SECURING AUSTRALIA'S FUTURE

The role of science, research and technology in lifting Australia's productivity

4

PROJECT

EXTRACT

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ACADEMY OF THE SOCIAL SCIENCES IN AUSTRALIA

AUSTRALIAN ACADEMY OF TECHNOLOGICAL SCIENCES AND ENGINEERING

ACOLA

AUSTRALIAN COUNCIL OF LEARNED ACADEMIES

SECURING AUSTRALIA'S FUTURE

A three-year research program funded by the Australian Research Council and conducted by the four Learned Academies through the Australian Council of Learned Academies for PMSEIC, through the Office of the Chief Scientist. Securing Australia's Future delivers research-based evidence and findings to support policy development in areas of importance to Australia's future.

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The role of science, research and technology in lifting Australia's productivity

ACOLA is the interface of the four Learned Academies:

Australian Academy of the Humanities

Australian Academy of Science

Academy of the Social Sciences in Australia

Australian Academy of Technological Sciences and Engineering

Australia's Learned Academies

Australian Academy of the Humanities

The Australian Academy of the Humanities advances knowledge of, and the pursuit of excellence in, the humanities in Australia. Established by Royal Charter in 1969, the Academy is an independent organisation of more than 500 elected scholars who are leaders and experts in the humanities disciplines.

The Academy promotes the contribution of the humanities disciplines for public good and to the national research and innovation system, including their critical role in the interdisciplinary collaboration required to address societal challenges and opportunities. The Academy supports the next generation of humanities researchers and teachers through its grants programme, and provides authoritative and independent advice to governments, industry, the media and the public on matters concerning the humanities.

www.humanities.org.au

Australian Academy of Science

The Australian Academy of Science is a private organisation established by Royal Charter in 1954. It comprises ~450 of Australia's leading scientists, elected for outstanding contributions to the life sciences and physical sciences. The Academy recognises and fosters science excellence through awards to established and early career researchers, provides evidence-based advice to assist public policy development, organises scientific conferences, and publishes scientific books and journals. The Academy represents Australian science internationally, through its National Committees for Science, and fosters international scientific relations through exchanges, events and meetings. The Academy promotes public awareness of science and its school education programs support and inspire primary and secondary teachers to bring inquiry-based science into classrooms around Australia.

www.science.org.au

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The Australian Council of Learned Academies (ACOLA) combines the strengths of the four Australian Learned Academies: Australian Academy of the Humanities, Australian Academy of Science, Academy of Social Sciences in Australia, and Australian Academy of Technological Sciences and Engineering.

ACADEMY OF THE SOCIAL SCIENCES IN AUSTRALIA

Academy of Social Sciences in Australia

The Academy of the Social Sciences in Australia (ASSA) promotes excellence in the social sciences in Australia and in their contribution to public policy. It coordinates the promotion of research, teaching and advice in the social sciences, promote national and international scholarly cooperation across disciplines and sectors, comment on national needs and priorities in the social sciences and provide advice to government on issues of national importance.

Established in 1971, replacing its parent body the Social Science Research Council of Australia, itself founded in 1942, the academy is an independent, interdisciplinary body of elected Fellows. The Fellows are elected by their peers for their distinguished achievements and exceptional contributions made to the social sciences across 18 disciplines.

It is an autonomous, non-governmental organisation, devoted to the advancement of knowledge and research in the various social sciences.

www.assa.edu.au

Australian Academy of Technological Sciences and Engineering

ATSE advocates for a future in which technological sciences and engineering and innovation contribute significantly to Australia's social, economic and environmental wellbeing. The Academy is empowered in its mission by some 800 Fellows drawn from industry, academia, research institutes and government, who represent the brightest and the best in technological sciences and engineering in Australia. Through engagement by our Fellows, the Academy provides robust, independent and trusted evidence-based advice on technological issues of national importance. We do this via activities including policy submissions, workshops, symposia, conferences parliamentary briefings, international exchanges and visits and the publication of scientific and technical reports. The Academy promotes science, and maths education via programs focusing on enquiry-based learning, teaching quality and career promotion. ATSE fosters national and international collaboration and encourages technology transfer for economic, social and environmental benefit.

www.atse.org.au

By providing a forum that brings together great minds, broad perspectives and knowledge, ACOLA is the nexus for true interdisciplinary cooperation to develop integrated problem solving and cutting edge thinking on key issues for the benefit of Australia.

ACOLA receives Australian Government funding from the Australian Research Council and the Department of Industry, Innovation, Science, Research and Tertiary Education. www.acola.org.au

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Project aims

This project aimed to identify opportunities for applying knowledge and skills in science and research across a range of industries and sectors including private and public enterprises, and examine how to enhance innovation, creativity and productivity in the Australian workforce and business practices that will drive Australia's prosperity.

This project aimed to address issues including, but not limited to the following:

1. What are the attributes of an innovative workforce?
    a. How do we generate increased awareness and acceptance of the value of a science degree in business and in industry?
    b. How do we build a broader science, research and technology base in the workforce?

2. What are the future workforce needs of Australian industries?
3. What are the future manufacturing issues we need to address?
4. How can we maximise the translation of research and innovation into productivity?
5. How can we more effectively collaborate internationally to improve Australia's global reach and international impact in science, research and technology?

The above aims form the terms of reference for the project.

