how applicable and practical research findings are to decisions that need to be made on policy priorities.
Procurement	The action of obtaining or procuring something.

Phrase	Meaning
Product	A product is a good or service (including knowledge-capturing products as well as combinations of goods and services) that results from a process of production. See also Goods and Services.
Product innovation	A product innovation is a new or improved good or service that differs significantly from the business's previous goods or services and that has been introduced on the market. Product innovations must provide significant improvements to one or more characteristics or performance specifications. See also Product.
Productivity	A measure of the efficiency of a person, machine, factory, system, etc., in converting inputs into useful outputs. Productivity is computed by dividing average output per period by the total costs incurred or resources (capital, energy, material, personnel) consumed in that period. Productivity is a critical determinant of cost efficiency.
Public sector	The public sector includes all institutions controlled by government, including public business enterprises. The latter should not be confused with publicly listed (and traded) corporations. The public sector is a broader concept than the General government sector.
Purchasers' Prices	Purchasers' prices are the amounts paid by the purchasers, excluding the deductible part of value-added taxes and similar taxes. Purchasers' prices reflect the actual costs to the users. This means that the valuation of current and capital expenditures on goods and services for R&D is the total price paid by the reporting unit, including any taxes on products, which act to increase the price paid, and the price-reducing effect of any subsidies on the products purchased.
R&D	Research and development
R&D Personnel	R&D personnel in a statistical unit include all persons engaged directly in R&D, whether employed by the statistical unit or external contributors fully integrated into the statistical unit's R&D activities, as well as those providing direct services for the R&D activities (such as R&D managers, administrators, technicians and clerical staff). See also 'internal R&D personnel' and 'external R&D personnel'.

Phrase	Meaning
Reference period	The reference period is the final year of the overall survey reference period and is used as the effective reference period for collecting interval level data items, such as expenditures or the number of employed persons.
Regulation	Regulation refers to the implementation of rules by public authorities and governmental bodies to influence market activity and the behaviour of private actors in the economy. A wide variety of regulations can affect the innovation activities of businesss, industries and economies.
Regulatory barriers	Legal or regulatory barriers include agreements, contracts, patents, trademarks, copyrights and/or regulatory protection. Vendors should clearly define the protection and the extent of the protection.
Relational Database	A relational database is a type of database that stores and provides access to data points that are related to one another. In a relational database, each row in the table is a record with a unique ID called the *key.* The columns of the table hold attributes of the data, and each record usually has a value for each attribute, making it easy to establish the relationships among data points.
Reliability and precision	A metric should be based upon stable and consistent data collection processes across collection points and over time. Progress toward performance targets should reflect real changes rather than variations in data collection approaches or methods. Source data should be clearly identified and readily available from manual, automated or other systems and records.
Research and Experimental Development (R&D)	Research and experimental development (R&D) comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge.
Researchers	Researchers are professionals engaged in the conception or creation of new knowledge. They conduct research and improve or develop concepts, theories, models, techniques instrumentation, software or operational methods.

Phrase	Meaning
Satellite account	Satellite accounts are not part of the National Accounts, which are produced according to the SNA. They are closely linked to the main system but are not bound to employ exactly the same concepts or restrict themselves to data expressed in monetary terms. They are used to meet the needs of a particular country or countries where the international community as a whole has not agreed to include them in the SNA.
Seed	Start-ups at this level have already validated their value proposition. They have monthly revenue which is consistent, constant and the business is growing month on month. The start-up needs its next level of funding to find true product/market fir, scale, grow and become a competitor in the current market place.
Services	Services are the result of a production activity that changes the conditions of the consuming units, or facilitates the exchange of products or financial assets. They cannot be traded separately from their production. Services can also include some knowledge-capturing products. See also Products.
Socio-Economic Objectives (SEO) Classification	A socio-economic objectives (SEO) classification is used to distribute GBARD. The criteria for classification should be the purpose of the R&D programme or project, i.e. its primary objective. The allocation of R&D budgets to socio-economic objectives should be at the level that most accurately reflects the funder's objective(s). The recommended distribution list is based on the European Union classification adopted by Eurostat for the Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets (NA BS) at the one-digit level. See also 'Government budget allocations for R&D (GBARD)'.

