SECURING AUSTRALIA'S FUTURE

Securing Australia's Future Program: Summary Report

12

PROJECT

AUSTRALIAN ACADEMY OF THE HUMANITIES

AUSTRALIAN ACADEMY OF SCIENCE

ACADEMY OF THE SOCIAL SCIENCES IN AUSTRALIA

AUSTRALIAN ACADEMY OF TECHNOLOGY AND ENGINEERING

ACOLA

AUSTRALIAN COUNCIL OF LEARNED ACADEMIES

SECURING AUSTRALIA'S FUTURE

Funded by the Australian Research Council and conducted by the four Learned Academies through the Australian Council of Learned Academies for the Australian Chief Scientist and the Commonwealth Science Council. Securing Australia's Future delivers evidence-based research and interdisciplinary findings to support policy development in areas of importance to Australia's future.

This report was produced by the ACOLA Secretariat Ltd, with project management and additional content provided by Andy Jones.

The SAF report summaries reproduced in this report, not including SAF13, were prepared by Simon Torok and Paul Holper, the authors of a book about the Securing Australia's Future Program, due for publication by CSIRO Publishing in May 2017.

The SAF13 summary is a reproduction of the Executive Summary from the SAF 13 report.

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Securing Australia's Future Program: Summary Report

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 Technology 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 ~500 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

Working Together—ACOLA

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 Technology 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 Technology 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 Education and Training.

www.acola.org.au

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Introduction

About ACOLA

The Australian Council of Learned Academies (ACOLA) provides a forum for evidence-based interdisciplinary research to inform national policy. It combines the strengths of the four Australian Learned Academies: Australian Academy of the Humanities, Australian Academy of Science, Academy of the Social Sciences in Australia, and Australian Academy of Technology and Engineering.

Bringing together more than 2,000 of the nation's most eminent researchers, scholars and practitioners, ACOLA is the nexus of true interdisciplinary cooperation and cutting edge thinking to help solve complex societal issues for the benefit of Australia's social, cultural, economic and environmental wellbeing.

Established in 2010, ACOLA is the successor to the National Academies Forum (established in 1995) and comprises a Council, Board and Secretariat. ACOLA Secretariat is an independent, not-for-profit incorporated entity that receives Australian Government funding from the Australian Research Council and the Department of Education.

Securing Australia's Future

In June 2012 the Australian Government announced the Securing Australia's Future Program (SAF), a $10 million investment in a series of strategic research projects delivered to the Chief Scientist of Australia and the Commonwealth Science Council (prior to October 2014, the Prime Minister's Science, Engineering and Innovation Council).

Funded by the Australian Research Council, under the auspices of the Office of the Chief Scientist of Australia and coordinated by ACOLA, the SAF Program was a response to global and national trends, and the opportunities and challenges facing an economy in transition.

The SAF Program was uniquely positioned, relative to other policy research organisations and programs, to provide ongoing support for public policy development by virtue of its:

- Truly interdisciplinary approach essential in addressing complex policy issues
- Access to Australia's leading experts, scholars and practitioners, particularly Fellows of the Learned Academies
- Ability to efficiently mobilise and leverage diverse and qualified expert investigation panels
- Established relationships with public policy makers and influencers
- Assurance of quality and independence via the development of balanced and peer-reviewed findings.

Six initial research topics were identified:

- Australia's comparative advantage
- STEM: Country comparisons
- Smart engagement with Asia: Leveraging language, research and culture
- The role of science, research and technology in lifting Australian productivity
- New technologies and their role in our security, cultural, democratic, social and economic systems
- Engineering energy: unconventional gas production

In 2014 two new research topics commenced:

- Australia's agricultural future
- Sustainable urban mobility

In 2015 three new research topics commenced:

- Translating research for economic and social benefit: country comparisons
- Skills and capabilities for Australian enterprise innovation
- Australia's Diaspora Advantage: Realising the potential for building transnational business networks with Asia

In addition to these eleven research projects, in 2015 the Minister of Education and Training commissioned a 'Review of the Australian Research Training System' (SAF13) and a 'Synthesis and Review' of the SAF Program (SAF12), of which this report is a component, also commenced.

…the SAF [Program]'s unique contribution to national policy-making is the interdisciplinary nature of the enterprise. The ability to mobilize first-rate expertise across the science, engineering, social science and humanities communities is quite extraordinary. Indeed, there is no comparable effort outside Australia that has been able to sustain such an integrated structure beyond a one-off study.

Dr Richard Bissell
Executive Director, Public Policy & Global Affairs
The National Academies, Washington

SAF Program governance

A Program Steering Committee (PSC), consisting of three Fellows from each of the Learned Academies, was established to oversee the Program, with responsibility for the overall quality of the SAF Program including project scoping, establishment of Expert Working Groups and the peer review process.

Expert Working Groups, consisting of approximately five to eight Academy Fellows and expert non-Fellows, were responsible for developing and implementing the project methodology, including conducting research and analysis and/or managing research consultants, responding to peer reviewer and PSC feedback, and drafting the final report.

The ACOLA Secretariat was responsible for the final delivery of project reports to the Office of the Chief Scientist and for publishing and publicly launching project reports. ACOLA Secretariat was also responsible for establishing and maintaining governance processes and for acquitting the program funding in accordance with ARC requirements.

The distinctive feature of the SAF Program has been to draw upon the collective expertise of all four academies to deliver evidence-based findings to support policy development, the intent being to deliver those findings within a wider understanding of the relevant societal, cultural and political context.

Professor Michael Barber FAA FTSE
Chair, SAF Program Steering Committee

Acknowledgements

ACOLA wishes to acknowledge and thank the following for their support and contribution to the success of the SAF Program:

- The Australian Research Council for its funding
- The Office of the Chief Scientist and particularly the former Australian Chief Scientist, Professor Ian Chubb AC, FTSE for his initial concept and, support through the program
- The 12 Fellows who chaired or co-chaired the 11 EWGs and without whose active leaderships no reports would have been completed
- The pro-bono contributions of the 75 Fellows and non-Fellows who served on the EWGs
- The experts, not all Fellows and not all Australians, who peer reviewed the reports, often with considerable insight
- The Academies for their project management
- The ACOLA Secretariat.

About this report

This report, SAF12, provides summaries of the SAF01 to SAF11 and SAF13 reports. The summaries, excluding SAF13, were prepared by Simon Torok and Paul Holper and will appear as appendices in their yet to be titled book about the SAF Program, due for publication by CSIRO Publishing in 2017. SAF13 is reproduced directly from the Executive Summary of SAF13, which will also appear as an appendix in the book.

Engagement and impact

The Securing Australia's Future (SAF) Program has been successful in achieving its objective of providing findings from evidenced-based interdisciplinary research to support public policy development on multiple occasions. The Office of the Chief Scientist presented policy recommendations, based on the findings from two SAF reports, to the Prime Minister's Science, Engineering and Innovation Council (now the Commonwealth Science Council) and is currently developing recommendations based on the findings of all other SAF reports for the Commonwealth Science Council.

Other examples of the SAF Program's support for public policy development include:

- Report findings underpinned the development of the Chief Scientist's position paper Science, Technology, Engineering and Mathematics in the National Interest: A Strategic Approach (2013)
- Influence on the development of the National STEM School Education Strategy (2015) and the Vision for a Science Nation Consultation Paper (2015)
- Substantial influence on the development of a benchmark approach to unconventional gas extraction and development policies at Federal and State/Territory level (2014)
- Substantive input to the development of Boosting the Commercial Returns from Research (2015) and the Industry Innovation and Competitiveness Agenda (2014)
- Report findings incorporated in the National Innovation and Science Agenda (2015), the Watt Review of Research Policy and Funding Arrangements (2015) and the Research Block Grant Consultation Paper (2016)
- References in the Australian Infrastructure Plan: Priorities and reforms for our nation's future (2016)
- Influence on the development of the Department of Foreign Affairs and Trade's Public Diplomacy Strategy 2014–2016 (2014)
- Report findings incorporated in the CEDA report *Australia's economic future: an agenda for growth* (2016).

Policy makers' receptiveness to SAF project findings was likely influenced by the alignment between SAF report scopes and identified areas of policy need, particularly where policy makers were involved in the commissioning and/or scoping of projects. Furthermore, the pre-existing networks and relationships of SAF Program participants, combined with their reputation and credibility as experts in their fields, was shown to have contributed to these outcomes.

Notwithstanding this, the SAF Program's success, as evidenced above, also reflects the deliberate efforts of SAF Program participants to scope and deliver projects capable of supporting public policy development and also ACOLA's unique ability to leverage the networks and expertise of the four Learned Academies. Moreover, SAF project Expert Working Groups demonstrated agility in responding to the demands for timely public policy development support.

On behalf of the State Government of Western Australia I would like to congratulate both ATSE and ACOLA on the thoroughness and quality of the Report. The State Government was pleased that the Department of Mines and Petroleum was able to contribute to the technical discussions that formed part of the report generation process.

The Hon Colin Barnett MLA
Premier

The success of the SAF Program is underpinned by extensive targeted stakeholder engagement activities, including stakeholder forums to inform the development of SAF project reports, targeted briefings on the findings of SAF reports and panel discussions at key industry events and conferences.

Broad stakeholder interest in SAF reports, and their relevance to public policy development is demonstrated by the SAF project engagement activities undertaken directly in response to requests from influential stakeholders, including:

- The Knowledge Nation Summit (2016)
- The Financial Review inaugural Innovation Summit (2016)
- The Business Council of Australia (2015)
- The Department of Foreign Affairs and Trade (2015)
- The Victorian Auditor General's Office (2015)
- The Victorian Essential Services Commission (2015)
- *China in the World from the Maritime Perspective: The First International Conference of the Silk Road* Prof Louie convened by the Asia-Pacific Research Cluster for Chinese Entrepreneurial Studies, The University of Queensland (2015)
- The *Race, Identity and Advocacy* conference convened by the Asian Australian Alliance (2016).

In addition, SAF projects were cited in policy-related publications including:

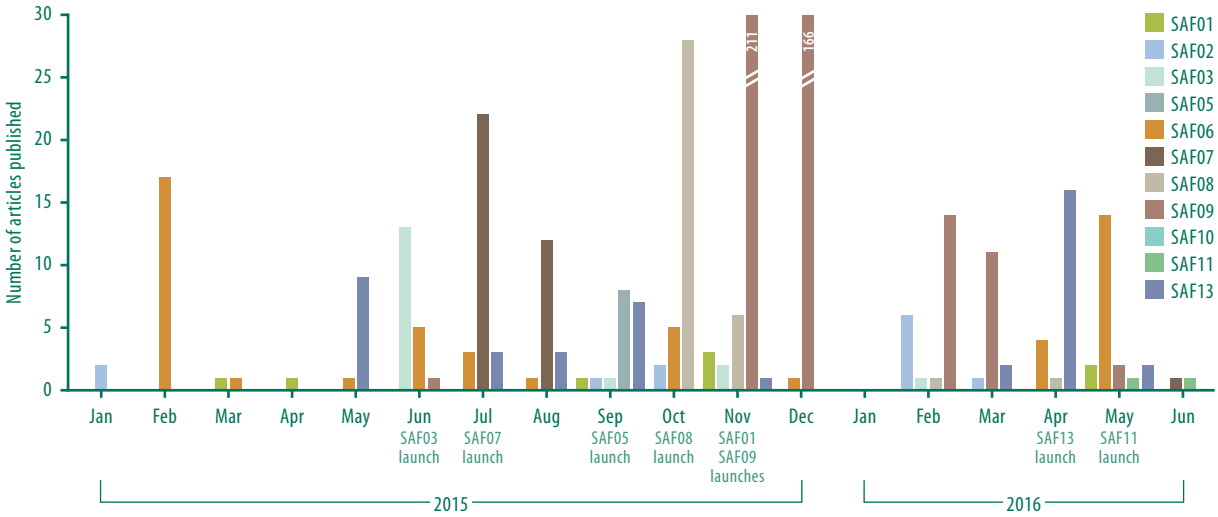
- *Two Futures: Australia at a Critical Moment* (Text Publishing, 2015) by Tim Watts, Federal Member for Gellibrand and Claire O'Neil, Federal Member for Hotham
- *The Fusion Effect: The Economic Returns from Combining Arts and Science Skills* (2016), published by Nesta (an organisation based in the UK, which promotes innovation for public good <www.nesta.org.uk>).

Table 1. Summary of launch events for all SAF projects

Project	Report title	EWG Chair(s)	Project management services provider	
SAF01	*Australia's Comparative Advantage*	Prof Glenn Withers AO FASSA	ASSA	
SAF02	*STEM: Country Comparisons*	Prof Simon Marginson FASSA	ACOLA Secretariat	
SAF03	*Smart engagement with Asia: Leveraging language, research and culture*	Prof Ien Ang FAHA	AAH	
SAF04	*The role of science, research and technology in lifting Australian productivity*	Dr John Bell FTSE	ATSE	
SAF05	*Technology and Australia's Future: New technologies and their role in our security, cultural, democratic, social and economic systems*	Prof Rob Evans FAA FTSE & Prof Bob Williamson FAA (Co-Chairs)	AAS	
SAF06	*Engineering Energy: Unconventional Gas Production*	Prof Peter Cook CBE FTSE	ATSE	
SAF07	*Australia's Agricultural Future*	Dr Joanne Daly FTSE	ATSE	
SAF08	*Delivering Sustainable Urban Mobility*	Dr Bruce Godfrey FTSE	ACOLA Secretariat	
SAF09	*Translating research for economic and social benefit: country comparisons*	Dr John Bell FTSE	ATSE	
SAF10	*Capabilities for Australian enterprise innovation*	Prof Stuart Cunningham AM FAHA	AAH	
SAF11	*Business diasporas in Australia: maximising people to people links with Asia*	Prof Kam Louie FAHA & Prof Fazal Rizvi FASSA (Co-Chairs)	AAH	
SAF13	*Review of Australia's Research Training System*	Mr John McGagh FTSE	ATSE & AAS	

The various stakeholder engagement activities undertaken by SAF Program participants were supported by project-specific launch and communication plans intended to raise awareness of the project findings. The implementation of these plans resulted in extensive exposure in local and national media and, in some instances, local foreign language media and international media. The occurrence of print and online media articles during the period when the majority of SAF reports were launched, from the start of 2015 until mid-June 2016, is shown in Figure 1. Table 1 provides a summary of the launch events for all SAF projects.