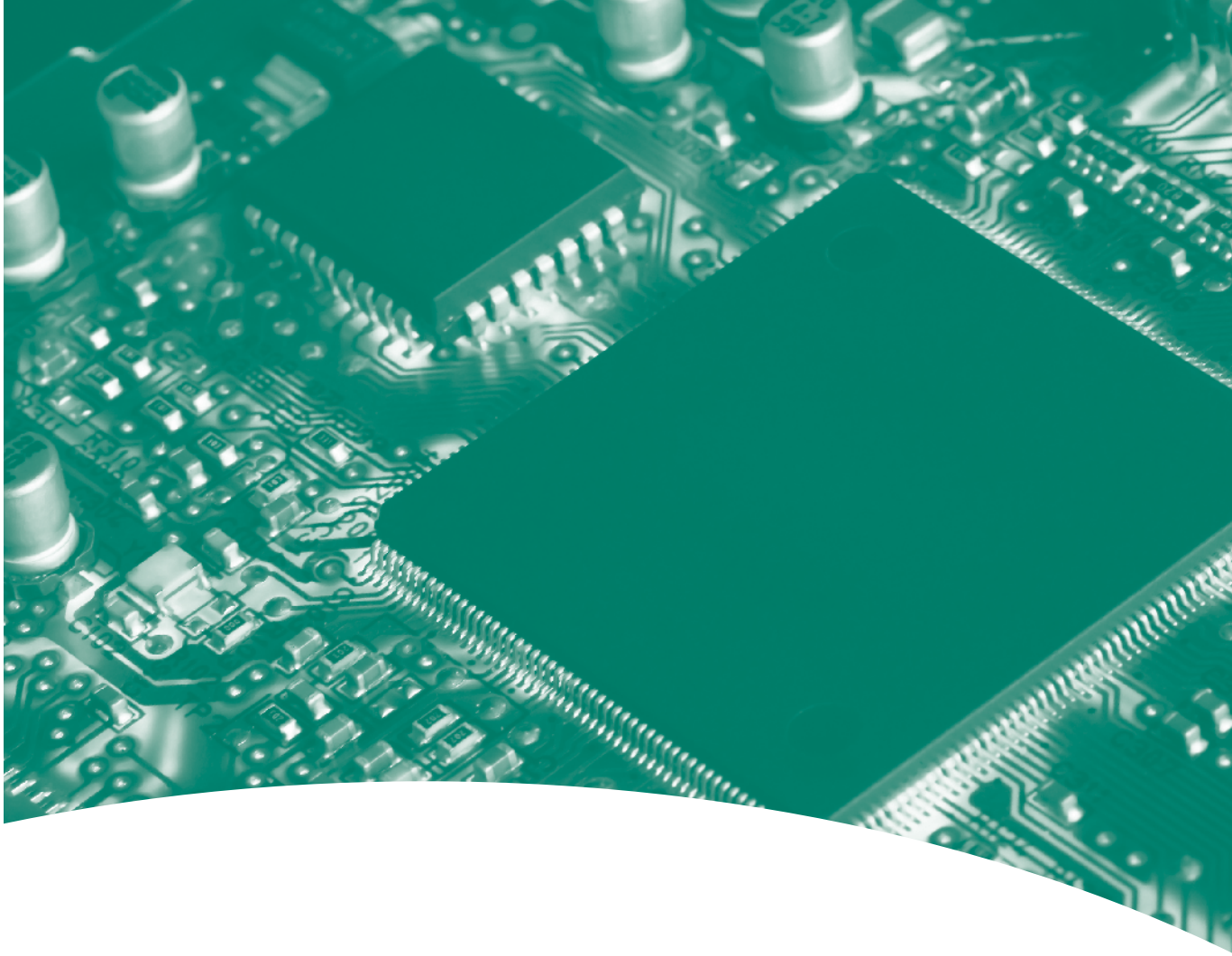
Executive summary

Lifting productivity growth is the key to Australia's prosperity

Productivity is critical for Australia's prosperity, economic growth, and social wellbeing. Lifting productivity growth is a critical priority for Australia. Innovation is a key driver of productivity growth. This report examines how investment in and application of science, research and technology can enhance creativity and innovation to lift productivity in Australia.

This report has three major conclusions:

- Building Australia's future industries will depend on adopting technological innovation to develop high-value products and services for a global market.
- Improving collaboration in Australia, between businesses and between business and publicly funded reseach, will significantly enhance innovation. International collaboration is also critically important. Both domestic and international collaboration improves the productivity and competitiveness of Australian technology-based firms.
- An innovative workforce that combines technical and non-technical disciplines, and enables good business management, is essential to underpin the competitive advantage of Australian industries and realise opportunities to lift productivity.



Innovation is vital to Australia's future manufacturing industries

Manufacturing plays an important role in Australia's economy. It accounts for around 7 per cent of GDP ($104 billion), 11 per cent of employment, 25 per cent of business R&D and 34 per cent of merchandise exports. However, there are many challenges facing Australia's manufacturing sector. In recent decades there has been a decline in the contribution of manufacturing to Australia's gross domestic product (GDP), employment share and productivity, while the contribution of the services sector to GDP has increased.

There is no longer a clear delineation between the manufacturing and services sectors. Firms are increasingly offering services integrated with a manufactured product. This is enabled by an Internet-connected world, where innovations are frequently tied to a service component.