Phrase	Meaning
Software	A software development project is classified as R&D if its completion is dependent on a scientific and/or technological advance, and the aim of the project is the systematic resolution of a scientific and/or technological uncertainty. In addition to the software that is part of an overall R&D project, the R&D associated with software as an end product or software embedded in an end product could also be classified as R&D when the R&D criteria apply. Software development is an integral part of many projects that in themselves have no element of R&D. The software development component of such projects, however, may be classified as R&D if it leads to an advance in the area of computer software. An upgrade, addition or change to an existing program or system may be classified as R&D if it embodies scientific and/or technological advances that result in an increase in the stock of knowledge. Software-related activities of a routine nature are not to be considered R&D.
Start-up	A start-up is a company or project initiated by an entrepreneur to seek, effectively develop, and validate a scalable business model. The concepts of start-ups and entrepreneurship are similar. However, entrepreneurship refers all new businesses, including self-employment and businesses that never intend to grow big or become registered, while start-ups refer to new businesses that intend to grow beyond the solo founder, have employees, and intend to grow large. Start-ups face high uncertainty, and do have high rates of failure, but the minority that go to be successful companies have the potential to become large and influential. Some start-ups become unicorns, i.e. privately held start-up companies valued at over US$1 billion.
Suppliers	Suppliers are businesses or organisations that supply goods (equipment, materials, software, components etc.) or services (consulting, business services, etc.) to other businesses or organisations. This includes providers of knowledge capturing products such as IP rights.
Survey frame	The frame population is the set of target population members that has a chance to be selected into the survey sample.
System of National Accounts (SNA)	The SNA is a statistical framework that provides a comprehensive, consistent and flexible set of macroeconomic accounts for policymaking, analysis and research purposes. The most recent version is the 2008 SNA.

Phrase	Meaning
Tangible assets	A tangible asset is an asset that has a finite monetary value and usually a physical form. Tangible assets can typically always be transacted for some monetary value through the liquidity of different markets will vary. Tangible assets are the opposite of intangible assets which have a theorized value rather than a transactional exchange value.
Tax Credit	A tax credit is an amount subtracted directly from the tax liability due by the beneficiary household or corporation after the liability has been computed.
Technology	Technology refers to the state of knowledge on how to convert resources into outputs. This includes the practical use and application to business processes or products of technical methods, systems, devices, skills and practices.
Tertiary education	Tertiary education includes what is commonly understood as academic education but also includes advanced vocational or professional education. It comprises ISCED levels 5, 6, 7 and 8, which are labelled as short-cycle tertiary education, Bachelor's or equivalent level, Master's or equivalent level, and doctoral or equivalent level, respectively.
Timeliness	The measure of timeliness is the delay between the end of the reference period to which the information pertains, and the date on which the information becomes available. Timeliness is typically involved in a trade-off against accuracy. The timeliness of information will influence its relevance.
Trademark	A symbol, word, or words legally registered or established by use as representing a company or product.
Training	Training includes all activities that are paid for or subsidised by the business to develop knowledge and skills required for the specific trade, occupation or vocation of a business's employees. Training includes on-the-job training and job-related education at training and educational institutions. Examples of training as an innovation activity include training personnel to use innovations, such as new software logistical systems or new equipment; and training relevant to the implementation of an innovation, such as instructing marketing personnel or customers on the features of a product innovation.