Figure 1: The number of online and print media articles published about SAF reports from 2015 to June 2016



Note: The data presented in this graph represents primarily print and online media. It was sourced from a third party and all attempts have been made to ensure its accuracy, however it may be an under-representation.

Duration (months)	Launch		
	Date	Venue/event	Keynote
27	16/11/15	ASSA Symposium, University House, ANU	John Hewson AM
5.5	05/06/13	Parliament House	Prof Ian Chubb AC FTSE Chief Scientist of Australia
27	05/06/15	Footscray Community Arts Centre	Prof Ian Chubb AC FTSE Chief Scientist of Australia
24	03/06/14	National Press Club	Dr John Bell FTSE
29	23/09/15	The Shine Dome	Prof Ian Chubb AC FTSE Chief Scientist of Australia
5	05/06/13	Parliament House	Prof Ian Chubb AC FTSE Chief Scientist of Australia
12	27/07/15	CSIRO Discovery Centre	Prof Ian Chubb AC FTSE Chief Scientist of Australia
14	07/10/15	National Portrait Gallery	Hon Jamie Briggs, MP, Minister for Cities and the Built Environment
10.5	27/11/15	Parliament House	Prof Ian Chubb AC FTSE Chief Scientist of Australia
12.5	TBC	TBC	TBC
11.5	26/05/16	National Library foyer	Dr Alan Finkel AO FTSE Chief Scientist of Australia
10	14/04/16	Knowledge Nation Summit, Sydney	Minister for Education and Training, Senator the Hon Simon Birmingham

1 Australia's comparative advantage

Introduction

Establishing proper policy foundations now, combined with public support and effective leadership, will better place Australia on a trajectory for national well-being. While change is challenging, the benefits of systematic reform and investment in our future to build Australia's comparative advantage will mean higher living standards, increased equity and greater sustainability.

A reform package entailing institutional change and investment could add more than 20 per cent to living standards by 2030 above trends based on current policy settings.

The interdisciplinary report, *Australia's comparative advantage*, explores how to build and secure Australia's future through comparative advantage. For the report, this means creating and taking advantage of Australia's strengths, and ensuring flexibility and resilience in the pursuit of this ambition. The report provides a national roadmap for decisions about the future and the conditions that can underpin achieving Australia's best.

Rating our performance

We perform strongly against other countries on a range of social measures. For example, Australia is an attractive place to live. Four state capitals are considered among the most liveable cities in the world. We rate as one of the highest on the UN's Human Development Index.

Conversely, a number of international assessments have found weaknesses. People believe that regulation and taxation for example, place a high burden on business, and Australia rates poorly on competitiveness against similar advanced economies.

Various rankings rate Australia as competent at basic innovation, but weaker at the next stage of developing or commercialising those ideas.

The Australian education system rates highly at the school, tertiary and vocational stages, and is particularly good at attracting foreign students. Government education expenditure, however, is parsimonious compared to our international peers, especially in pre-school and post-school education.

Australia does well on environmental measures such as health impacts (child mortality), water and sanitation, water resources and air quality. We rank well or reasonably well on key aspects of ecosystem health such as forestry and water resources. However, we rank more poorly on biodiversity and habitat, agriculture, fisheries, climate and energy environmental measures.

Respondents to surveys for the project by the Committee for Economic Development of Australia and the Institute of Public Administration of Australia rated the ability of various industries to innovate. Highly rated were arts and recreation services, retail trade, transport, postal service and warehousing. Rating low on innovation capability were public administration and safety, and electricity, gas, water and waste services.

There are perceived problems with leadership in industry and government, though research for the study found that we rate ourselves less highly than do overseas executives who know Australia. There is value in government and the public service improving their awareness of global and other country directions.

Sector performance and opportunities

The services sector dominates the economy. In 2013, it accounted for close to 60 per cent of Australia's GDP and for 78 per cent of employment. Education (post school), health and financial services have the potential to drive productivity growth in all other sectors. The economic rise of Asia provides a significant opportunity for Australia to increase its net trade in the service sectors.

Agriculture is one of Australia's oldest and most important sectors, yet its relative contribution to the Australian economy has steadily declined over the past century. The decline is due in part to a long-term reduction in agricultural terms of trade and an increase in global agricultural production, but also to structural and systemic factors. The ACIL Allen report for this project identified three main ways in which Australia could expand its supply capacity: farming new areas of land; moving from low input, low production systems into high input, high production systems; and producing more from less by increasing water-use efficiency or employing innovation-based productivity.

Although the mining industry has been a leading contributor to Australia's economic growth and international impact, we do now need to adjust to reduced future reliance on mining. However, proactive policies would allow the sector to move into higher value-added downstream activities and to create value through collaboration with non-mining sectors such as manufacturing and services.

The manufacturing sector itself still plays an important role in our economy but its contribution to GDP has declined. Australia has a growing advanced manufacturing sector, which is poised to build on Australia's comparative advantages and increase its contribution to economic growth and global trade. The focus now should be on collaboration to develop an innovative workforce, and improving entrepreneurship and business management skills, especially in the formerly protected non-traded sectors.

Institutions, investment and society

The long period of sustained income, employment growth and economic resilience in recent decades has been much underpinned by a process of micro-economic reform that began in the 1980s and continued into the current century. Reform entailed substantial review of legislation, regulation and public finances to free up market operations and make the role of government more market-consistent.

Australia has an experienced, educated, and highly skilled population. Maintaining and enhancing strength across educational skills should be a major national priority. Investment in education and in skills training is a core principle for building comparative advantage; it is also a key to addressing issues of equity such as indigenous disadvantage and inter-generational poverty.

The rise of Asia is the biggest economic trend of the 21st century. This presents great opportunities for Australia; modelling shows that in addition to resources-related business, Asia could contribute an additional $275 billion to the Australian economy over the next 10 years. A vibrant immigration program can help underpin this and provide wider benefit, as it did in helping Australia weather the GFC better than most countries.

Lack of access to adequate finance is a major contributor to poor innovation outcomes in Australia, and may even be the biggest impediment to innovation in Australian firms, over 90 per cent of which are classed as small-to medium enterprises.

Policy directions

Change is difficult for government and society. However, change becomes easier to implement if the benefits can be shown both for the economy and for people's wider prospects and living standards.

Broad policy change and reform as well as increases in investment for the future would have real sustained benefits for the economy and society. They can stimulate private initiative and underpin all of the industry sectors that are crucial to Australia's future. These will provide the foundations for future progress.

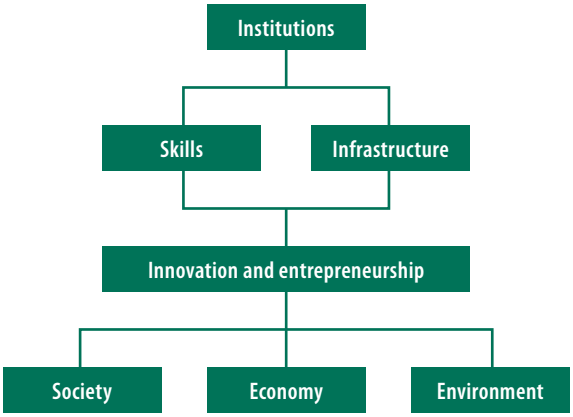
Policy reforms require support from the public. People need to be convinced that reforms are necessary and sensible. In 2015, ACOLA commissioned a public opinion study on expenditure, tax and policy reform. All age groups and most educational levels agreed on the following priority areas for increased government spending: health, schooling and tertiary education, transport and communications, social security for seniors, and public order and safety, and were willing to see appropriate tax support.

Conclusion

Building Australia's comparative advantage will require steps that include:

1. ensuring the necessary leadership and partnerships
2. maintaining and enhancing Australia's strengths, and guarding against emerging challenges that could undermine them
3. complementing past strengths with opportunities, such as globalisation, Asia links and information technology advances
4. a more effective taxation and legal system that encourages innovation and risk-taking
5. realignment by institutions, including our federation, to adapt to a changing strategic environment and 21st century imperatives
6. boosting investment in our capability to compete.

Foundation for creating advantage



Expert Working Group Members

Professor Glenn Withers AO, FASSA (Chair)
Peter Laver AM, FTSE, HonFIEAust, FAusIMM (Deputy)
Professor Graham Farquhar AO, FAA, FRS
Professor Chris Gibson
Associate Professor Sally Gras
Professor Joseph Lo Bianco AM,FAHA
Professor Rodney Maddock
Dr John Prescott AC, FTSE

2

STEM: Country comparisons

International comparisons of science, technology, engineering and mathematics (STEM) education

Introduction

STEM is a central preoccupation of policy makers across the world. A robust capacity in science, technology, engineering and mathematics (STEM) is pivotal to increasing Australia's productivity.

Governments seek to lift the overall scientific literacy of their populations and to draw most, or all, students into senior secondary school studies in STEM. For most countries, initiatives targeted at student attitudes and identity were a significant part of the strategic mix. This included initiatives to increase awareness of the nature of STEM professions.

The report, *STEM: Country comparisons (International comparisons of science, technology, engineering and mathematics (STEM) education)*, focuses on strategies, policies and programs used to enhance STEM at all levels of education and in the education/work interface. The interdisciplinary report examines solutions to the STEM skills shortage in comparable countries to determine which, if any, could be usefully applied in Australia to overcome similar shortages here.

The importance of STEM

The international push to enhance STEM is part of a broader objective to lift educational qualifications and increase the number of people capable in research, commercial innovation and responding to technological change.

Countries regard the STEM disciplines as essential for global economic positioning and social creativity. Nations with leading and dynamic economies tend to be those with the strongest performing education and/or research science systems.

Countries rarely have a shortage of STEM graduates. Periodically in Australia there is a lack of STEM graduates in disciplines such as engineering and computing. Currently there are challenges facing our research and development and innovation sectors, and there are some labour market shortages in STEM occupations, principally engineering.

Features of strong STEM countries

There are five distinguishing characteristics of countries strong in STEM:

1. School teachers are held in high esteem, are well paid and are rewarded for performance and professional development.
2. Unlike in Australia, STEM teachers are expected to be fully qualified in their discipline and to teach solely in that field.
3. The most successful countries have instituted active curriculum programs that make science and mathematics more engaging and practical.
4. Many of the successful countries have implemented innovative policies to lift STEM participation among formerly excluded groups, such as low achieving and indigenous students.

5. There are national STEM policy frameworks that support centrally driven and funded programs; world class university courses; the recruitment of foreign science talent; and partnerships that link STEM activities in schools, vocational and higher education with industry, business and the professions. Frequently, there are agencies that have been specifically created to advance the national STEM agenda.

How does Australia rate?

The 2009 study by the Program for International Student Assessment ranked Australia as equal 7th of all nations in science and equal 13th in mathematics. The 2012 study ranked Australia 16th in science and 19th in mathematics[1].

The percentage of year 12 students enrolled in higher level STEM in Australia has been declining for decades. From 1992 to 2010 the proportion of year 12 students in biology fell from 35 to 24 per cent, and in physics from 21 to 14 per cent.

There was a lesser decline in mathematics, from 77 per cent to 72 per cent, but most students were enrolled in elementary mathematics subjects. Only 10 per cent participated in advanced mathematics at year 12 level. A growing proportion of high-achieving year 12 students, particularly girls, participate in no mathematics program at all.

Australia does not have enough mathematics and science teachers. There are shortages, especially in rural and remote communities. However, a larger problem is teaching 'out of field', such as in mathematics, where teachers take classes for which they have little, or even no, university training.

Australia is relatively strong in participation in the sciences at tertiary level, but weak in mathematics and engineering. 26 per cent of PhDs awarded in 2008 were in science, with 14 per cent—a low figure by international standards—in engineering. But any growth in science and engineering has been among international students: the number of domestic students starting a PhD in Australia in science and engineering in 2010 was below the 2004 level. This was in sharp contrast with the rapid growth of STEM doctorates in many other countries.

Despite a plethora of government policies and reviews focused on education, science and innovation and the relatively recent emergence of the STEM agenda, Australia still needs to lift its performance in the foundation skills of literacy (reading and writing skills) and numeracy (arithmetic skills); in the enabling sciences (physics and chemistry); in general scientific literacy; and in mathematics.

International attitudes

Of 22 commissioned studies of educational policies and practices in relation to STEM around the world, most found that science and technology are valued by the public in the countries concerned and by parents of school students. There is a strong influence of families, and public attitudes, on STEM participation.

The negative correlation between student attitudes to STEM learning and country index of development highlights the challenge of engaging students with science-related subjects and STEM futures in Australia. That is, students in *developing* countries are more likely to say that they like school science better than most other subjects than those in *developed* countries.

1. <www.acer.edu.au/documents/PISA-2012-Report.pdf> [Published post-ACOLA report]

Conclusion

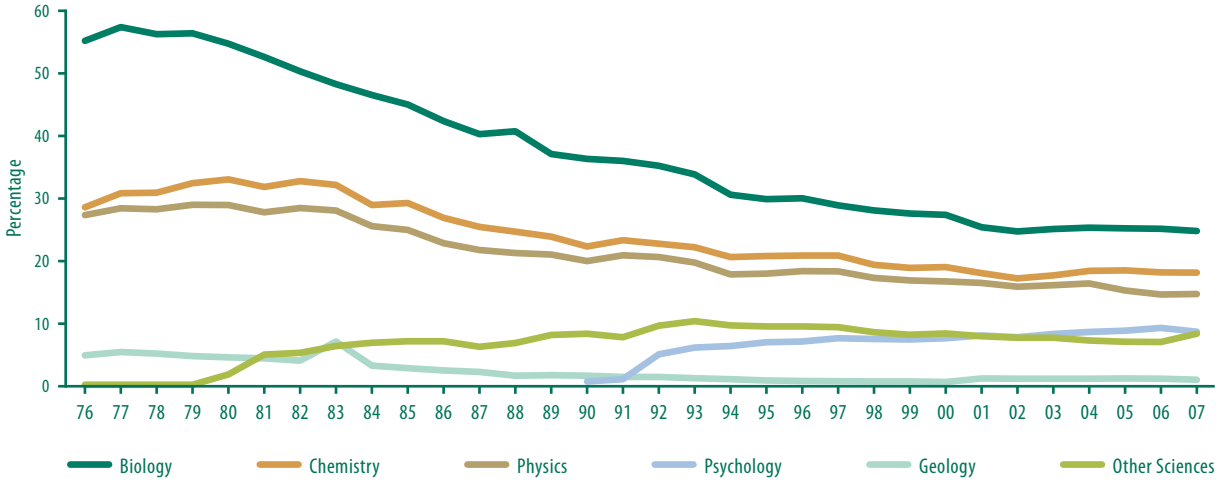
It is in Australia's interests to inspire more students to learn STEM and to enter STEM-based careers, and to have more high achieving students study science, mathematics and engineering.