Advanced manufacturing technologies provide opportunities for Australia. Advanced manufacturing builds new industrial sectors and creates high quality jobs. Technological advances, such as 3D printing and bio-manufacturing, are opening up opportunities for the growth of high-tech manufacturing industries and services, especially where these are linked into global value chains.

Advanced manufacturing involves the innovative application of technologies, processes and methods to product design and production. A number of leading OECD countries including the USA, Canada, Korea and Germany have adopting targeted measures to assist firms in this area.

To compete in a global market, Australian firms need to understand international trends in manufacturing. Where firms are not leaders in their field (e.g. through the performance of R&D), they need to be 'fast followers' through the adoption of technologies from overseas. To be competitive, firms need to invest in new knowledge and practices, in order to benefit from emerging opportunities. Becoming an early adopter of technology and fostering advanced manufacturing techniques allows greater output and efficiency, enhancing a firm's share of the market. The low level of international engagement by Australian firms makes it difficult for them to access new, high-technology, niche sectors.

Global value chains provide the ability to share knowledge, processes and skills. Global value chains involve the creation, production and delivery of product, spread between a number of companies across the world. Global value chains can initiate longer term collaborations. They can make an important contribution to productivity and firm growth. However, Australian firms are generally not well linked to global value chains compared to firms in other OECD countries.

Information and communications technology (ICT) infrastructure is critical to the operation of effective global value chains. A high-speed open-access broadband network has the potential to drive economic growth and lift productivity by reducing business costs.

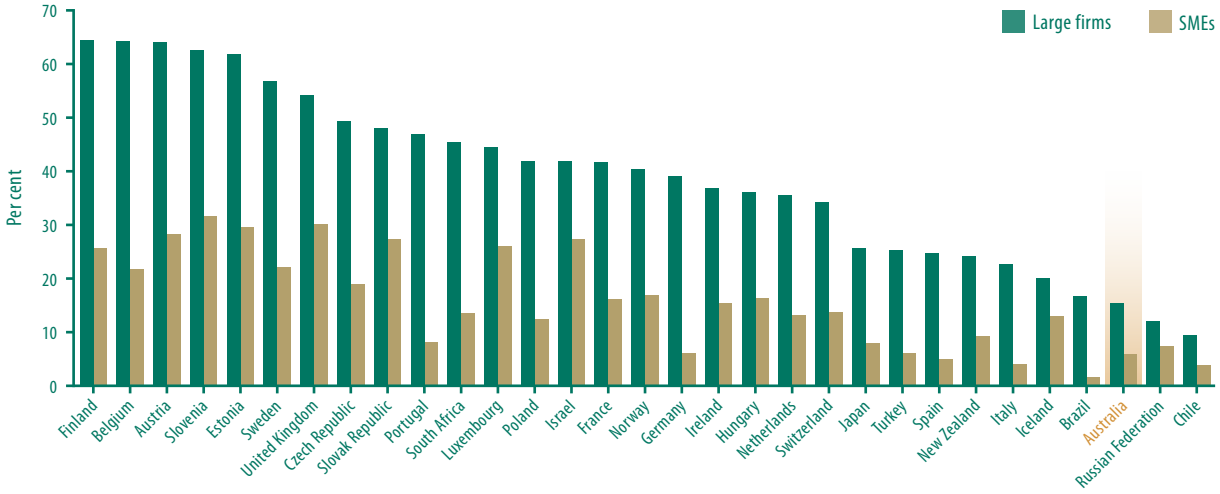
Manufacturing in Australia is dominated by small to medium enterprises. SMEs make up more than 90 per cent of all firms in this sector and most do not operate on a global scale. They have strong innovative potential but are faced with several barriers to growth, such as: a lack of funds; risk; and a lack of access to infrastructure, processes and knowledge networks.

Facilitating the creation and growth of innovative firms of all sizes is essential to build Australia's future industries. This requires access to venture capital and new measures such as crowd sourced equity funding. However, the lack of venture capital in Australia, in comparison with other leading OECD countries, can cause some start-up companies with innovations to fail or to move overseas.

Moving overseas can be to Australia's disadvantage, particularly if it takes place before a company has established an Australian base.

Australia can learn from international best practice in providing support to SMEs. Examples of successful measures include the US Small Business Innovation Research (SBIR) Program and Manufacturing Extension Partnership, the Danish Funding Agency for Technology and Innovation, and the UK Knowledge Transfer Partnerships. Long-term stability is a key factor in the success of these assistance programs, for example the SBIR program has been in operation for over thirty years.

