Introduction

We can't know the future, we can't predict it with great certainty, but we ought to know it's going to be different, so we may as well think as constructively as we can about how to make it better.

– Ian Chubb, launch of SAF08 Delivering Sustainable Urban Mobility, 7 October 2015

An evidence-based approach to informing policy

Early in the second decade of the 21st century, the Australian Government recognised that a rapidly evolving global environment presents both opportunities and challenges. The Government engaged the Australian Council of Learned Academies (ACOLA) to undertake a series of detailed interdisciplinary national and international assessments to help guide Australian thinking and policy decisions.

ACOLA, an independent organisation that links more than 2000 of Australia's most eminent academics to support evidence-based interdisciplinary research, harnessed the expertise from across the country's academies. This included many of Australia's most influential leaders in the humanities, arts and social sciences (HASS) and science, technology, engineering and mathematics (STEM) domains. They did extensive research and, based on extensive evidence, compiled a series of well-supported findings designed to encourage Australia to be creative and innovative, adaptable and resilient. The ultimate objective of the work is 'to secure the country's future'.

The scope of the SAF project was limited by the commission agreed between the government of the day and the Office of the Chief Scientist. There was no suggestion that the project would examine every major challenge facing Australia, so, for example, there was no specific report that examined health policy, nor the implications of Australia's demographic changes such as increased life expectancy. There was no report devoted to climate change, although the imperatives of environmental sustainability underpin many of the reports and this book. All pervasive, too, is the assumption that governments at all levels have responsibilities for providing leadership and, as much as possible, the social, political and economic policy settings to enable successful responses to the challenges identified by ACOLA.

Any significant challenge will often span many disciplines. It is essential to have an interdisciplinary approach to provide complementary worldviews when addressing complex policy issues. The interdisciplinary Securing Australia's Future research program aimed to identify Australia's distinctive strengths and advantages; to establish the contexts and policies that would encourage creativity and innovation, as well as adaptability and

resilience; and to explore the natural, geographical, economic, social, cultural and scientific characteristics and capabilities that Australia needs to succeed and thrive.

The term 'innovation' has many definitions. Here we use the word broadly, to mean the implementation of a new or significantly improved product (good or service), or process, a new marketing method or a new method in business practices, workplace organisation, external relations and public policy.

In this book, we have primarily used the 11 Securing Australia's Future reports (each summarised in the appendices) to draw out from an independent perspective the key findings, themes and threads that emerged from the program. These are presented as findings – rather than recommendations – as the SAF program sought to present analysis and research-based evidence grounded in the many related studies, providing a foundation for further future policy development. It was beyond our scope to draw on new research outside the research-based evidence delivered by the authors and expert panels associated with the 11 reports. We have not included references, but full lists of references are available in each of the reports listed below. Therefore, we have not aimed to provide a summary of the program or repetition of the 11 reports. Rather, this book is a synthesis and consolidation of the approximately one million words contained within the reports, distilled to independently interpret and represent ACOLA's findings.

Securing Australia's future

The Australian Government announced the Securing Australia's Future program in June 2012. In the face of an ever-uncertain future, the aim of the project, as described by then Chief Scientist Ian Chubb, was for trans-disciplinary researchers to come together for the benefit of the country: 'The answers to the challenges we face, and the contributions that can be made, don't come from one discipline; they actually require disciplines to work together in different ways from the ways that we have in the past.'

His sentiments were reflected in the foreword to the ACOLA report on technology and Australia's future by Robin Batterham, Former Chief Scientist of Australia and Fellow of the Australian Academy of Science and the Australian Academy of Technology and Engineering: 'Just because we are uncertain of the future doesn't mean that it is not clear that action is required … Interventions can succeed even in the face of the uncertain future.'

The Securing Australia's Future program was a four-year, $10 million research program, funded by the Australian Research Council. The program, responding to changes in Australia and around the world, aimed to identify and enable preparation for the opportunities and challenges that may arise through a period of transition in Australia's economy. It was conducted through ACOLA, by the Australian Academy of the Humanities, the Australian Academy of Science, the Academy of Social Sciences in Australia, and the Australian Academy of Technology and Engineering. Experts from across these disciplines worked together to deliver a series of 11 strategic research projects (see the details of each project below). ACOLA undertook the program for the Prime Minister's Science Engineering and Innovation Council (PMSEIC) and, subsequent to changes in October 2014, the Commonwealth Science Council, through the Office of the Chief Scientist.

Ian Chubb, as Chief Scientist, commissioned the learned academies to work together to investigate challenges and opportunities facing Australia. Such an undertaking could only have been possible through an interdisciplinary approach enabled by ACOLA (for more information on the genesis of the project, see the Preface by Ian Chubb). The four national

academies – covering the humanities, arts, social sciences, science, engineering and technology – worked together to deliver interdisciplinary, research-based evidence to support proactive policy development in areas of importance to our future (for more details about ACOLA's approach, see the Foreword by Michael Barber).

Six research topics were initially identified by PMSEIC. Another five topics were subsequently identified by ACOLA and then approved by the Australian Research Council and the Office of the Chief Scientist, as well as a summary of the program reports, and a review of higher degrees by research (the latter is not considered in this book).