Many countries have a more stringent approach to curriculum offerings than Australia, for example requiring the study of mathematics to Year 11.

In order to encourage Australian students to consider choosing STEM subjects and associated career choices:

1. Mathematics and science experiences prior to the early middle years of schooling need to be positive and engaging.
2. Students should be made aware of the range of people and activities comprising STEM work in society.
3. Mathematics should possibly be made compulsory for everyone to the end of year 11 or even year 12.
4. Effective partnerships need to be fostered between civil and business organisations and education institutions that support innovation in school mathematics and science.
5. Australia would benefit from national coordination of approaches to improving participation in STEM.

Year 12 science participation as a percentage of the year 12 cohort in Australian schools, 1976 to 2007



Source: Ainley, J, Kos, J & Nicholas, M 2008, *Participation in science, mathematics and technology in Australian education*, Research Monograph no. 63, ACER, Melbourne.

3 Smart engagement with Asia: leveraging language, research and culture

Introduction

The rise of the countries of Asia requires vision and action in Australia. In future, the Asia-Pacific region will present us with major challenges and opportunities economically, socially and culturally. Our geography opens opportunities for business and research, but what we make of them will be determined by Australia's strategy and commitment to our future in the region.

In a timely reminder of the barriers that remain to cultural understanding and economic exchange, the report, *Smart engagement with Asia: leveraging language, research and culture*, provides new insights into the complexities of our relationships in the region, and lays out a blueprint for the bridges Australia can build to improve connections between people, businesses and institutions. The report draws on the authors' expertise in social science, cultural studies, and education, and an interdisciplinary panel of scientists, engineers and social scientists.

The depth of Australia's linguistic and inter-cultural competence will be a determining factor in the future success of developments in innovation, science and technology, research capacity, international mobility, trade relations and economic competitiveness.

Interactions with a growing Asia

The rise of Asia is dominated by the influence of the giant regional powers of China and India. China is now Australia's largest trading partner, taking almost a quarter of Australia's total exports and imports in 2013.

Australian businesses need to be ready to make the most of the economic opportunities the rise of Asia presents. However, only 9 per cent of Australian businesses operate in Asia, with 12 per cent having business experience in Asia, and around 65 per cent having no intention of doing business there in the near future.

International education is one of Australia's largest export industries, contributing $16.3 billion to the economy in 2013–14. In 2013 there were 410,925 international students studying in Australia, with China contributing 29 per cent, India 8.8 per cent, South Korea 4.9 per cent, and Vietnam, Malaysia, Thailand, Indonesia and Nepal in the top ten.

Much of Australia's relationship with the diverse countries of Asia has been filtered through this rapidly growing international education industry, as well as other businesses such as tourism. In the next few decades, these areas will continue to be of enormous importance to Australia's economic development, but we need to progress from opportunism to smart engagement.

Smart engagement with Asia involves more than pursuing short-term economic benefit, and works towards nurturing wide-ranging, long-term, mutually beneficial relations. It promotes active interactions between Australians and Asians; involves businesses, community groups and others; it recognises that building sustained relationships requires long-term investment and commitment; it embraces mutuality and collaboration as key principles; and it builds on the resources and connections already represented by Asian communities in Australia and Australian communities in Asia.

Learning the language

81 per cent of Australians speak only in English at home, and interest in foreign languages remains low. Just 13 per cent of Australian Year 12 students study a language other than English.

Multilingual people have an advantage in increasingly international companies and organisations. In addition, foreign language learning has a significant positive effect on knowledge and perception of another country. Knowledge of Asian languages is also critical for deep, mutual and long-term engagement with Asia.

Therefore, continued support, incentives, and fresh approaches for learning languages and intercultural skills are essential at school, university, and the workplace if Australia's Asia capabilities are to grow.

Meanwhile, the capacity to speak more than one language is widespread in the Asian region with many Asians learning English. It is spoken by nearly 800 million people in Asia, but the level of proficiency varies across countries.

Commentators have put it this way: while not knowing English is a disadvantage, knowing only English is a disadvantage too.

Collaboration in research

The ambition of our Asian neighbours is reflected in their strategies to grow their economies through innovation. Science and research are central to their national plans. Asia is the most dynamic region in the world for research investment and output: the Asian Pacific region had the most rapid rise in share of global publications in the past 15 years. China is now the third largest producer of research articles, on course to overtake the top-ranked United States before the end of the decade.

The humanities, arts and social sciences do not seem to be a major focus of national policies in the region. Many Asian countries are focused instead on science and technology. Nevertheless, research publications in the arts and humanities are the fastest growing across the region (albeit from a low base) as these societies become more developed.

Research collaboration between countries in the region has increased strongly in the past decade. International research collaboration represents a significant mode of institutional and people-to-people connectivity between countries. When aligned with wider foreign policy goals, international research collaboration can contribute to coalition building, conflict resolution, and building trust and understanding between countries. Science diplomacy can advance our broader interests in the Asia Pacific region. Furthermore, internationally co-authored publications in science, technology, engineering and mathematics achieve higher citation rates than average.

However, while collaboration between Asian researchers has risen steeply, Australian researchers collaborate less with colleagues in Asia than in Western countries. The exception is collaboration with China, which has risen exponentially. Australia depends to a larger degree than other developed nations (including the US and the UK) on the work of Chinese diaspora researchers working in Australian research institutions for its research collaboration with China. Government support for collaboration with Asia has been lacking, and the strategic significance of international research collaboration receives little attention in Australian foreign policy.

Culture and community

Historically, Australia's cultural relationship with Asia has not been close because of major differences in history, politics and culture. Cultural diplomacy is an important tool to influence international attitudes and perceptions. However, Australian activity has not kept up with the rapid increase in cultural diplomacy activity in Asian countries over the past decade. Only long-term investment in cultural engagement may alleviate the profound sense of distance and barriers to close cultural relations.

About 8 per cent of Australia's population was born in Asia, a much higher percentage than the USA (4 per cent) or UK (2 per cent). Communities of people of Asian descent (Asian diasporas) have a role in establishing and facilitating trade, investment and commercial opportunities between Australia and their home countries, and in strengthening bilateral relationships through their informal networks. Asian diasporas also are a resource for linguistic skills, cultural knowledge and social networks, which can help connect Australia and various parts of Asia. Asian diasporas should be involved regularly as informal ambassadors focusing on entrepreneurship, innovation, philanthropy and volunteerism. These relationships exist informally but if Australia were to scale them up, all Australians would reap the benefits.

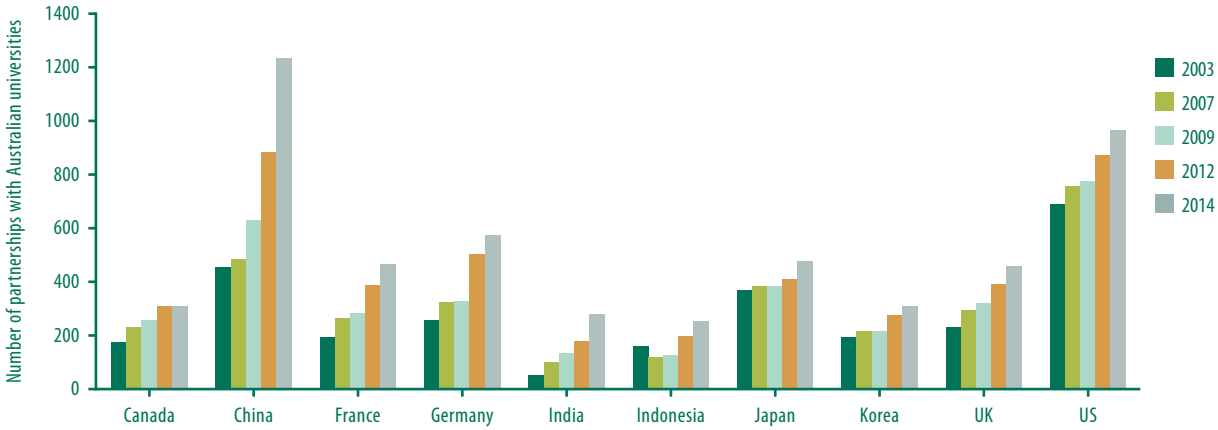
Conclusion

Australia will be left behind if it does not step up its transnational connectivity in the region. Smart engagement with Asia is a national necessity for Australia, and needs to be focused on the development of a range of sustained connections and relationships.

Priority actions include:

- encouraging greater interest and proficiency in Asian languages
- investing strategically in science and cultural diplomacy through a national framework
- using Asian communities in Australia and Australian communities in Asia to play a bridging role
- recognising and nurturing grassroot community initiatives as an essential complement to short-term missions and delegations.

The top ten countries for formal agreements between Australian and international universities (2014), which account for 62 per cent of total agreements. Five of the top ten are in Asia: China, Japan, South Korea, India and Indonesia.



Source: Universities Australia 2014, *International Links of Australian Universities: Formal agreements between Australian universities and overseas higher education institutions*, Universities Australia, Canberra, accessed February 19, 2015, from <www.universitiesaustralia.edu.au/ArticleDocuments/188/International%20Links%20of%20Australian%20Universities%20-%20October%202014.pdf.aspx>.

4

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

Introduction

Building the industries of the future through enhanced productivity will require increased investment in research and development, a commitment to innovation, better links between business and research, focused international collaboration, and the effective training and use of an innovation-capable workforce.

The report, *The role of science, research and technology in lifting Australian productivity*, identifies opportunities for applying knowledge and skills in science and research across a range of industries and sectors to enhance innovation, creativity and productivity, and recommends business practices that will drive Australia's prosperity. The report draws on the authors' expertise in government, business, science, technology, economics and communication.

The report finds that innovation—including research, science and technology—is the key to increasing productivity in the economy, by lowering the cost of production, improving the quality of goods and services or by introducing new products to the market.

Manufacturing in Australia

Manufacturing is important to Australia's economy. In 2014–15 it accounted for around 6[1] 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, the sector faces many challenges. In recent decades, manufacturing's contribution to GDP has fallen, while the contribution of the services sector has increased. The success of Australia's future manufacturing industries will depend on technological innovation, a shift to advanced manufacturing, integration with services, international connectedness and enhanced participation in global value chains.

Small and medium sized enterprises are major employers and an important source of new products and services. Such enterprises account for nearly half of Australia's private sector employment. Improvements in productivity will largely depend on the collective performance of many individual firms.

Australian firms need to increase their research and development to position themselves in new, high-technology, niche industries. They should become better linked with global value chains, which provide the ability to share knowledge, processes and skills, and can initiate longer term collaborations.

The sector offers good opportunities for those with STEM qualifications and a mix of technical and commercial know-how and problem solving skills. Further advances in technology will require highly skilled workers in all parts of the development-to-market process, particularly within high-value added manufacturing.

Businesses find continual change to government assistance programs confusing. More stability is needed and unnecessary changes should be avoided. Difficulties in raising capital continue to be a major barrier to business 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.

1. <www.industry.gov.au/INDUSTRY/MANUFACTURINGPERFORMANCE/Pages/ManufacturingDataCard.aspx>

The benefits of collaboration

Collaboration with researchers can provide businesses, particularly small and medium sized enterprises, with opportunities to boost productivity. Australian businesses collaborate less than their international counterparts. Small and medium sized enterprises are even less likely to collaborate than larger firms. Increasingly we are a net importer of technology and know-how and rely on foreign direct investment for technology more than most other OECD countries.

There are systemic barriers to increasing collaboration. We can learn from successful measures used in other countries to promote collaboration. There are some examples of well established policies and programs that are effective in helping to build and sustain business.

International collaboration could help to address declining productivity and trade performance in key sectors, such as the food industry. Australia's small and medium sized enterprises find it difficult to participate in global supply chains, but there are considerable benefits when they do so.

An innovative workforce

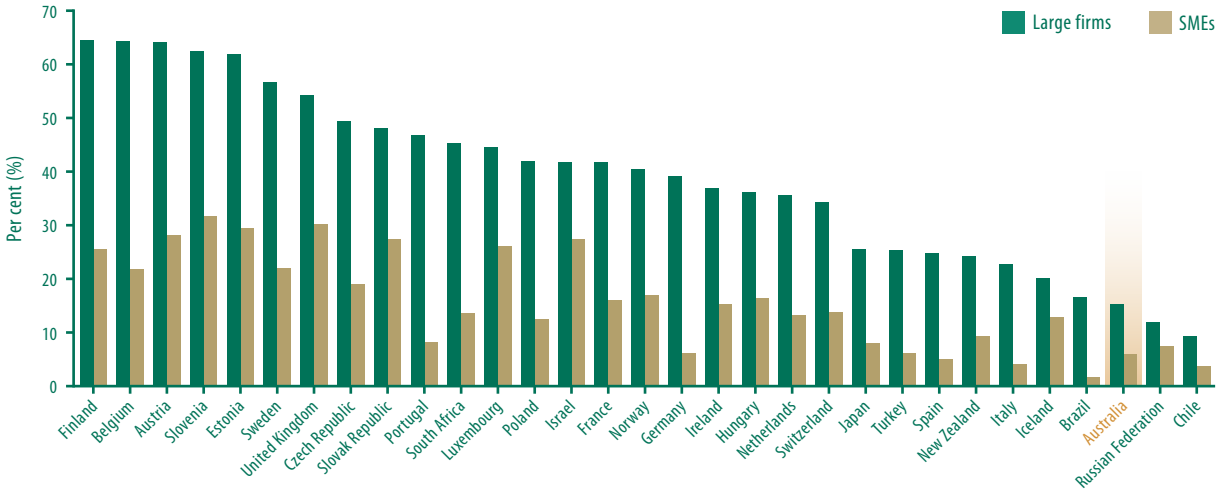
Skilled labour is one of the key contributors to productivity gains through innovation. Requirements for an innovative workforce include skills in reading, writing and numeracy, information and communications technology, management and leadership; and academic, analytic and social skills.