Australian firms have low levels of international collaboration



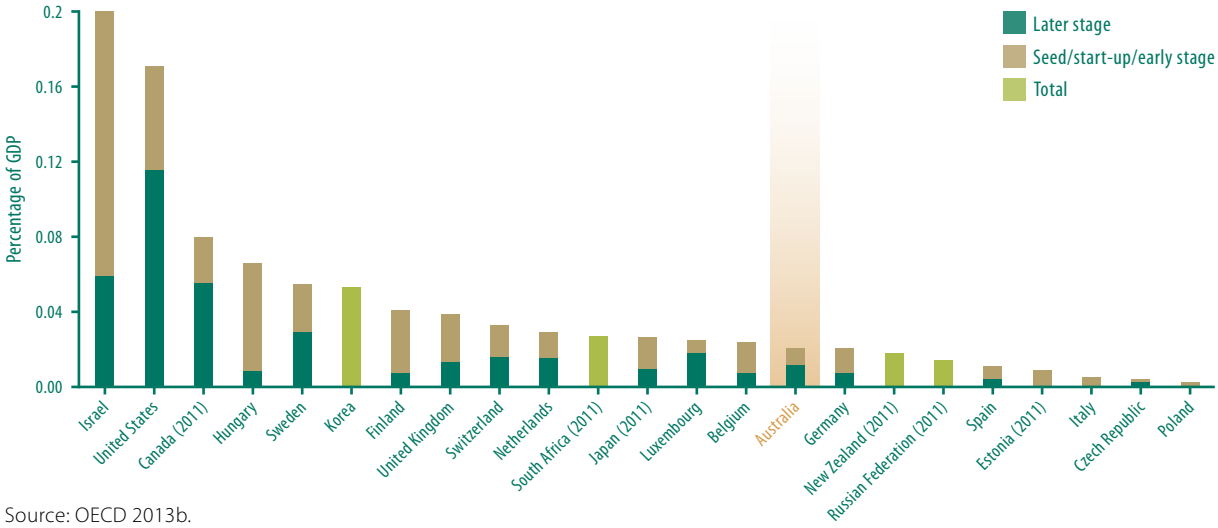
Note: Firms engaged in international collaboration by firm size, 2008-2010, as a percentage of product and/or process innovative firms in each size category.

Source: OECD 2013c, p. 129, based on Eurostat (CIS-2010) and national data sources, June 2013.

Unlike most other OECD countries, Australia has a history of frequent changes to assistance measures. This makes it difficult for business to plan for and have confidence in government assistance. The Commonwealth Government has a few examples of well-designed measures to assist firms (e.g. the Researchers in Business Program), however they are fragmented, lack scale and continuity. In contrast, Canada's Industrial Research Assistance Program has been in operation since 1965, albeit with some minor adjustments over the years. Its budget in 2012 was more than $A250 million.

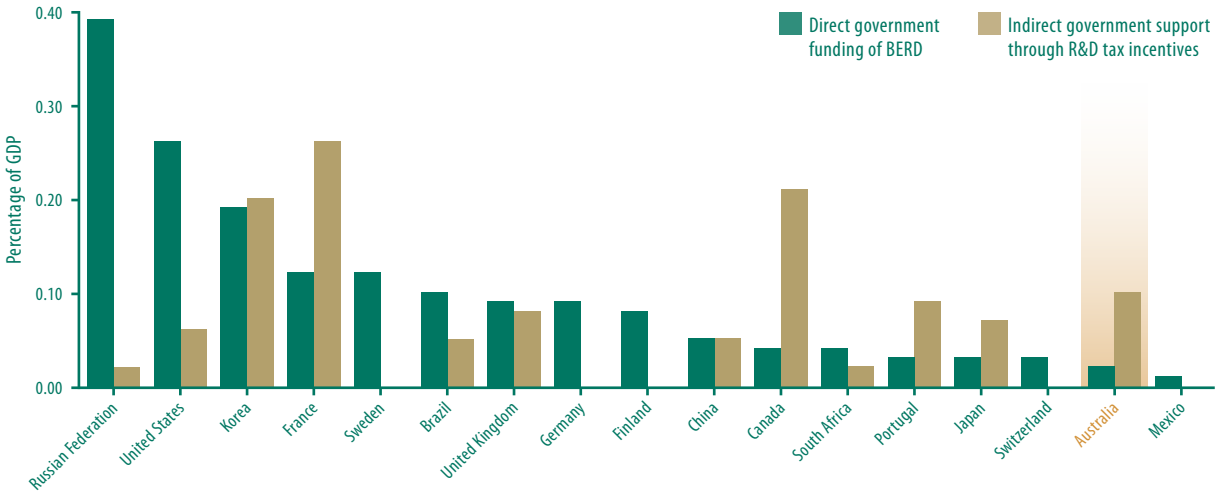
In comparison to other leading countries, direct government support for Australian business R&D is very low. By working together and adopting some of these measures, Commonwealth and State governments could build innovative capability, enhance economic growth and improve productivity. Providing appropriate assistance to Australian SMEs will enable them to grow into globally competitive multi-national enterprises (MNEs). MNEs play an important role in supporting a strong, innovative and diversified industry base.

Venture capital investments as a percentage of GDP 2012 (US$ current prices)



Source: OECD 2013b.

Direct government investment in business R&D and tax incentives for R&D, 2011



Source: Adapted from OECD 2013c, p. 106.

Effective collaboration is critical to improve Australian innovation and research impact

Collaboration between firms and researchers can increase innovation in many ways. Examples include promoting awareness of innovative opportunities as well as facilitating the adoption of new technologies, approaches and ideas. Collaboration has significant benefits for boosting business competitiveness and enhancing the impact of publicly funded research.