The Securing Australia's Future reports are a unique contribution to the consideration of Australia's future, and an ambitious undertaking involving a dozen significant results delivered in a short period of three to four years. The reports resulted from informed discussions among experts from a wide range of fields. Such a wide-ranging interdisciplinary approach is novel. Richard Bissell from the US National Academies assessed the program, observing that, 'a fundamental tenet about the SAF'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'.

Bissell goes on to say that 'indeed, there is no comparable effort outside Australia that has been able to sustain such an integrated structure beyond a one-off study (for instance, in reports issued by the American Academy of Arts and Sciences). In that sense, the work of the SAF is not only a unique asset in Australia; it is also a model that academies abroad should watch closely to see whether it can be institutionalized'.

The program's interdisciplinary approach was not the only factor that made the work unique. The program accessed Australia's leading experts, scholars and practitioners, including through several expert panels; established relationships with public policy makers and influencers; and provided an assurance of quality and independence through the development of balanced and peer-reviewed findings.

Such interdisciplinary cooperation can be challenging. However, reading the reports suggests that the authors, expert working groups and steering committee members arrived at a large degree of consensus about the nature of the issues and, to some extent, about the solutions.

Securing Australia's Future uses research concepts and methods drawn from across the range of academic disciplines to help address fundamental issues involved in positioning Australia for the future. The program focuses on the medium and the long term, and also on the pathways that need to be built between today and that future. Many aspects of Australia's past, present and – in particular – future are considered, including the characteristics of our environment, biodiversity, location, population and culture, and other attributes that define the unique domains where the country can succeed in an evolving global environment. Securing Australia's Future examines what makes Australia an attractive international partner in research and development, industry and innovation. It also identifies the advantages we have and can build on to help the country enhance productivity, innovation, fairness and equity.

Golden threads

ACOLA's Securing Australia's Future (SAF) program provides evidence demonstrating that continued increases in Australia's productivity and economic growth can be achieved by stimulating creativity, instilling adaptability and fostering innovation. Embracing an

education system that values excellence in the pursuit of knowledge across all domains – science, technology, engineering, mathematics (STEM), humanities, arts and social sciences (HASS) – the 11 SAF reports call for a system that extends Australia's strengths and finds opportunities for a confident, regionally connected and globally minded nation.

This book identifies cross-cutting themes and common threads from across all 11 SAF reports (see below). Each chapter explores an overarching theme and distils the interdisciplinary research and evidence presented as a single 'golden thread':

1. A prosperous future is more than just technological advancement. For us to secure an Australian future characterised by social wellbeing and increased equity, prosperity and sustainability, we need to understand international trends and position Australia to take maximum advantage of its strengths. Achievement will entail economic, social and cultural changes, facilitated by visionary leadership and by targeted investments in skills, infrastructure and innovation.

2. Australia must celebrate its relationships in the Asia-Pacific region. We need to engage better and cement Australia's prominent place in the Asia-Pacific region. Finding these new opportunities must embrace the invaluable resources of Asian and Pacific communities by improving Australia's language ability, increasing cultural awareness, building on current export strengths and extending networks and linkages.

3. Building the industries of the future will enhance productivity and ensure resilience. Adapting to change and creating new opportunities for all Australians in the future require increased investment in research and development, a commitment to innovation, better links between business and research, and the training and use of an innovation-capable workforce that effectively combines HASS and STEM capabilities for creative problem solving.

4. Australia must maintain its strong and broad foundations in education, including STEM subjects. We should nurture and challenge those who are enthusiastic in STEM, by better engaging primary and secondary school students, and supporting teachers. A major objective should be increasing participation in STEM by girls, those from lower socioeconomic backgrounds and Indigenous students. One immediate initiative would be a well-funded national STEM coordinating agency.

5. Providing global leadership on environmental sustainability and adaptation is an area of great opportunity for Australia. With strengths in innovative research and a focus on community adoption consistent with a need to achieve a social licence to operate, Australia can seek to develop its own capabilities and give global advice on urban planning, transport and clean energy solutions. Achievement will protect our clean and green environment and international reputation.

To meet these cross-cutting objectives, we provide key findings in each chapter that need to be addressed and implemented for us to secure the country's future.

Interdisciplinary research topics

The golden threads above were synthesised from 11 SAF reports. Specifically, the reports are as follows:

1. *Australia's Comparative Advantage*, by Withers G, Gupta N, Curtis L and Larkins N (2015) (http://acola.org.au/wp/project-1/), as summarised in Appendix 1. The

report provided a national roadmap for decisions about the future and the conditions that can underpin us creating and taking advantage of Australia's strengths while ensuring flexibility and resilience.

2. *STEM: Country Comparisons*, by Marginson S, Tytler R, Freeman B and Roberts K (2013) (http://acola.org.au/wp/project-2/), as summarised in Appendix 2. The report focused on strategies, policies and programs used to enhance STEM at all levels of education and work, examining solutions to the STEM skills shortage in Australia.