Effective workplace training is important in building an innovative, capable workforce, as well as having a positive correlation with business performance. It also has an important role to play in meeting the demand for skills and addressing skills shortages.

Innovation needs to be valued and supported at every level with a risk-tolerant culture that allows diversity, flexibility and inclusivity. Businesses need to ensure that opportunities and incentives are provided for all staff to contribute ideas and that processes are in place through which ideas can be translated to outcomes.

Encouraging the take-up of good management behaviour could be the single most cost effective way for governments to improve the performance of their economies. There is a need to improve management education and equip science and engineering graduates for innovation and leadership.

Australian firms have low levels of international collaboration. Firms engaged in international collaboration by firm size, 2008–10, as a percentage of product and/or process innovative firms in each size category.



Source: OECD 2013, *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, p. 129, based on Eurostat (CIS-2010) and national data sources, June 2013.

Productivity and economic growth

Over recent decades, productivity growth has played a major role in the growth of the Australian economy. This was particularly the case during the mid-1990s, generally attributed to microeconomic reform and the uptake of information and communications technology.

Recently there has been concern in Australia and other developed economies about the apparent slowdown in innovation and productivity growth. Australia has suffered a reduction in labour productivity in all sectors except construction.

Public sector research and development expenditure by Australian government research agencies, the Australian Research Council and the universities has wide benefits and is an important source of gains in productivity. Moreover, private sector research, innovation and other intangibles benefit the community as well as business.

Australia's gross expenditure on research and development has been growing in recent years. Our research intensity and gross expenditure on research and development as a share of GDP has also increased and is starting to approach the OECD average.

Increasing the levels of research and development in the medium term to at least the OECD average should be a policy objective.

Conclusion

Enhancing creativity and innovation to lift productivity in Australia will require:

1. adopting technological innovation to develop high-value products and services for a global market
2. improving collaboration between businesses, and between business and publicly funded research
3. increasing international collaboration
4. ensuring an innovative workforce that combines technical and non-technical disciplines, and enables good business management.

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5

Technology and Australia's Future

New technologies and their role in Australia's security, cultural, democratic, social and economic systems

Introduction

Technological change is a major driver of social change and the dominant source of economic growth. It encompasses the processes of invention and innovation, as well as the diffusion of technology.

New technologies offer unprecedented opportunities for economic growth and community well-being. However, to capitalise on these opportunities Australians must be ready to adapt and learn.

The report, *Technology and Australia's Future (New technologies and their role in Australia's security, cultural, democratic, social and economic systems)*, examines how technology has changed in the past, how it will continue to change in the future, and implications for the impacts of new technologies on Australia. The report makes an interdisciplinary assessment of today's technologies and emerging technologies, as well as how technology changes, the nature of its impacts, how it can be predicted and the types of interventions that help deal with the complexity and uncertainty inherent in technological change. The report draws on the authors' expertise in engineering, information and communications technology, life sciences and history.

What is technology?

The term 'technology' has a broad meaning. It includes processes, products, material, structures, information and practices. The term can describe sectors, such as biotechnology, transport infrastructure, public health or mining technology. Technology can also refer to collective needs or uses such as information and communication or energy generation and storage.

New technological products develop and are adopted from existing technologies, including the skills required to create and use them. For example, contemporary self-driving cars build on past advances in transport technology that yielded horse-drawn carriages, bicycles, steam trains and engines—and the infrastructure, components and know-how to create, build, and support them.

Technological change, comprising the invention, innovation and diffusion of technology, happens in many ways. There can be gradual or incremental changes, new combinations of existing technological components, or emergence of technologies that depend on advances in other technologies.

Meaning, attitudes and cultural influences all play significant roles in how and why technology is created, implemented and adopted. Science and technology cannot be considered in isolation from values; many emerging technologies trigger debate about ethical, legal and social implications from invention to use. The introduction of new technology creates or affects social, cultural, economic and political processes. New technology is modified, adapted and changed as it interacts with people, cultures, governance and social structures.

The impacts of technology on Australia

Technology has created and sustained our security, cultural, democratic, social and economic systems in many ways.

Australia is part of an increasingly connected international system. Globalisation is an impact of technology, with further ramifications for security, culture, democracy, governance, society and the economy.

ICT and transport technologies, in particular, facilitate globalisation, which critically affects Australia's socio-cultural setting, our economy, governance, and security. Globalisation and technology have differentially affected Australians, producing costs and benefits to the nation. Some people have benefited and some have been disadvantaged, both domestically and internationally.

The context in which technology is deployed affects its impacts. Technology and human nature are closely related: just as we change technology, using technology changes us. Technology changes the way we act, think, learn, and socialise. The use of technologies helps shape national culture.

Australia's technological future

Despite being notoriously difficult, prediction of new technologies is useful. Prediction helps industry and users make decisions about adoption. It can spur action, and help planning, policy development and investment decisions. Prediction also can inspire technology development.

The global technology revolution 2020, a report released by the RAND Corporation, found that Australia has an excellent capacity to acquire a broad range of technologies.

Governments can play a central role in encouraging experimentation and entrepreneurship. To allow new technologies to develop and diffuse, policies and regulations must support the growth of niche markets and entrepreneurs. The Australian workforce should be supported by policies that encourage an acceptance of uncertainty, an understanding that failure is inherent in technology change and a culture of experimentation and adaptation.

Adaptability and creativity are key skills in creating, assimilating and adopting new technology. Enhancing technological literacy, including fostering skills appropriate to engaging with technology in all levels of education, can enhance Australia's ability to adopt and adapt new technologies.

The difficulty of appropriating economic returns from early-stage technology research and development means that substantial ongoing government investment in research is warranted. Increased investment in high-quality scientific and technological research will lead to greater commercial and economic outcomes for Australia.

Technology and economic policy are inextricably linked. When evaluating new technology, government should consider both the benefits and the risks. Blocking or delaying new technology due to overweighting the risks relative to the benefits can slow economic growth and affect standards of living.

Short-term policies to deal with inequality in the workplace caused by technological change should not delay the adoption of new technology. Instead they should focus on facilitating worker transfers and re-skilling to enable those harmed by new technology to be protected and to adapt to the change.

Technology evaluation is of central importance to technology adoption. The costs of a technology are complex to determine, context-dependent, variable, and contested. Governments can facilitate better technology evaluation by adopting international best practice and by minimising the role vested interests play in technology evaluation.

Australian institutions will have to make increasingly thoughtful trade-offs between the benefits of a hyper-connected world and the associated risks of disruption, loss and harm.

A multidisciplinary approach that brings together different perspectives to consider how people feel about, talk about, and use technology can contribute to technology prediction, and help determine adoption, use and impact. Providing information and facilitating deliberation can effectively increase public familiarity with technologies and allow better understanding of its broader impact.

Australia's future use of new technologies will continue to be informed by our national technological imaginary—the way we understand and perceive technology. Reinvigorating this imaginary through investment in tinkering skills, scientific education and inculcating an attitude of experimentation and global confidence can accelerate Australia's technological future.

Conclusion

Technology is complex and dynamic. Technologies and industries that have performed well in the past will not necessarily perform well in the future, at least without substantial adaptation and transformation.

While it is possible for companies to adapt to external disruption, they cannot do so by sticking with what has worked so far. Adaptation involves innovation, change, and new technologies.

What seems valuable now will not remain so in future.

Australia's growth and prosperity are likely to be enhanced by:

1. acknowledging that the world is changing, and embracing that change as a valuable business opportunity
2. changing strategy away from focusing on what worked well in the past
3. creating and sustaining the capacity, skills, culture and the will to adopt, adapt, and develop our future source of prosperity and well-being.

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6

Engineering energy: unconventional gas production

A study of shale gas in Australia

Introduction

World demand for natural gas is expected to increase over the first half of the 21st century, primarily due to industry's demand for electricity. Australia is already a major producer of conventional gas and coal seam gas. As technology and geological knowledge develop, it could be in a position to produce shale gas. The success of an Australian shale gas industry will require consideration of scientific, social, community, technological, environmental and economic issues and impacts. It will require human and financial capital and careful management of impacts on ecosystems and natural resources. It will also need informed and supportive communities, and transparent and effective regulations and codes of practice.

Drawing on an interdisciplinary panel and the authors' expertise in engineering, geology, petroleum, hydrology, physics, social science, public policy, and economics, the report, *Engineering energy: unconventional gas production (A study of shale gas in Australia)*, provides an impartial, dispassionate, and evidence-based review of shale gas. It fills knowledge gaps, identifies and considers community concerns, and addresses opportunities and challenges that might arise. It saw no insurmountable technical barriers to producing shale gas.

Shale gas availability, technology, and economic feasibility

Natural gas occurs in sedimentary basins. The geological setting and the manner in which the gas is trapped defines whether it is 'conventional' or 'unconventional'. Most gas produced in Australia (and globally) to date, has been conventional gas, but coal seam gas (CSG) is produced in large quantities in Queensland. Unconventional gas includes shale gas, tight gas, CSG and methane hydrates.

Shale gas and shale oil occur typically at depths of 1000 to 2000 m or deeper, in fine-grained, low permeability sediments, such as shales and silty mudstones. In Australia there is significant potential for shale gas in parts of Western Australia, Queensland, South Australia and the Northern Territory. In remote regions, the shale gas industry may develop slowly due to limited access to water and the lack of road and gas pipeline infrastructure, but any infrastructure that is developed may assist other local industries. Because of its established infrastructure, shale gas in the Cooper Basin could be the first to be developed at a large scale. Some shale gas resources may occur in parts of southeast Queensland, western Victoria and south-western Western Australia.

Undiscovered shale gas resources in Australia may be large compared to conventional gas, but as yet there are no identified economic shale gas reserves in Australia. More information and exploration and favourable economics is required to turn the prospective resource estimates into proven reserves.

The shale gas 'revolution' in the United States has rejuvenated industry, as a result of new technology converting what was previously an uneconomic resource into a reserve of great commercial and national and international significance.

Technologies such as horizontal drilling and hydraulic fracturing (fracking) are applied now in Australia. However, production costs to produce shale gas are likely to be significantly higher than those in North America, and the lack of infrastructure will further add to costs. Shale gas will not be cheap in Australia, but it could to be plentiful and it has the potential to be an economically important energy source.

The extent to which Australia's shale gas potential is realised will be highly dependent on the price of shale gas compared to the cost of

other energy sources. In Australia, shale gas will require a price of the order of $6–9 a gigajoule to make its production and transport profitable. By comparison, the Australian east coast wholesale gas price (at the time of publication of the report in 2013) was about $6 a gigajoule.

Environmental and community impact of shale gas

Increased use of shale (and other) gas in place of coal for Australian electricity generation could significantly decrease greenhouse gas emissions, provided emissions associated with shale gas production are minimised. Increased exploration and production of shale gas could adversely impact landscape, ecosystems (including vegetation, flora and fauna species, and soils), surface water supplies and groundwater, and communities and may result in habitat fragmentation and some environmental contamination. However if best practice is followed, these problems can be avoided. Induced seismicity is unlikely to be a significant issue.

Water will need to be managed, to minimise water extracted from the surface and groundwater resources. Additionally, there will be a need to minimise water with contaminants being discharged into streams and groundwater aquifers.

While the economic and other opportunities generated by the development of shale gas reserves will be widely welcomed, there are likely to be concerns about potentially adverse impacts. Governments and industry must address these concerns while exploration is at an early stage, by engaging with affected and interested parties, building confidence in the science and technology, and demonstrating a preparedness to adopt and enforce strong regulatory and internal controls.

Regulations

Given that shale gas developments are likely to cross state boundaries, it is necessary for state and federal governments to seek to harmonise regulations. A shale gas industry in Australia is not starting out with a blank sheet of paper as far as regulations are concerned. Overall, existing regulations for conventional gas production work well; however, the level of community opposition to some CSG developments suggests that there are issues to be addressed in the current approvals process.

If the shale gas industry is to earn and retain the social licence to operate, it is a matter of some urgency to have a transparent, adaptive and effective regulatory system in place, backed by best practice monitoring, and credible and high quality baseline surveys. Most if not all of the potential negative impacts could be minimised if these are in place. Robust and transparent regulation, underpinned by effective and credible monitoring, is key to public acceptability.

Conclusion

There are no profound gaps in technological knowledge relating to shale gas exploration and production. However, research requirements to ensure confidence among the regulators, community and industry include:

1. baseline data against which to measure change
2. knowledge to be able to predict change before it happens
3. using data and knowledge together to effectively deal with a minor impact before it has significant consequence
4. making data used and knowledge gained transparent and readily available.