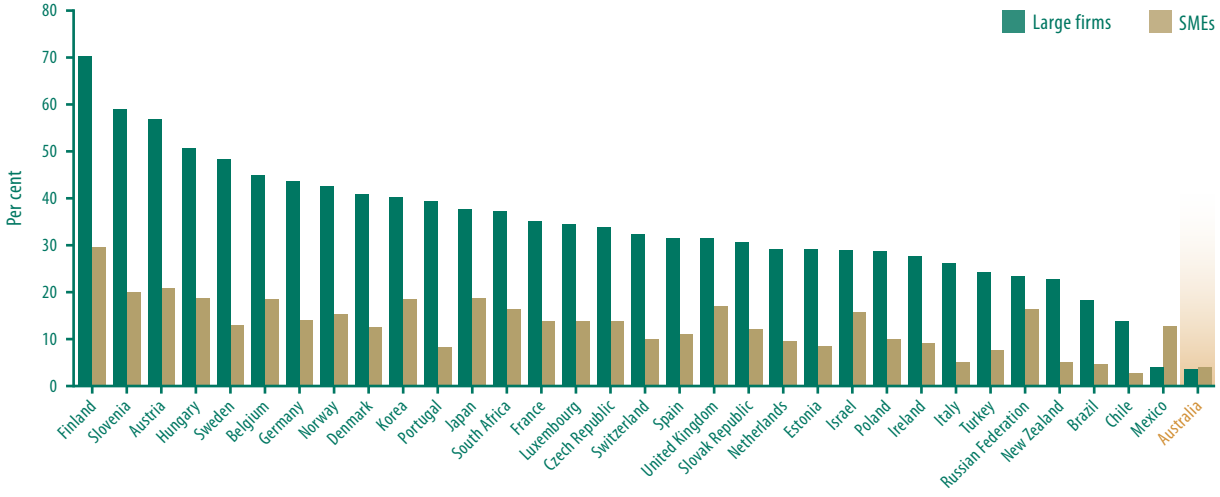
There are many forms of collaboration. It can occur through strategic alliances, joint ventures and R&D consortia. Collaboration can occur both nationally and internationally, in vertical arrangements within supply or value chains, and in horizontal structures involving parties engaged in similar activities. Collaboration between businesses (both SMEs and large firms) and publicly funded research organisations is an important driver of innovation and the translation of research into economic and social benefits. International scientific collaboration is increasingly necessary to address global challenges.

Collaboration can provide businesses, particularly SMEs, with opportunities to boost their productivity. Because we cannot be leaders in many technologies, Australian businesses must be early adopters of innovations developed elsewhere. International collaboration can help businesses to access new markets and networks. Through collaboration, firms can mobilise additional resources and access expertise needed to tackle complex issues and projects. This facilitates learning, capability development and an ability to deal with risk and uncertainty. The capacity to attract collaborators and work effectively with them is central to the ability of organisations to create, capture, and deliver value, and hence their continuing survival and development.

The key drivers of innovation are firm size, formalised planning and investment in employee skills, especially managerial. Putting this another way: well-managed firms are more innovative. A study commissioned for this project highlighted the existence of a number of virtuous cycles between productivity, internationalisation and innovation. It demonstrated that there is a cyclical relationship between innovation and collaboration where collaboration improves the innovativeness of firms and innovation also supports further collaboration.

Despite the many recognised benefits of collaboration, evidence suggests that Australian businesses collaborate less than their OECD counterparts. This is the case for both national and international collaboration. Australia has not made effective use of collaboration between businesses and publicly funded research organisations to build innovative capability.

Firms collaborating on innovation with higher education or public research institutions



Note: By firm size, 2008-10, as a percentage of product and/or process innovative firms in each size category.

Source: OECD 2013c, p. 127.

The low levels of networking and collaboration remain a significant shortcoming in the Australian innovation system, which is a problem for Australia because so much of our research effort takes place in the public sector.

There are fundamental systemic barriers to collaboration between businesses and research organisations. For example, there are: some barriers (e.g. Excellence in Research Australia); few incentives for researchers to collaborate with business; financial barriers for SMEs to becoming involved in collaboration; mismatches in the timing horizons of potential partners; low levels of technically-skilled employees in Australian firms to interact with public sector researchers; and a paucity of collaborative management skills. The level of government support in Australia for international collaboration is declining at a time when its significance is increasing.

There are opportunities to learn from good practice approaches to improve collaboration. Evidence from both Australia and overseas suggests there is value in utilising procurement policies and innovation intermediaries of various types. With the right incentives research organisations, especially universities, could become more strategic in developing partnerships and more effective in their incentivisation and management.

Broadening the criteria by which government evaluates research organisation collaboration performance would more accurately capture the breadth of their engagement activities. Greater dividends from collaboration, and making better use of public investment in research, would improve innovation, research management and productivity in Australia.

Australia needs an innovative workforce

An innovation-capable workforce is critical to the goal of increasing productivity. There has been a shift in developed economies towards greater requirements for business acumen and interpersonal skills, driving increased levels of education. Many of the fastest growing occupations and emerging industries require STEM skills and knowledge, as well as general business skills.

Urgent efforts are needed to improve language, literacy and numeracy skills. This will enable the skill deepening and increased participation that the Australian economy needs. The Australian Workforce and Productivity Agency's 2013 National Workforce Development Strategy provides a roadmap to develop Australia as a knowledge intensive economy, supporting productivity growth through cutting-edge innovation. Increasing participation will require greater participation in tertiary education from less advantaged sectors of the population.

Innovation involves more than technical skills. It also needs people who understand systems, cultures and the way society uses and adopts new ideas. Much has been made of the importance of having people in knowledge-based enterprises who have both depth and breadth. Innovation needs depth of disciplinary and/or technological expertise. However, this expertise needs to be allied with the ability to effectively and efficiently integrate various knowledge bases and skill sets and deploy skills such as team building and emotional intelligence. Social sciences and the humanities make a significant contribution to innovation and productivity improvement.