Phrase	Meaning
Transactional data	Transactional data documents an exchange, agreement or transfer that occurs between organisations or individuals or both, such as purchases and payments.
Users innovation	Users innovation refers to activities whereby consumers or end-users modify a business's products, with or without the business's consent, or when users develop entirely new products.
Value creation	The existence of opportunity costs implies the likely intention to pursue some form of value creation (or value preservation) by the actors responsible for an innovation activity. Value is therefore an implicit goal of innovation, but cannot be guaranteed on an ex ante basis. The realisation of the value of an innovation is uncertain and can only be fully assessed sometime after its implementation. The value of an innovation can also evolve over time and provide different types of benefits to different stakeholders.
Venture capital	Capital invested in a project in which there is a substantial element of risk, typically a new or expanding business.

Abbreviations

Abbreviations	Meaning
ABN	Australian Business Number
ABS	Australian Bureau of Statistics
ABSBR	Australian Bureau of Statistics Business Register
ACCC	Australian Competition and Consumer Commission
ACN	Australian Company Number
AI	Artificial intelligence
AIS Monitor	Australian Innovation System Monitor
AISR	Australian Innovation Systems Report
ANSTO	Australian Nuclear Science and Technology Organisation
ANZSCO	Australian and New Zealand Standard Classification of Occupations
ANZSIC	Australian and New Zealand Standard Industrial Classification
ANZSRC	Australian and New Zealand Standard Research Classification
APS	Adult Population Survey
ARC	Australian Research Council
ARTG	Australian Register of Therapeutic Goods
ATO	Australian Taxation Office
ATSE	Australian Academy of Technology and Engineering
AUTM	Association of University Technology Managers
BCS	Business Characteristics Survey
BEA	(US) Bureau of Economic Analysis
BEIS	(NZ) Department of Business, Energy and Industrial Strategy
BERD	Businesses Expenditure on Research and Development
BLADE	Business Longitudinal Analysis Data Environment
BLS	Bureau of Labor Statistics
BUIT	Business Use of Information Technology

Abbreviations	Meaning
CABEE	Counts of Australian Businesses, including Entries and Exits
CEO	Chief Executive Officer
CIS	Community Innovation Survey
CRC	Cooperative Research Centre
CRM	Customer relationship management
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTS	Consolidated Tariff Schedules
CURF	Confidentialised Unit Record File
DESSFB	(Australian) Department of Employment, Skills, Small and Family Business
DET	(Australian) Department of Education and Training
DIIS	(Australian) Department of Industry, Innovation and Science
DIPA	Data Integration Partnership for Australia
DITCRD	(Australian) Department of Infrastructure, Transport, Cities and Regional Development
DOCA	(Australian) Department of Communications and the Arts
DOI	Digital object identifier
EAAG	OECD Entrepreneurship At A Glance
EAS	Economic Activity Survey
EDAN	Economic Data and Analysis Network
EFCs	Entrepreneurial Framework Conditions
EFI	Commission of Experts for Research and Innovation
EIS	European Innovation Scoreboard
EP	Entrepreneurs' Programme
ERP	Enterprise resource planning
ESS	European Statistical System
EUR	Euro
FoR	Field of Research

Abbreviations	Meaning
FTE	Full-time equivalent
GBARD	Government Budget Allocation for Research and Development
GCR	Global Competitiveness Report
GDP	Gross Domestic Product
GEM	Global Entrepreneurship Monitor
GERD	Gross Expenditure on Research and Development
GII	Global Innovation Index
GOVERD	Government Expenditure on Research and Development
GST	Goods and Services Tax
GTARD	Government Tax Relief for Research and Development Expenditure
HC	Headcount
HDI	Human Development Index
HEFP	Higher Education Finance Publication
HERD	Higher Education Expenditure on Research and Development
HERDC	Higher Education Research Data Collection
HR	Human Resources
IAS	Internet Activity Survey
IATA	International Air Transport Association
IC	Innovation Connections
ICT	Information and Communication Technology
IDB	Integrated Data Base
IEA	International Energy Agency
IHME	(US) Institute for Health Metrics and Evaluation
ILO	International Labour Organization
IMF	International Monetary Fund
IMR	Innovation Metrics Review
INSEAD	Institut European d'Administration des Affairs