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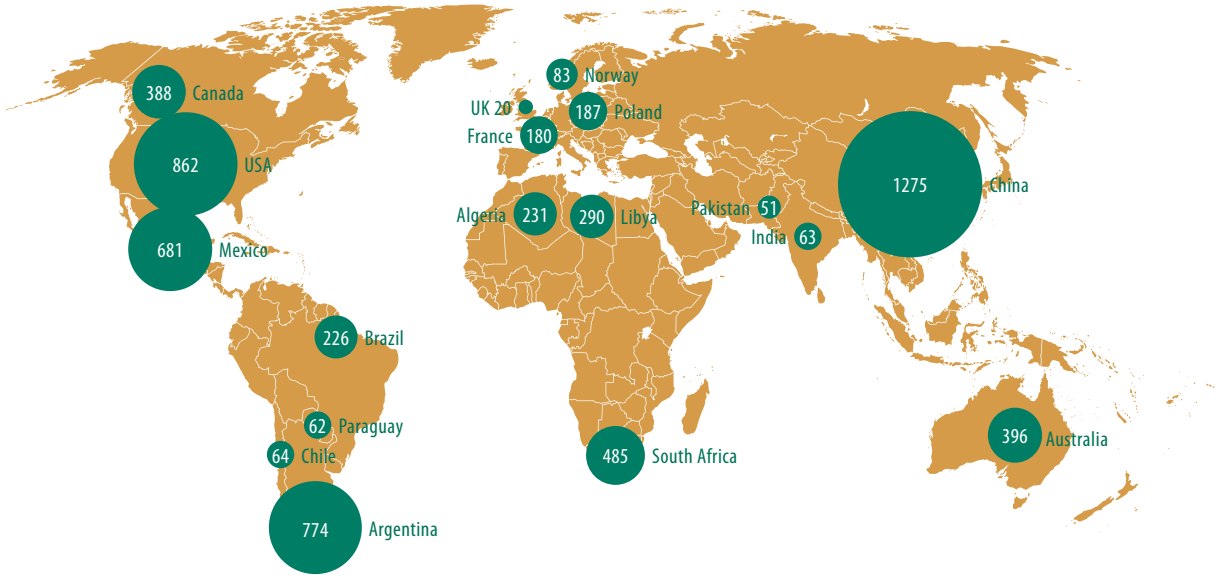
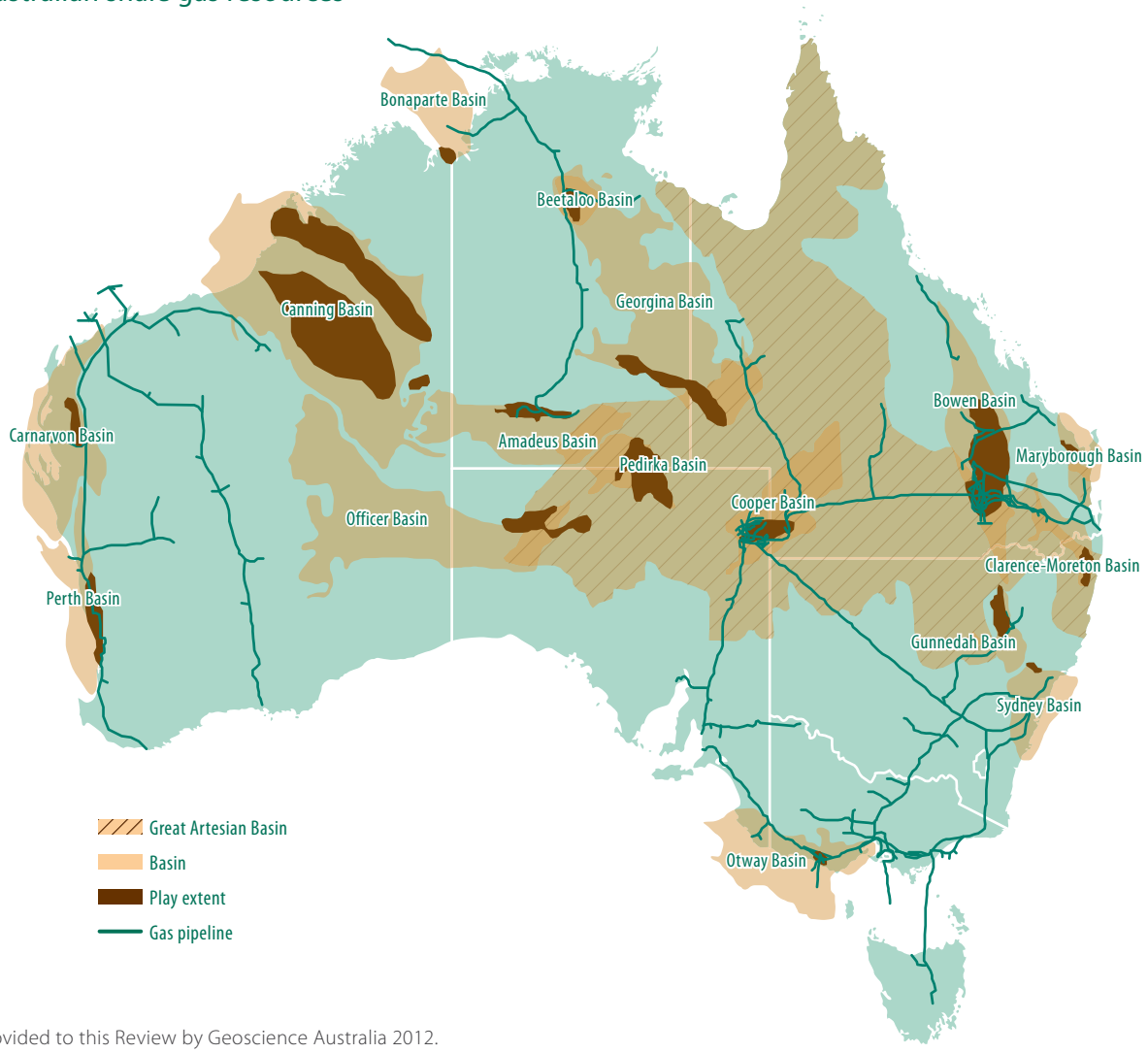
World shale gas resources



Estimates of technically recoverable shale gas resources (trillion cubic feet, tcf) based on 48 major shale formations in 32 countries (EIA 2011) Russia, Central Asia, Middle East, South East Asia and central Africa were not addressed in the Energy Information Administration report from which this data was taken.

Source: International Energy Agency 2012, *World Energy Outlook 2012,* Paris, France.

Australian shale gas resources



Provided to this Review by Geoscience Australia 2012.

7 Australia's Agricultural Future

Introduction

Australia's agricultural sector is at a crossroads—the future is bright but there are challenges. The value of Australia's agricultural exports could double by 2050 in response to rising global population. Increasing affluence in Asia presents opportunities for growth. However, agriculture faces unprecedented pressures through climate change, funding, and workforce issues.

There is a critical role for science and innovation in Australian agriculture today, and these will be even more vital for our farming future. New technologies are particularly important to dryland crops, pasture-based production, and protection against the introduction of pests and diseases. Australia has a reputation for clean, green, safe, affordable, sustainable and ethical agricultural products; hence the sector must optimise production while maintaining its national and global reputation.

Drawing on the authors' interdisciplinary expertise in agriculture, biosecurity, economics, history and philosophy of science, bioethics, science policy, food studies, mathematics and statistics, and history, the report, *Australia's Agricultural Future*, provides a vision of Australian agriculture's future, and maps the pathway towards enhancing our outstanding reputation in agriculture, while producing more food in a sustainable way.

Australian agriculture's advantage

Agriculture accounts for about 2 per cent of Australia's total gross domestic product (GDP). The gross value of agricultural production in 2013–14 was $53 billion, with $41 billion of exported agricultural commodities.

Exports have tended to be unprocessed, and Australia is now a net importer of processed food. Australia is a major exporter of wheat, beef, cotton, wool, oilseeds, wine, lamb, sugar, barley, and dairy products, driven by our comparative advantage in these commodities and by the trust in the product's quality and safety. Australia's reputation for 'clean and green' products will continue to be important for bulk commodities, as well as processed products. Such claims must be supported by evidence and accreditation.

The expected overall growth in demand for food will translate into opportunities for bulk commodity exporters. However, increased global demand for food will bring increased global competition in our markets and Australia will be generally unable to compete on price internationally with processed products.

Australia can develop niche markets for specialised, high-valued products for consumers who value safety, sustainable production, high quality and perceived health benefits over price. However, it is crucial to develop a better understanding of domestic and international consumers' views on 'clean and green' attributes, including nutrition and environmental impacts, and the premiums they are willing to pay for such products. Sophisticated information systems and marketing strategies will be required to exploit this niche.

Furthermore, Australian farmers face challenges dealing with highly variable rainfall and poor soils. Agriculture depends on healthy soil, water, and biodiversity. Cropping and grazing use about 60 per cent (456 million hectares) of the Australian continent, and agriculture accounts for 50 to 70 per cent of all water consumed in Australia. Climate change and climate variability present significant long-term risks to agriculture that need to be managed.

In summary, the major growth opportunities for Australian agriculture are in (1) raw bulk commodities and (2) high-value specialised products. The sector may also export the knowledge, experience, skills, and technology to increase agricultural productivity in developing countries.

To capitalise on these opportunities, policy makers need to ensure that:

- demand growth is sustained in line with population and income drivers
- there is access to markets, particularly international
- agricultural protectionism is limited
- the diversity of consumer demands is reflected in market and regulatory processes.

Community concerns

The bush has held a special place in the traditional Australian identity. Farming employed some 270,000 people in 2013-14 (excluding forestry and fishing), or 2.3 per cent of Australia's workforce. However, this is just half of what it was in 2000. Nevertheless, labour shortages remain a problem in rural areas. The median age of Australian farmers is increasing at a faster rate than that of the general population, although Australia still has the second highest proportion of farmers under 35 years of age (14 per cent) compared with 29 other developed countries.

Understanding the variations in Australia's agricultural sector is essential for securing its future well-being. The sector contains a wide variety of farms, including tiny lifestyle farms, long-run family farms, and large corporate farms. Family-owned farms account for 95 per cent of farms and 77 per cent of farmland. However, small family farm businesses may lack ability to adopt advanced technologies and adapt to environmental and market changes.

Communities and consumers recently have expressed passionate views about production methods (e.g. pesticide usage) and technological innovations (e.g. genetic modification). These views have attracted considerable political attention, in part because they are connected deeply to our perception of national identity and because food is a fundamental part of life, the safety of which is considered paramount.

Furthermore, community groups have concerns about the extent of foreign ownership and foreign labour in agriculture. Without more foreign investment in farms and agribusinesses, alternative models of farm financing need to be developed to meet the needs for farm businesses faced with fluctuating incomes and reduced capacity to borrow. Local superannuation funds and other Australian funders may need to be encouraged to invest in potentially risky farming enterprises.

Technology and opportunities to increase productivity

By 2050, global agriculture will need to feed a world population of 9 billion. Population growth and changing dietary preferences in Asia, particularly China, India, and Indonesia, could result in export opportunities worth many hundreds of billions of dollars over the next few decades.

A move to more profitable commodities and an increase in productivity of traditional commodities will require existing and new technologies, improvements in breeding made possible through advanced genomics, and improvements to management practices. Farmer-driven innovation has always been a feature of Australian agriculture, which has a long history of innovation, resilience, adaptability and growth in productivity. Partnerships between farmers, researchers, communities and others will foster innovation. But a higher level of research and development investment is needed in areas including technology and practices, advances in genetics, and knowledge-driven systems.

Farms of the future will be unrecognisable. Robots will harvest and prune, and drones will survey fences and check for problems in high-valued crops. Farmers will use real-time information to decide on levels of fertiliser and other inputs. Automation could see reduced demand for some labour while increasing the need for new skills; for example, engineers and computing experts will be needed to run machinery, which will place agriculture in competition with other sectors for these skills.

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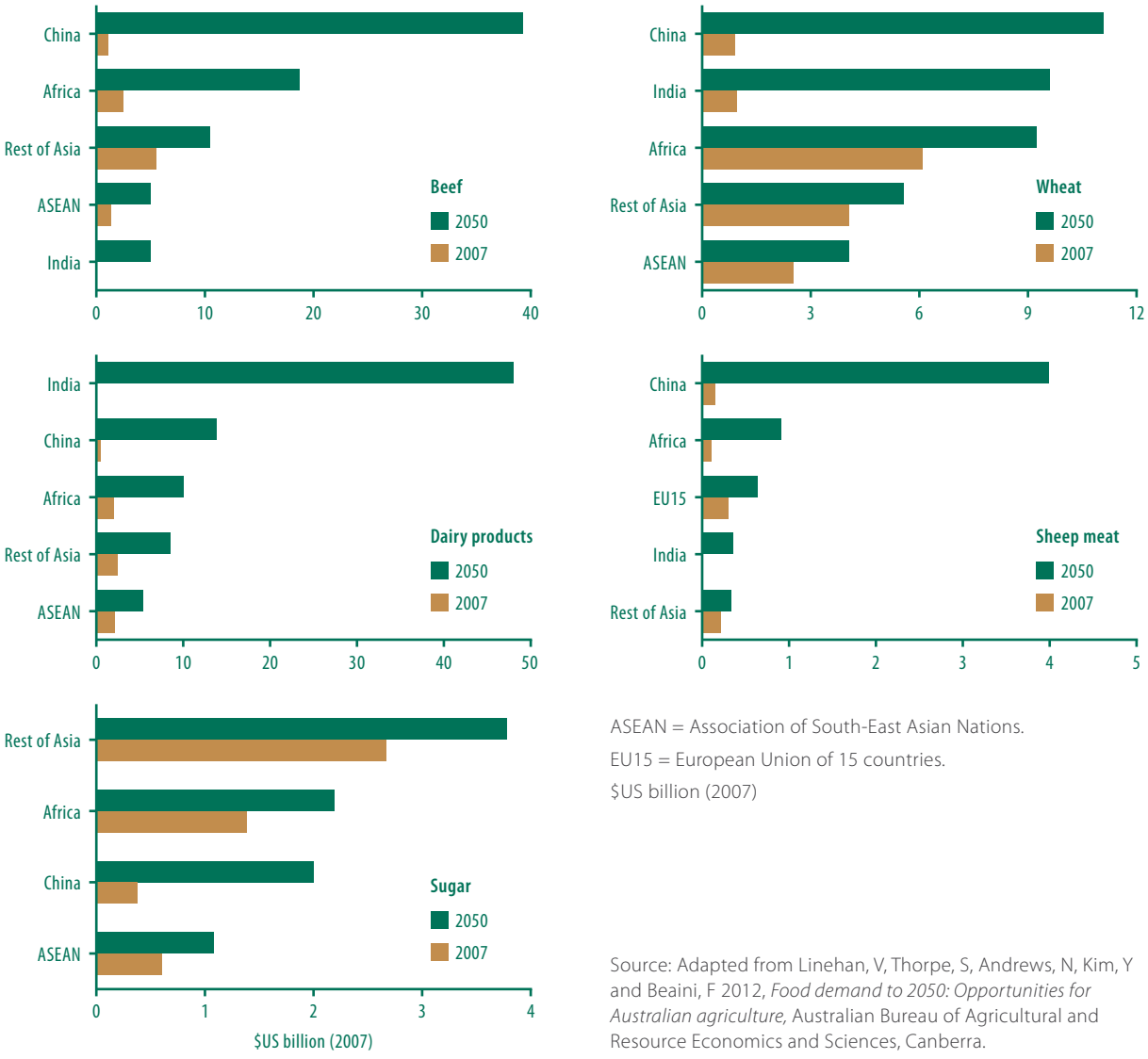
Conclusion

Community perceptions of agriculture as a 'sunset industry' do not match the resilience shown by the sector or its bright future. Australian will have continuing comparative advantage in the export of bulk commodities and increasing opportunities to respond to the growth in demand for high-value products domestically and in Asia.