Another way to understand the importance of this combination of depth and breadth is by seeing it as the intersection of science, technology, engineering and mathematics (STEM) and humanities, arts and social sciences (HASS) disciplinary inputs in knowledge-based firms.

Innovation management is becoming increasingly important to enable firms to adapt to new challenges. The quality of business management is critical. The concept of management, and particularly innovation management, covers a wide area incorporating governance, leadership, culture, finance, skills and strategy, new product and service developments and intellectual property management. Some, but not all, of these require or benefit from formal STEM education. However, evidence suggests that Australia's business management performance is well behind the leading countries.

Business management in Australian firms falls well short of best-practice. Given the importance of business management for business growth and competitiveness, lifting business management performance in Australia is an important objective for government, business and industry organisations.

Entrepreneurial skills are needed to encourage and enable graduates to set up new business enterprises, particularly those with strong technical backgrounds. This could be facilitated by entrepreneurial training at secondary and tertiary education stages.

There is a positive association between investment in training and firm performance. This is particularly so where training forms part of a business or wider human resource management strategy. Effective workplace training is also an important aspect of a firm's response to potential skills shortages.

Research and innovation make important contributions to productivity and economic growth

There is widespread agreement in the literature that research and innovation are major driving forces behind long-term productivity and economic growth. However, productivity has a number of components that are difficult to measure. This makes analysis a more complex task. Some of the commentary in the media on single-year multifactor productivity figures is superficial.

Australia's productivity grew during the mid-1990s as a result of the adoption of ICT and microeconomic reform. Since that time, productivity growth has declined. Sources of productivity growth include: changes in the quality and quantity of labour and other inputs; diffusion of ideas; technological improvements; sources of new knowledge; changes in efficiency; changes in the functioning of markets; returns to scale; and changes in incentives.

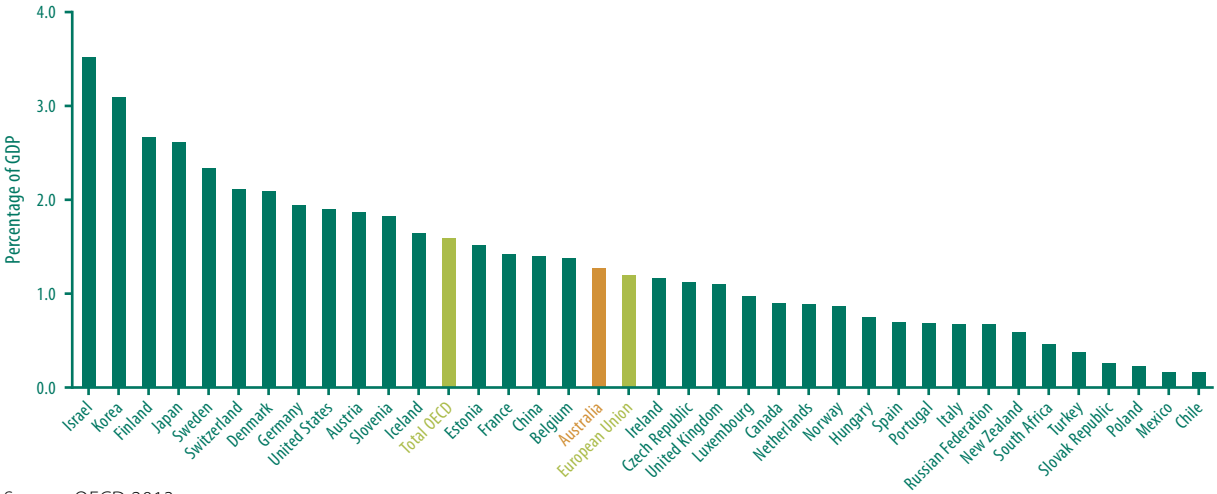
There is a wide dispersion in the productivity performance of Australia's 'market sectors'. Overall, multi-factor productivity for these sectors has grown by 16 per cent in the period 1989-90 to 2012-13. However, mining was 35 per cent less productive in 2012-13 than in 1989-90, largely explained by extensive capital investment without a corresponding increase in output. On the other hand the agriculture, forestry and fishing sector improved its productivity by 72 per cent over the same period, partly due to investment in research and uptake of new technology.

While there are many possible influences on productivity, the literature shows that innovation makes an important contribution to increasing productivity. Productivity benefits from research and successful innovations are not fully absorbed by the innovating organisations or firms, but rather they diffuse through the rest of the economy leading to positive externalities in growth and the productivity performance of the other users. Spill-over benefits occur when the benefits flow to parties other than those involved in the research, such as the users of new products derived from the research.

OECD work has found that a one per cent increase in business research and development (R&D) could be expected to generate a long run increase in productivity of 0.11 per cent and a similar increase in public research would increase productivity by 0.28 per cent. R&D is a major contributor to knowledge capital and an important element of innovation. There is a broad range of other business sector knowledge capital and other intangible assets that can significantly affect productivity. Examples include product design, market development and organisational capability.

Increasing levels of R&D in the medium-term to at least the OECD average would be an appropriate immediate policy objective. Australia's gross expenditure on R&D (GERD) has been growing in recent years and is starting to approach the OECD average. Australian business expenditure on R&D (BERD) has also been approaching the OECD average, however, it still lags well behind leading OECD counties.