Abbreviations	Meaning
IP	Intellectual Property
IPA	IP Australia
IPGOD	Intellectual Property Government Open Data
IPLORD	IP Australia’s Intellectual Property Longitudinal Research Data
IPR	Intellectual property rights
IPU	Inter-Parliamentary Union
ISA	Innovation and Science Australia
ISCED	International Standard Classification of Education
ISCO	International Standard Classification of Occupations
ISIC	International Standard Industrial Classification
IT	Information Technology
ITU	International Telecommunication Union
ITUC	International Trade Union Confederation
KBC	Knowledge-based capital
KCA	Knowledge Commercialisation Australia
LLEED	Longitudinal Linked Employer-Employee Database
LMIP	Labour Market Information Portal
LSPE	Later Stage Private Equity
MBIE	(NZ) Ministry of Business, Innovation and Employment
MCM	Management Capabilities Module
MCS	Management Capability Survey
MFP	Multifactor productivity
MP	Member of Parliament
MSTI	Main Science and Technology Indicators
MYEFO	Mid-year Economic and Fiscal Outlook
NAIF	Northern Australia Infrastructure Facility
NCSES	(US) National Center for Science and Engineering Statistics
NCVER	(Australian) National Centre for Vocational Education Research

Abbreviations	Meaning
NES	(Global Entrepreneurship Monitor) National Expert Survey
Nesta	An innovation foundation and independent charity. Formerly (UK) National Endowment for Science, Technology and the Arts.
NESTI	(OECD) National Experts on Science and Technology Indicators
NHMRC	Australian National Health and Medical Research Council
NIST	Australian National Institute of Standards and Technology
NOPSEMA	Australian National Offshore Petroleum Safety and Environmental Management Authority
NPI	Non-profit institutions
NSB	(Australian) National Science Board
NSF	(Australian) National Science Foundation
NSO	National statistical office
NSRC	(Australian) National Survey of Research Commercialisation
NSW	New South Wales
NZ	New Zealand
OECD	Organisation for Economic Cooperation and Development
OISA	Office of Innovation and Science Australia
PBR	Plant breeders' rights
PCT	Patent Cooperation Treaty
PFRO	Publicly funded research organisations
PhD	Doctor of Philosophy
PIAAC	Programme for the International Assessment of Adult Competencies
PISA	Programme of International Student Assessment
PMR	Product Market Regulation
PNPERD	Private Non-Profit Expenditure on Research and Development

Abbreviations	Meaning
PPP	Purchasing Power Parities
QILT	Quality Indicators for Learning and Teaching
R&D	Research and Development
RD&D	Research, Development and Demonstration
RDTI	Research and Development Tax Incentive
RKR	Record Keeping Rule
RRDC	Rural R&D Corporations
S&P	Standard and Poor's Sovereign Rating
SDBS	Structural and demographic business statistics
SEO	Socio-Economic Objective
SHWAU	Social Health and Welfare Analytical Unit
SIOs	Services in Operation
SISCA	Standard Institutional Sector Classification of Australia
SME	Small and Medium Enterprises
SNA	System of National Accounts
SPE	Societas Privata Europaea
SRI	Science, Research and Innovation
SRIBT	Science, Research and Innovation Budget Tables
STI	Science, Technology and Industry
STIS	Science, Technology and Industry Scoreboard
TOA	Type of Activity
TRAINS	Trade Analysis and Information System
UK	United Kingdom
UNCTAD	United Nations Conference on Trade and Development
UNE	(Australian) University of New England
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPOV	International Union for the Protection of New Varieties of Plants
US	United States of America
UTS	University of Technology, Sydney

Abbreviations	Meaning
VC	Venture Capital
VC&LSPE	Venture Capital and Later Stage Private Equity
VET	Vocational Education and Training
WEF	World Economic Forum
WIPO	World Intellectual Property Organization
WTO	World Trade Organization