Key findings for Australia's agricultural future include:

1. Australia's reputation for safe, clean and green food needs to be sustained and underpinned by internationally recognised standards and certification.
2. The agricultural sector will need to efficiently manage its soil and water resources, including the risks associated with climate change and climate variability, to meet increased demand.
3. The sector will need to attract capital and skilled labour in competition with other parts of the Australian economy.
4. A range of community concerns with food safety, product labelling, gene technology in plant and animal breeding, foreign investment and foreign workers, and other issues call for informed and respectful conversations to ensure the Australian community is onside.
5. Accelerating the uptake of advanced technologies, communications and knowledge systems are critical for success, and ongoing investment in private and public research and development is vital.

Current and projected (2050) global demand for major Australian agricultural export commodities



ASEAN = Association of South-East Asian Nations.
EU15 = European Union of 15 countries.
$US billion (2007)

Source: Adapted from Linehan, V, Thorpe, S, Andrews, N, Kim, Y and Beaini, F 2012, *Food demand to 2050: Opportunities for Australian agriculture,* Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.

8 Delivering Sustainable Urban Mobility

Introduction

Australia is one of the most urbanised countries in the world, with almost two-thirds of the population concentrated in five cities. The large number of cars and trucks in urban areas cause traffic congestion costing billions of dollars, harm human health, and add to greenhouse gas emissions.

Throughout the 20th century there are examples in Australian cities of forward-thinking urban planning that were successful within the constraints and priorities of the time. However, from the late 20th century through to today, urban plans for Australian cities have increasingly not delivered urban mobility that is sustainable in the long term. A business-as-usual approach will not work—a major rethink is required.

The report, *Delivering Sustainable Urban Mobility*, brings together research on optimising mobility options in and between urban areas. This research was sourced from disciplines as varied as history, urban policy and design, technology commercialisation, health and medical science, and interdisciplinary research management. The report calls for a new approach to urban transport that prioritises *people* rather than one particular mode of transport, to ensure our future cities are productive, liveable, and accessible.

Increasing pressure on Australian cities

Only 3 per cent of the world's population lived in urban centres 200 years ago. Today, half the world's population lives in cities, and this is expected to increase to 75 per cent by 2050, when world population is projected to reach 9 billion.

In Australia, population is forecast to reach 37 million by 2050, with Melbourne and Sydney alone expected to exceed 14 million this century. Without proper infrastructure management, congestion costs in Australian capital cities are forecast to grow from $13.7 billion in 2011 to around $53.3 billion in 2031.

Australians desire and deserve equitable, reliable and cost effective mobility choices—no matter whether they live in inner cities (where transport choices are greatest) or outer urban locations (where the practical mobility choice usually is only a car, even for short trips). Some aspects of transport systems in Australian cities are more than 100 years old. Several cities have grown to extend well beyond the reach of public transport. Adding roads is not necessarily the solution for the urban mobility challenges of today and tomorrow.

Australian transport infrastructure spending has declined over the past 40 years. Australia's current infrastructure shortfall in urban areas is estimated at $145 billion. The cost of addressing this deficit may exceed $350 billion by 2025, but if implemented well such investment in Australia's mobility infrastructure is forecast to lead to a continuing annual economic benefit of $75 billion.

There are also environmental pressures. As the Australian population increases, and is further concentrated in major cities with an increasing proportion of older people, the social inequities and economic consequences of fossil fuel dependence will intensify.

Cities cover less than 2 per cent of the Earth's surface, but use 78 per cent of world energy. Globally there are about 1.2 billion cars (a figure that is expected to double by 2030), but their use is inefficient with the average car parked 96 per cent of the time. In major Australian cities, about three-quarters of the journeys to work in 2011 were by car.

Australian cities generally rate high on measures of liveability, but they have environmental footprints that are not sustainable. The expansive nature of Australia's largest cities has consequences for water quality, air quality and ocean cleanliness. Transport is a major source (about a quarter, globally) of greenhouse gas emissions, with Australia one of the world's highest emitters in this sector.

As well as contributing to climate change, cities and their transport systems are affected by its impacts. A high proportion of the world's cities with populations of 1 million or more are on the coast and hence vulnerable to sea-level rise. Cities act as amplifiers of global warming, creating urban heat islands. Many cities are introducing trees, open green spaces and other vegetation to reduce local temperatures. But cities have limited capacity to withstand the combined pressures of population expansion, climate change and outdated transport.

Sustainable urban design

Transport plays an essential role in economic and social development, ensuring access to jobs, housing, goods and services, providing mobility, and opening up isolated regions. Access, mobility and how we shape our cities have a profound influence on perceptions of quality of life.

Sustainable urban planning involves reducing or avoiding the need to travel by bringing workplaces closer to homes, increasing the number of homes in areas with the greatest number of jobs, and improving transport links between work and home.

The approach of 'smart growth' or a 'compact city' reduces urban sprawl by focusing on walkable city centres, bicycle-friendly land use, and mixed-use neighbourhood development. Traditionally, the central business district and inner city have been the most important employment hubs. However, in recent years there has been growth in employment in health and education services in suburban locations, and an increased importance of the 'forgotten middle suburbs' as places for future employment growth.

Furthermore, online retail and teleworking in Australia currently represent less than 10 per cent of the workforce, but this is forecast to grow rapidly. Digital technology and human behaviour are deeply interlinked, so increased telecommuting will change labour markets and retail models, and lead to a decentralised city design.

Transport technology

Australia faces a fuel security risk. In 2013–14, Australia's net import bill for crude oil and petroleum products was $30.7 billion, or 2 per cent of GDP. As a country heavily reliant on road transport, it is surprising that Australia has small and declining fuel stocks, holding no more than three weeks' worth of oil and refined fuels onshore.

Sustainable urban planning could address this risk by considering more environmentally friendly transport options, and improved energy efficiency of public and private transport. Greater use of electric cars drawing on renewable energy grids, use of biofuels, gaseous fuels and synthetic fuels, and greater use of other energy technologies such as fuel cells, would reduce dependence on imported transport fuels, as well as lowering emissions. The provision of attractive public transport alternatives can discourage the habit, attitude and inertia of road use.

The cost of moving freight by road is more than double the cost by rail, and the greenhouse gas emissions for road are more than triple those of rail. Despite this, over the past 40 years the share of rail freight compared to heavy vehicles has steadily declined in Australia.

High-speed data transmission, digital sensors and data analytics ('big data') could better manage the flow of people, vehicles and goods through cities. Many cities already use technology to help manage traffic congestion, to police the streets and to allocate resources and services on the basis of real-time information.

Technology and innovation will be key to meeting the challenge of urban congestion. But technology alone will not be enough. Meeting the challenges of urban transport and the urban built environment will require long-term, nimble policy development and sustained investment in innovative mobility infrastructure.

Conclusion

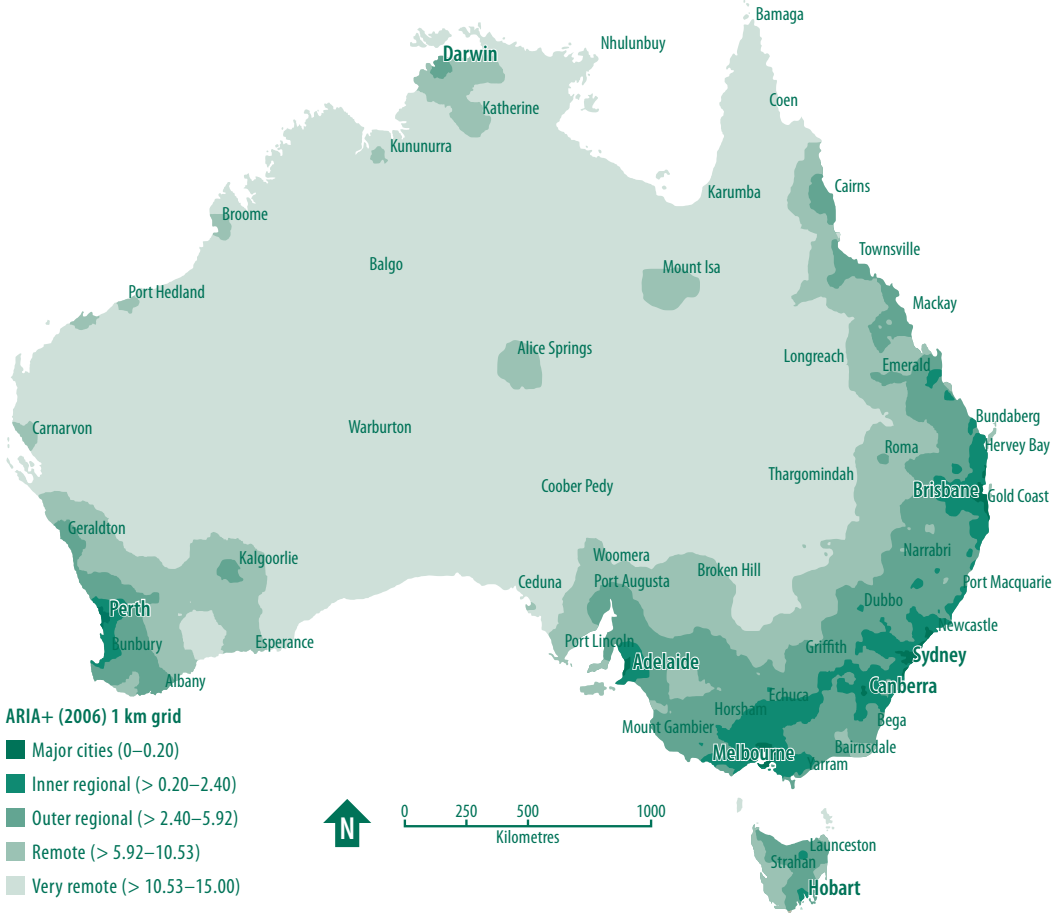
Urban mobility planning in the 21st century must aim to ensure the accessibility needs of citizens and businesses are met at the lowest individual and collective environmental and social impacts and economic cost. Best practice planning for Australian cities will deliver new and economically sound responses to our citizens and businesses for sustainable living, working and playing.

Delivering Sustainable Urban Mobility envisages a far-sighted urban planning approach—across all tiers of government—for a resilient, nationally competitive future.

Areas requiring action include:

1. the development of compact, mixed-use cities that reduce travel requirements
2. a shift to low carbon transport options
3. improved vehicle occupancy rates and efficiency of freight transport
4. reduced vehicle emissions intensity, especially greenhouse gases and air pollutants
5. increased public transport and urban design to increase opportunities for active travel (including walking and cycling) to address Australia's level of chronic disease and obesity.

People living in rural and remote parts of Australia face major accessibility challenges



Note: ARIA+ and ARIA++ are indices of remoteness derived from measures of road distance between populated localities and service centres. These road distance measures are then used to generate a remoteness score for any location in Australia.

Data sources: GISCA, The University of Adelaide, GeoScience Australia and Australian Bureau of Statistics.

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9

Translating research for economic and social benefit: country comparisons

Introduction

Innovation in Australia is suffering from a lack of a national innovation strategy, short-termism, inadequate scale and a fragmented approach. We need to urgently improve the application of publicly funded research, in order to generate economic and other benefits.

The interdisciplinary report, *Translating research for economic and social benefit: country comparisons*, analyses international approaches to encouraging and facilitating research translation, commercialisation and collaboration. The report draws on consultant reports and the authors' expertise in government, science and innovation.

The 14 nations studied were Finland, Denmark, Sweden, Germany, United Kingdom, Israel, United States, Canada, South Korea, Japan, Singapore, China, Brazil and Chile. There is a clear link between national policy on innovation and innovation performance. Nations that do better than Australia in innovation are characterised by rigorous policy-setting and programs that encourage a culture of innovation and collaboration.

Learning from overseas

One of the challenges for Australian public sector researchers is finding an industry partner with which to engage. We have relatively few firms that do research and development. Australian researchers are not well engaged with industry or with other parties.

Australia's higher education research spending is above the OECD average. Australian public sector expenditure on research and development is also strong. Public sector research is a major part of Australia's research system. Accountability to the public makes it particularly important that we encourage and accelerate the translation of public sector research into economic and social benefits.

Recognising the importance of the flow of knowledge to application, many countries have developed a range of mechanisms to bring together researchers and potential users.

Governments have a vital role in adopting polices that can support and drive innovation, and to reflect emerging challenges and priorities. Governments must ensure public investment in science and research, and encourage and support innovation within the private sector.

As well as funding research, the countries reviewed offer policies and programs to encourage and enhance the application of research. These include funding for start-ups, university-based incubators and technology parks, training for managers of intellectual property, and mentoring for university student and faculty entrepreneurs.

Furthermore, such funding, policies and programs can provide assistance to researchers for collaboration, assistance to businesses, exchange and placement of researchers, technology transfer support and intellectual property support.

The countries reviewed have each adopted a suite of measures to encourage the translation of public sector research to benefit the broader community.

Recipes for success

Australia's efforts to support the translation of public sector research have been minimal. In many cases, there has been inadequate reporting of program results and minimal evaluation of achievement.

There are a number of overseas examples where stable, well-designed and funded measures have created jobs, increased business turnover and provided other benefits.

Supporting small and medium-sized enterprises and start-ups that have high growth potential will help to increase the translation of Australian public sector research. Such enterprises with high growth potential are an important source of future jobs and economic growth and are the target for many of the overseas government measures reviewed.

Start-ups help commercialise public sector research. Government support should be available to help start-ups, subject to the start-ups having essential prerequisites, such as intellectual property and business strategies, and researchers willing to continue the development process.

Firms that undertake research and development are more likely to become involved in the translation of public sector research. Australia is overly reliant on indirect support for business research and development through the research and development tax incentive. The incentive could be adjusted to encourage collaboration with public sector researchers.

Shifting the balance of government support for business innovation to greater use of direct measures such as grants, loans and procurement contracts would allow a more focused and targeted approach to support research collaboration and translation.