BERD as a percentage of GDP, 2011



Source: OECD 2013c.

Research undertaken for this project suggests that direct public sector R&D expenditure by government research agencies, the Australian Research Council and the universities has strong spill-over benefits with positive impacts on productivity. Public support for R&D has a number of channels, both direct and indirect. A study undertaken for this project has shown Australian evidence of this for the first time, consistent with international findings.

While Australia's system of National Accounts has capitalised some intangibles (computer software, artistic originals, mineral exploration and, more recently, R&D), some other countries are yet to adopt this approach, making it difficult to compare productivity performance between countries.

There is an urgent need for action

This report finds that there is an urgent need for Australia to increase innovation to lift productivity and build future industries. Time is not on our side. In the past ten years, other countries have moved ahead of us. Addressing the findings of this report will help to reposition Australia as a competitive economy based on a highly productive innovation system.

Key findings

Chapter 2: Building Australia's future manufacturing industries

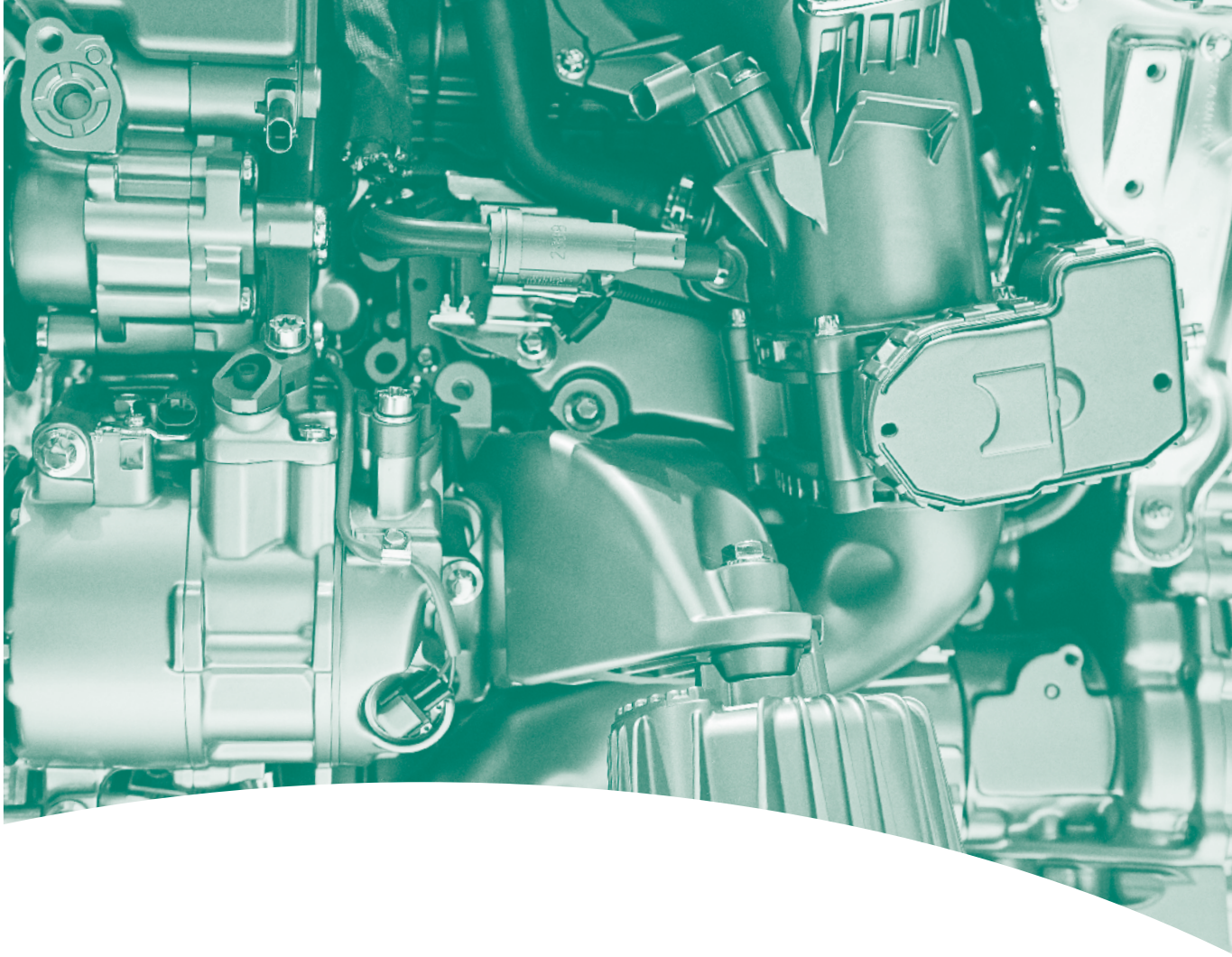
2.1 Some areas of Australia's innovation system are underperforming. These need urgent attention if Australia is to avoid being left behind international competitors.

2.2 The future of much of Australian manufacturing in many areas depends on enhanced interconnection with services.

2.3 Advanced manufacturing has been recognised by leading OECD countries as an important source of economic growth and quality jobs. Australia needs to build on existing initiatives such as the Advanced Manufacturing CRC and expand its efforts in this area.

2.4 Businesses find continual change to government assistance programs confusing. More stability is needed and unnecessary changes should be avoided.

2.5 New approaches to promoting the creation and growth of new firms, including small business 'set-asides', crowd-sourced equity funding and support for innovation intermediaries, are worthy of serious consideration.



2.6 Australian firms need to adopt better management practices, improve their access to information on business opportunities and develop greater agility in order to be internationally competitive and, where appropriate, early adopters of new technologies.

2.7 Difficulties in raising capital continue to be a major barrier to firm growth. New measures are needed to assist start-ups, such as crowd funding, tax concessions for investors in start-up companies and reform of the tax treatment of employee share options.

2.8 SBIR-type procurement schemes, used successfully in many OECD countries and in place in Victoria and South Australia, could be adopted by the Commonwealth Government.

2.9 High-speed broadband communications are a vital element of industry competitiveness in the 21st Century. Australia needs to catch up to the leading OECD countries in this regard.

Chapter 3: Effective collaboration to improve Australian innovation and impact

3.1 Collaboration plays an important role in innovation, but is under-recognised by government. The level of Australian collaboration, both nationally and internationally, is low by OECD standards. This limits our ability to capitalise on research investments and access knowledge from overseas.

3.2 Current measures to encourage collaboration between firms and researchers are inadequate. New approaches are needed. Examples of successful measures used in other countries include:

- Enhanced incentives and rewards, and removal of disincentives for public sector researchers to engage with business;
- Additional funding for collaborative activities, including voucher schemes to encourage SMEs to collaborate with research organisations; and increased funding for the Researchers in Business Program;
- Encouragement of dynamic clusters integrating small and large firms, research organisations and government.

3.3 Innovation intermediary organisations operating outside government but with government support are an effective way of assisting SMEs to develop collaboration with other businesses and with research organisations.

3.4 Australia should take a strategic approach to research collaboration with other countries, supporting activity in areas of mutual interest, particularly with those countries with which Australia has science and technology agreements.

Chapter 4: An innovative workforce to meet Australia's future needs

4.1 Long-term market demand for STEM skills is difficult to predict — many of today's STEM jobs did not exist a decade ago, as illustrated by the convergence between the life sciences, physical sciences and engineering.

4.2 The best way to ensure that supply meets demand is to improve the quality and currency of information available to students when they make career choices and throughout their education. By preparing students for life-long learning, the education system will help to meet evolving workforce needs. Government has an important role to play in this regard.

4.3 Productivity improvements driven by innovation rely on a mix of STEM and HASS skills, together with an understanding of innovation systems.

4.4 Government, universities and industry organisations should work together to improve entrepreneurship and business management skills, including the ability to manage innovation.

4.5 STEM training needs to encourage entrepreneurship and the development of management skills both at university and VET levels. Education providers need to engage with business to gain a better understanding of trends in STEM skill needs.

4.6 Providing work experience for university students as part of their training is a way of increasing the awareness of the benefits of STEM skills on the part of employers. Programs such as Researchers in Business are also valuable in this regard.

Chapter 5: The contribution of innovation to productivity and economic growth

5.1 There is strong evidence that research, science and technology contribute positively to productivity.

5.2 Measuring research and innovation by focusing only on those assets which are currently capitalised in the System of National Accounts distorts analysis of growth in capital services and consequently, productivity. Different countries have capitalised intangibles to different degrees, making international comparisons difficult.

5.3 Private sector knowledge capital is a source of positive benefits (spill-overs) to productivity. This implies that innovative activity has broad benefits that diffuse throughout the economy.

5.4 Public sector R&D expenditure by Australian government research agencies, the Australian Research Council and the universities has strong spill-over benefits and is an important source of gains in productivity.

5.5 Increasing levels of R&D in the medium-term to at least the OECD average would be an appropriate policy objective.

5.6 More comprehensive and better-linked databases are needed to inform science, research and innovation policy analysis in Australia. There is also a case for the establishment of sustained, independent research effort in this area.

About Securing Australia's Future

In June 2012 the Australian Government announced Securing Australia's Future, a $10 million investment funded by the Australia Research Council in a series of strategic research projects for the Prime Ministers Science, Engineering and Innovation Council (PMSEIC), delivered through the Australian Council of Learned Academies (ACOLA) via the Office of the Chief Scientist and the Chief Scientist.

Securing Australia's Future is a response to global and national changes and the opportunities and challenges of an economy in transition. Productivity and economic growth will result from: an increased understanding in how to best stimulate and support creativity, innovation and adaptability; an education system that values the pursuit of knowledge across all domains, including science, technology, engineering and mathematics; and an increased willingness to support change through effective risk management.

PMSEIC identified six initial research topics:

i. Australia's comparative advantage

ii. STEM: Country comparisons

iii. Asia literacy – language and beyond

iv. The role of science, research and technology in lifting Australian productivity

v. New technologies and their role in our security, cultural, democratic, social and economic systems

vi. Engineering energy: unconventional gas production

The Program Steering Committee responsible for the overall quality of the program, including selection of the Expert Working Groups and the peer review process, is comprised of three Fellows from each of the four Learned Academies:

Professor Michael Barber FAA FTSE (Chair)

Mr Dennis Trewin AO FASSA (Deputy Chair – Research)

Professor James Angus AO FAA

Professor Bruce Chapman AO FASSA

Professor Ruth Fincher FASSA

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