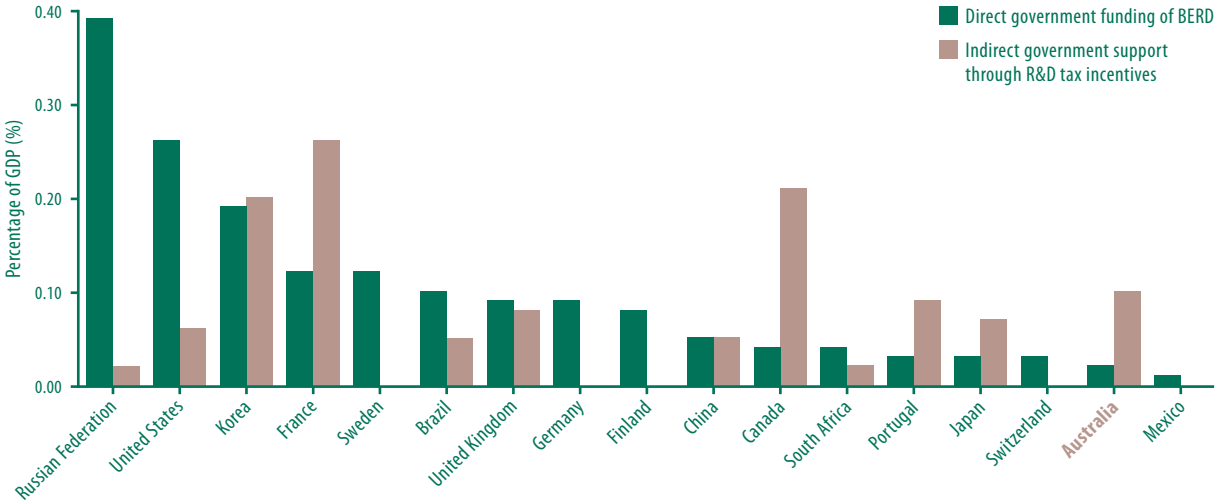
We need to reform research collaboration programs, such as Australian Research Council Linkage Programs, by increasing funding and adopting the leading grant administration practices of the overseas programs reviewed.

Measures that require a joint proposal from public sector researchers and external partners (often business) work well. Australia's Cooperative Research Centres Program is a good example of this approach.

Programs that support the placement of students and new graduates within external organisations will help to transfer new creative and technical skills to business, government and not-for-profit sectors. Work-integrated learning placements can also help build relations between universities and external parties that can lead to future collaborations.

The engagement of researchers from humanities, arts, and social science disciplines has opportunities and challenges that are

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



Source: Adapted from OECD 2013, *OECD Science, Technology and Industry Scoreboard 2013*, OECD Publishing (Paris, France), DOI: <http://dx.doi.org/10.1787/sti_scoreboard-2013-graph97-en>.

different from those of the science, technology, engineering and maths disciplines. For these reasons, some countries have adopted specific measures to encourage such engagement and collaboration. It is important to ensure that humanities, arts, and social science researchers are not excluded from measures to encourage public sector researcher engagement with external parties.

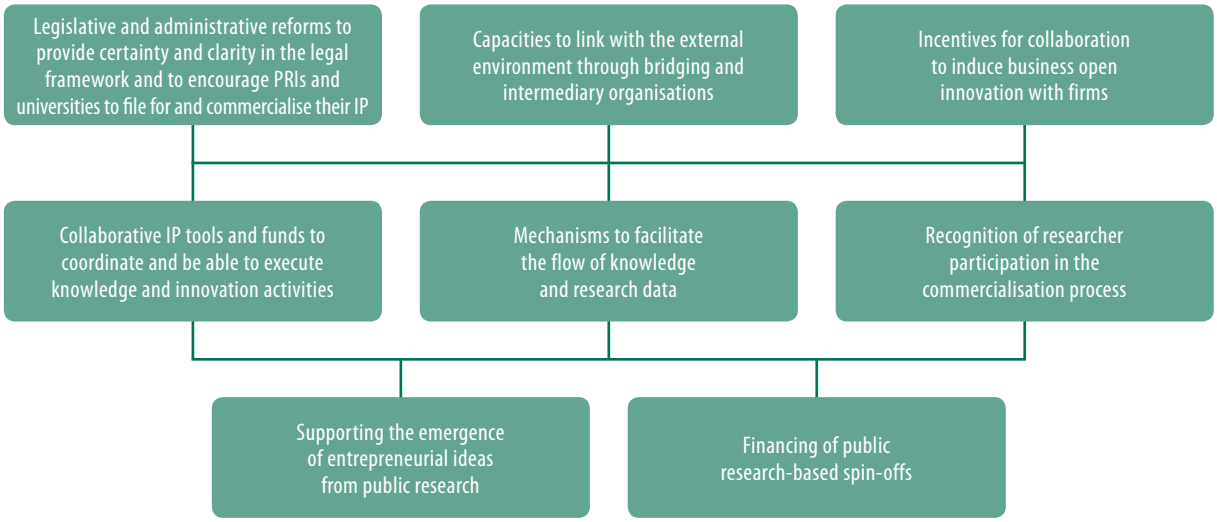
Conclusion

Australia would gain from a coherent national innovation strategy with an agency to manage it, and less reliance on indirect support for business such as through the research and development tax incentive. Most leading practice countries have well-resourced and coordinated innovation strategies, which guide the selection of policy and program options.

Other important steps to lift research application and business-researcher collaboration include:

1. increasing assistance for collaborative research
2. providing targeted incentives to universities to increase their engagement with external agencies
3. employing commercial managers to help researchers engage with commercial partners from the early stages of projects
4. implementing measures to support the financing of commercial outcomes from public sector research
5. commissioning independent reviews and evaluations of research translation measures to ensure that they are achieving their objectives.

Strategies for enhancing the transfer and commercialisation of public sector research



Source: Adapted from OECD 2013, *Commercialising Public Research: New Trends and Strategies*, OECD Publishing, Paris, France.

10 Skills and capabilities for Australian enterprise innovation

Introduction

Australia needs an innovative, flexible and creative workforce with the skills and capabilities to enable the country to secure its future productivity. Technical and scientific capabilities are critical to innovation, but innovation also requires people who understand business, systems, culture and the way society uses and adopts new ideas. This project examines the way that Australia's high-performing enterprises identify, manage, build and mix the capabilities to succeed.

Drawing on extensive research and data, the report, *Skills and capabilities for Australian enterprise innovation*, investigated the extent to which technical and non-technical skills underpin innovation, how they interact to meet innovation challenges, and the potential for industry, education, and government to properly invest in the skills and capabilities that support enterprise innovation. This report builds on SAF04, SAF05 and SAF09.

Australia needs to improve the way it turns knowledge inputs into outputs to become a more efficient and successful innovator. The manner in which Australian enterprises use and manage skills and capabilities is a critical component of the broader strategy needed to enhance Australia's innovation performance.

This report represents the first in-depth investigation of how many of Australia's best-known innovative enterprises build and combine the technical and non-technical skills to drive the development of new products and services and to capture new markets and consumers. In the process, it explores potential mechanisms for achieving more efficient and effective innovation outcomes.

Australia's innovation performance

The 2015 Global Innovation Index reveals that Australia is a relatively inefficient innovator. Australia's overall ranking for innovation inputs is a reasonable 10th. However, our overall ranking for innovation outputs is 24th. This means our innovation efficiency is low. The Index shows that Australia has the relevant skills but lacks the capacity to manage and use these skills and other inputs for innovation.

The most often stated challenge to innovation reported by innovative businesses is the lack of access to the additional funds required to develop and implement innovation. In contrast to this view, however, the Australian Bureau of Statistics' Business Characteristics Survey reveals that a lack of access to skills was the most significant barrier to innovation among these businesses.

The ACOLA project team commissioned Swinburne University of Technology to undertake a statistical analysis of the factors associated with innovation performance among Australian businesses. The analysis confirms that different types of skills are more important for different types of innovation. Science, Technology, Engineering and Mathematics (STEM) skills are more strongly associated with innovation in products and processes, while business skills are associated with process, organisational and marketing innovation.

Innovation policy

Innovation thinking in policy has evolved from 'first generation' (linear) approaches, to 'second generation' (systems) approaches, to third generation (ecological) approaches. Knowledge for innovation can come from a range of sources. Contemporary research and debate on the future of work, work skills, and sources of innovation highlight the growing importance of higher-order integrative skills.

Innovation, in third generation policy frameworks, requires people with sets of skills that integrate, and may go beyond, STEM. Organisations need teams that maximise diversity and creativity, supported by their connections to larger innovation 'ecosystems'. Organisations do not need to have all of the skills and competencies to initiate and sustain innovation. Rather, they need to work cooperatively and in competition, developing and even sharing capabilities.

Lessons from innovative organisations

The ACOLA report includes findings from interviews with 19 Australian organisations which are independently recognised as highly innovative. All of the organisations use people and teams with a mix of skills, and draw on external skills. They invest in finding and developing the right candidates. Attitude, cultural fit and emotional intelligence or 'cleverness' are important skills.

Different skills are required at various stages in the innovation cycle, so skills mixing in individuals, in teams and across organisations is important for innovation. Innovative organisations value external ideas and viewpoints and cooperate with other organisations. Networks, partnerships and clusters help provide the skills needed for innovation.

There is a transition from tackling technical challenges at the initial stages of innovation development to a strong focus on understanding the value of innovations from the customer perspective. The important consideration is how innovations in products, services and processes will add value that customers are willing to pay for.

Many of the profiled organisations have a strong track record of 'holism' in their approaches to managing staff. This often includes developing employees' attitudes and supporting activities beyond formal education, driven by the knowledge that technical skills are necessary but not sufficient for optimum contributions. These firms foster the development of individual, team and life skills.

Improve Australia's focus on technical and non-technical skills mixing

Governments cannot rely on traditional policy instruments to create innovation ecosystems. They must assume a broader role as facilitators, connectors and enablers of system-level collaborations. A government's primary role should be to facilitate collaboration and cooperation; this will provide conditions and support to encourage enterprise and education, resulting in a mix and use of skills beyond organisational and sectoral boundaries.

Highly innovative organisations overcome significant barriers to innovation through strengthening management and leadership capabilities. Many Australian business organisations do not have sufficient managerial talent required to meet critical innovation challenges.

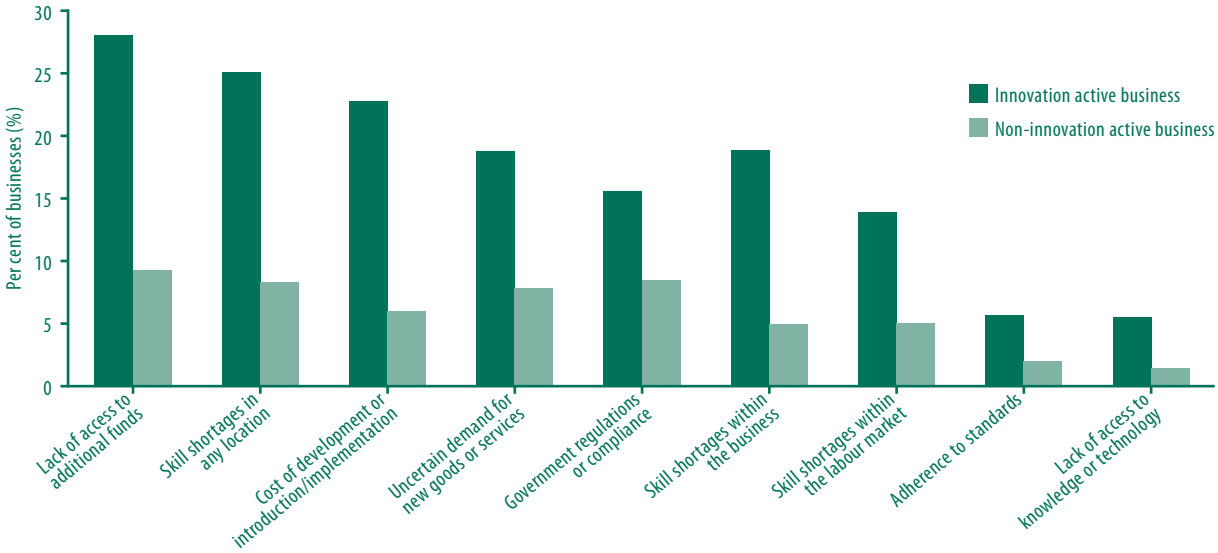
The consistent finding, with challenging implications for enterprise, education and government, is the potential to broaden yet complement the current policy focus on science and technology, enabling a more holistic approach to tackling Australia's innovation challenges that teams humanities, arts and social sciences (HASS)-based skills with science, technology, engineering and mathematics (STEM)-based skills.

Conclusion

Supporting Australia's enterprise innovation will require steps that include:

1. more effectively transforming innovation inputs, such as investments in human capital and research, into knowledge and technology innovation outputs
2. supporting and developing strong innovation ecosystems that enable access to a mix of skills
3. employing and developing employees with broad knowledge bases and strong integrative skills (beyond a single discipline)
4. sophisticated recruitment and retention practices, internal training and development, and strong cultures and engagement
5. strengthening management and leadership capabilities
6. encouraging deeper collaboration across enterprise boundaries, including integrating Australian organisations into global value chains
7. investment in innovation ecosystems in specific industries and regions.

Barriers to innovation: innovative active versus non-innovation active, 2013–14



Source: ABS Catalogue Number 8167.0—Selected Characteristics of Australian Business, 2013–14, available at <www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8167.02013-14?OpenDocument>. Last accessed 25 May 2016.

11 Australia's diaspora advantage

Realising the potential for building transnational business networks with Asia

Introduction

Australia's business and economics links with Asian countries have expanded rapidly in recent years. This has been strengthened by communities of people of Asian origin living in Australia, who use cultural, linguistic and other skills to build people-to-people links across diverse areas including science, culture, business and trade. However, many of the potential benefits of these connections are underused, under-developed or unknown.

Focusing on the Chinese and Indian business communities in Australia, the report, *Australia's diaspora advantage: realising the potential for building transnational business networks with Asia,* explored the extent, diversity and nature of Australia's Asian business diasporas. It builds on SAF3, and draws on an interdisciplinary expert working group and the authors' expertise in philosophy, educational strategy, public policy, global studies, and Chinese language, literature, and history.

As a dynamic economy in a rapidly developing region, Australia cannot overlook the importance of transnational business networks or the knowledge and skills held by Asian communities in Australia. In fact, Australia could lead the world in developing policies and programs that encourage more effective engagement of Asian business diasporas.

Diasporas in Australia

Diversity Council Australia estimates that 17 per cent of people (4 million) living and working in Australia identify as being of Asian origin. Australia's two largest Asian populations are the Chinese and Indian communities, estimated in 2016 to number at least 1.7 million people, of whom some 850,000 people were born in China and India (2015 data). By 2031 the number of people of Chinese and Indian descent living and working in Australia is expected to rise to 2.7 million.

The report adopts the concept of diasporas—populations that are dispersed yet remain connected to transnational networks. Asian diasporas include new migrants, their Australian-born descendants, people of mixed-parentage, and temporary residents here for work or study.

The Chinese and Indian diasporas in Australia comprise a large proportion of educated, highly skilled and globally networked individuals. They are generally better educated than the rest of the Australian population: India-born Australians are almost three times as likely as other Australians to have a Bachelor degree or above, while those born in China are almost twice as likely.

Their enthusiasm, entrepreneurial energy and preparedness to take risks is shown to form the drivers of their success. Their transnational networks are a major source of business opportunities, innovation and entrepreneurialism.

Business diasporas are those within the diaspora communities who are engaged in activities that involve trade, investment and commercial collaborations. Between 2006 and 2011, businesses owned by Australia's China-born population rose 40 per cent, and for those born in India by 72 per cent, to a combined total of 45,500 businesses. Chinese and Indian business diasporas are mostly active in professional, scientific and technical, health, education, and information and communication technologies (ICT) fields. Business activities are bolstered by connections, high mobility and skill in circulating ideas and resources around the world.

The idea of 'diaspora advantage' suggests how the linguistic skills, cultural knowledge and global networks constitute an advantage that benefits the members of the Asian diasporas personally and helps Australia extend its economic links with Asia, and promote a culture of innovation. Rather than a brain drain from the country of origin and brain gain for the country of residency, diasporas promote brain circulation as well as the circulation of people, and cultural and financial capital.

However, much of the available data on business in Australia is based on migration and ethnicity, which does not fully take into account diasporas. Hence new ways of mapping the number and contribution of business diasporas who circulate between countries are needed to deepen our understanding of business diasporas.

Challenges

In the past 15 years there have been positive shifts in public perceptions of Asia and Asians in Australia, which has contributed to a supportive climate for Asian business diasporas. Governments, business associations and industries appear committed to expanding economic links with Asia. However, opinions are mixed, and barriers still exist—including bureaucratic impediments, and the uncertainty in both Australia and Asia about the rules of business activities across borders.

Of key concern is the under-representation of Australia's Chinese and Indian business diasporas across government and in public office, on industry councils and business associations, in educational leadership, within peak bodies that promote Australia-Asia diplomacy, and in trade discussions and delegations. Diversity Council Australia identified only around 4 per cent of Australia's top 200 publically listed companies' board directors are of Asian descent. This underrepresentation of Australia's Asian diasporas occurs in an era that demands cultural understanding as well as technical knowledge and research.

Recognising the complex differences and historical sensitivities of how knowledge is created and information shared in China and India is essential to better business, policy processes and decision making. Australia's Asian business diasporas have a role in brokering this understanding, as well as helping Australian enterprises advance their Asia capability.

The Chinese and Indian governments are deeply conscious of their global diasporas – they plan to increase the benefits they already gain from the knowledge and skills of the estimated 40 million overseas Chinese and 25 million overseas Indians. They are active in developing policies that aim to increase trade, investment and research collaboration. In contrast, the policies of advanced economies, such as United States, Canada, Germany, Ireland and Singapore, are mostly designed to attract skilled migrants and investors who have business networks in Asia for improved economic productivity.

These nations' policies do not adequately address the dynamic circulation, connectivity and valued flexible forms of belonging to business diasporas. Australia has the potential to lead the world in developing policies and programs that encourage more effective engagement of the Asian business diasporas in building transnational networks for trade, investment and innovation.

Conclusion

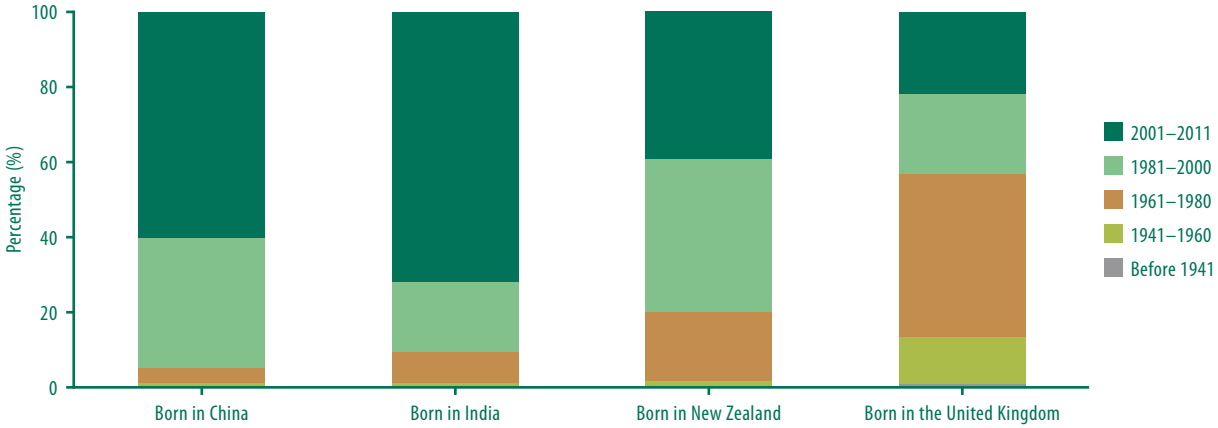
Multiculturalism and diversity have provided Australia with a strong foundation that may now benefit from a new approach—a diaspora approach—to developing policies and programs. Underlining this is a long-term vision for Australia in Asia, and vice versa.

This opportunity comes at an important time for Australia. China will soon pass the United States as the world's largest economy; India is the world's fastest growing economy and is likely to reach third behind China and the US by 2030. China has become Australia's number one trading partner. Just over half of Australia's two-way trade is conducted with countries of South, Southeast and East Asia. Asian investment in Australia has also risen.

To benefit from its diaspora advantage, Australian governments, businesses, and organisations need to:

- move from previous notions of migration and multiculturalism towards diaspora as a more apt concept with which to make sense of the ways in which people of Asian origins living and working in Australia can participate in the social, cultural and economic life of both Australia and their country of family origin
- develop mutually beneficial ways of using diaspora resources for research, cultural and business collaborations
- ensure a supportive culture and greater representation and participation of Asian diasporas in the development of policies and programs that strengthen Australia's economic, political and cultural relations with Asia
- link diasporas to science, technology and research infrastructures, business communities and industry, and the cultural resources embedded within the broader Australian community
- consider Australia's other Asian diasporas, especially with the Association of South East Asian Nations (ASEAN)—notably Indonesia, Vietnam and the Philippines—touted as the next emerging Asian economic powers.

Year of arrival of those born in China and India to Australia from 1941 to 2011, compared with major source countries of New Zealand and the United Kingdom. The number of permanent immigrants from China has doubled and from India tripled since 2001.



Sources: Australian Bureau of Statistics 2013, 2011 QuickStats Country of Birth: China, Australian Bureau of Statistics, Canberra, Australia; Australian Bureau of Statistics 2013, 2011 QuickStats Country of Birth: India, Australian Bureau of Statistics, Canberra, Australia.

13

Review of Australia's Research Training System

Australia's Higher Degree by Research (HDR) training system is critical to our future economic strength. It provides a highly qualified research workforce, enabling research and innovation across the academic, industry, government and not-for-profit sectors, as well as contributing substantially to Australia's and the world's body of knowledge.

This Review has engaged widely with stakeholders, including higher education and research institutes, HDR candidates and graduates, peak bodies, industry, business groups, government agencies, experts, and not-for-profit organisations in order to deliver evidence-based findings which identify opportunities to improve Australia's HDR training system.

There was broad agreement from stakeholders that Australia's HDR training system currently performs well in the areas of academic outputs. Other strengths identified include: a rich variety of choices in pathways; flexible entry requirements with provision for academic equivalence assessment; an independent, high quality examination process; and an emphasis on high quality disciplinary research and the development of associated research skills. Nevertheless Australia's performance in the area of industry-research collaboration is amongst the lowest when measured against OECD competitor countries. This situation is extremely concerning for a nation that strives to develop a vibrant knowledge based economy.

Evidence suggests that there is significant room for improvement across a range of important areas relevant to HDR training. These improvements, which are detailed below, need to be implemented with high priority to ensure that the system delivers the best returns on investment for HDR candidates, graduates, and the nation. Australia must aspire to improve its industry–university collaboration performance to equal that of the top 25 per cent of our OECD international competitors. We consider that research training has a crucial role to play in achieving this aspiration.

Improvements to Australia's HDR training system must be delivered by the sector in collaboration with key government and industry stakeholders, and reform initiatives must be undertaken in an environment which provides the necessary time and policy stability to develop and implement solutions, and assess their outcomes. The vital issues at the heart of improving our research training system are not the responsibility of any particular stakeholder (be it universities, industry, governments or communities). Solutions, however, require the effective coordination and collaboration of all stakeholder groups.

Most of the findings and recommendations arising from this Review build on the findings of previous reviews, both within Australia and overseas. We believe that additional reviews are unlikely to uncover fundamentally new insights. The system now needs a strategy to develop and implement responses to the recommendations and findings of the past decade's reviews. As such, this Review recommends that the Australian Government should support the establishment of a sector-based implementation working group to develop such a strategy and timeline for implementation.

Outcomes from this reform strategy should be subject to ongoing monitoring, but further reviews of research training in Australia should not be undertaken until the reforms have had enough time to take effect. The highly influential 'Roberts Review' in the United Kingdom (UK) was undertaken in 2002. The reforms arising from the Robert's Review were given 8 years to take effect before a further comprehensive review was undertaken in 2010. This Review considers that Australia's HDR training system requires a similar period of time to implement a reform strategy and assess its outcomes before being subject to another review.

The need for better data and information on the system itself was a common thread across the different areas of the review. Poor data on the performance of our HDR training system makes it difficult to understand what return is generated from Australian Government investment of more than $1 billion annually and how best to go about improving the system. Longitudinal data sets on HDR graduate outcomes would provide valuable information to drive performance improvements in the system and enable prospective HDR candidates to make informed choices about their HDR training. Further, international benchmarking of HDR training performance at the disciplinary level would provide a nuanced understanding of the actions needed to ensure our HDR training system remains world class.

Within this report collaboration and engagement with industry refers to any potential end user of research including but not limited to: businesses, governments, government business enterprises, non-government organisations, not-for-profit groups and community organisations. Research training has the potential to drive closer and broader engagement between industry and the university research sector, and contribute to reversing Australia's unacceptable international performance in this critical area. Increased industry linkages during research training, through placements with industry partners and undertaking industry-defined research projects, will drive the establishment of long-term relationships between industry and researchers. This will help to overcome the cultural differences that stand in the way of increased collaboration.

The successful Canadian Mitacs Accelerate program of industry placements for HDR candidates provides a useful model for the development of a national scheme in Australia. Building on the lessons of existing placement schemes, and catalysed by the funding recommended by the 2015 *Review of Research Policy and Funding Arrangements*, Australia's HDR training system has the potential to place thousands of HDR candidates with industry partners over the coming years. Such placements will not only build engagement and cultural understanding between research and industry, but will also provide another mechanism for HDR graduates to develop industry-relevant transferable skills and obtain good employment outcomes following graduation.

Some funding arrangements currently underpinning Australia's HDR training system are preventing it achieving the best possible outcomes. Australia's unique Honours year as an extended Bachelor qualification is currently the most accepted entry pathway into HDR training, but it may not be providing the best preparation for candidates to undertake research training. Innovative entry pathways, such as a for-purpose HDR training Masters degree, would improve the overall outcomes of Australia's HDR training system but the development of such pathways is currently limited by regulatory and funding restrictions. Such pathways could also provide increased opportunity for industry placements.

Greater flexibility in the HDR training funding structure would also enable universities to tailor support as required, such as aligning the length of scholarships with the duration of HDR training. Targeted funding arrangements can also drive increased participation by underrepresented groups: providing an increased weighting of completions for Indigenous HDR candidates would send an unambiguous signal about the importance of Indigenous participation in HDR training.

One of the most fundamental factors determining the quality of HDR training experiences and output is the quality of supervision. Most universities have taken steps to improve the supervision of HDR candidates, such as the introduction of supervisory committees and the provision of training for new supervisors, but there is much greater scope to address the standards and consistency of HDR training supervision. Universities should move towards the professionalisation of HDR training supervision through performance monitoring, ongoing regular training and professional development, recognising and rewarding excellence in supervision, and the application of professional standards to manage underperformance. There are a number of examples of best practice in the sector at present, the challenge is to standardise these practices across the sector. These initiatives would give HDR candidates confidence in the quality of supervision they can expect, and drive broad improvements in HDR training quality.

Improving the examination of HDR candidates would complement a focus on supervision quality. The graduate is the most important outcome of the research training process, and a more holistic reporting of their achievements would provide graduates with a stronger evidence base to communicate their value to prospective employers. Research training milestones could be leveraged by universities to provide useful reference points for the ongoing evaluation of HDR candidates, combined with the preparation of a skills portfolio to record their transferable skills development and industry experience.

The sector is aware of the changes required, as identified in this and previous reviews. A coordinated, strategic national response is urgently required. This response must be owned and developed jointly by the sector, industry and government. The resultant initiatives must have sufficient time and space to demonstrate progress before being subject to further reviews.

This excerpt is taken from McGagh, J, Marsh, H, Western, M, Thomas, P, Hastings, A, Mihailova, M, Wenham, M (2016) *Review of Australia's Research Training System*. Report for the Australian Council of Learned Academies, www.acola.org.au.

Program Steering Committee

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.

At the completion of the SAF Program on 30 June 2016, the PSC members were:

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Professor Andrew Holmes is a Melbourne University Laureate Professor of Chemistry, CSIRO Fellow and Distinguished Research Fellow (Imperial College, London).

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Professor John Fitzgerald FAHA is a leading expert on China, Australia and the geo-politics of the Asia-Pacific region.

Professor Glenn Withers AO BEc PhD FASSA

President, Academy of the Social Sciences in Australia

Glenn Withers is a Professor of the University at ANU. He was previously foundation Chief Executive Officer of Universities Australia and has held various earlier academic and government appointments, including as Professor of Public Policy at ANU, Head of the Economic Planning Advisory Commission under Prime Minister Keating and Co-Chair of the National Population Council under Prime Minister Hawke.

Professor Peter Gray BSc Chem Eng (hons) PhD FTSE FIEAust, FAICD

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Professor Peter Gray was appointed in 2003 as the inaugural Director of the Australian Institute of Bioengineering and Nanotechnology (AIBN) at the University of Queensland.

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