3. *Smart Engagement with Asia: Leveraging Language, Research and Culture*, by Ang I, Tambiah Y, and Mar P (2015) (http://acola.org.au/wp/project-3/), as summarised in Appendix 3. The publication provided insights into the complexities of our relationships in the region, and laid out a blueprint for the bridges Australia can build to improve connections between people, businesses and institutions.

4. *The Role of Science, Research and Technology in Lifting Australian Productivity*, by Bell J, Frater B, Butterfield L, Cunningham S, Dodgson M, Fox K, Spurling T and Webster E (2014) (http://acola.org.au/wp/project-4/), as summarised in Appendix 4. The document identified 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.

5. *Technology and Australia's Future*, by Williamson R, Raghnaill M, Douglas K and Sanchez D (2015) (http://acola.org.au/wp/project-5/), as summarised in Appendix 5. This entailed 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.

6. *Engineering Energy: Unconventional Gas Production*, by Cook P, Beck V, Brereton D, Clark R, Fisher B, Kentish S, Toomey J and Williams J (2013) (http://acola.org.au/wp/project-6/), as summarised in Appendix 6. The publication filled knowledge gaps, identified and considered community concerns, and addressed opportunities and challenges that might arise in producing shale gas.

7. *Australia's Agricultural Future*, by Daly J, Anderson K, Ankeny R, Harch B, Hastings A, Rolfe J and Waterhouse R (2015) (http://acola.org.au/wp/7-australias-agricultural-future/), as summarised in Appendix 7. The report provided a vision of Australian agriculture's future, and mapped the pathway towards enhancing our outstanding reputation in agriculture, while producing more food in a sustainable way.

8. *Delivering Sustainable Urban Mobility*, by Armstrong B, Davison G, de Vos Malan J, Gleeson B and Godfrey B (2015) (http://acola.org.au/wp/8-delivering-sustainable-urban-mobility/), as summarised in Appendix 8. The publication called 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.

9. *Translating Research for Economic and Social Benefit: Country Comparisons*, by Bell J, Dodgson M, Field L, Gough P and Spurling T (2015) (http://acola.org.au/wp/saf09/), as summarised in Appendix 9. The work analysed international

approaches to encouraging and facilitating research translation, commercialisation and collaboration.

10. *Skills and Capabilities for Australian Enterprise Innovation*, by Cunningham S, Gahan P, Boal K, Callan V, Sridhar T and Zeitz C (2016) (http://acola.org.au/wp/saf10/), as summarised in Appendix 10. ACOLA 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.

11. *Australia's Diaspora Advantage: Realising the Potential for Building Transnational Business Networks with Asia*, by Rizvi F, Louie K and Evans J (2016) (http://acola.org.au/wp/saf11/), as summarised in Appendix 11. The report explored the extent, diversity and nature of Australia's Asian business diasporas.

In addition, a twelfth report provided a review of the above 11 reports, *Securing Australia's Future Program: Summary Report*, by the ACOLA Secretariat Ltd (2016) (http://acola.org.au/wp/saf12/). The document drew on the 11 appendices in this book to provide a summary of the Securing Australia's Future program.

There was also a comprehensive review of higher degree by research training in Australia, commissioned by the Minister for Education and Training and funded under the Securing Australia's Future program. The report was entitled *Review of Australia's Research Training System*, by McGagh J, Marsh H, Western M, Thomas P, Hastings A, Mihailova M and Wenham M (2016) (http://acola.org.au/wp/saf13-rts-review/).

The Securing Australia's Future Program Steering Committee was responsible for the overall quality of the program, including selection of the Expert Working Groups (members are listed in the appendices) and the peer-review process. In total, 56 Fellows from the four academies and 19 experts from outside the academies participated as members of Securing Australia's Future Expert Working Groups (about three-quarters of these were from universities). The Program Steering Committee comprised three Fellows from each of the four learned academies: Alan Finkel and then Michael Barber as Chair, with Dennis Trewin (Deputy Chair), James Angus, John Burgess, Bruce Chapman, Ruth Fincher, Paul Greenfield, Lesley Head, Peter McPhee, Stephen Powles, Susan Pond and Graeme Turner, as well as previous members Mark Finnane, Margaret Hartley, Iain McCalman, Graham Mitchell, Jim Peacock, John Quiggin, Leanna Read, Julianne Schulz and Richard Waterhouse.

The Australian Council of Learned Academies (ACOLA)

We must pursue innovation through technology as the main contributor to our future prosperity and happiness … Invoking the four academies covering the humanities, social sciences, science and engineering and technology was a brilliant step as any challenge of significance inevitably spans across the disciplines.

– Robin Batterham, SAF05 *Technology and Australia's Future*

ACOLA (www.acola.org.au) is an independent, not-for-profit organisation that supports evidence-based interdisciplinary research. It was established in 2010, as the successor to the National Academies Forum that had been established in 1995. It comprises a council and board, and an independent, not-for-profit secretariat that receives funding from the Australian Research Council and the Department of Education. 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.

The organisation combines the strengths of the four Australian learned academies: the Australian Academy of the Humanities, the Australian Academy of Science, the Academy of Social Sciences in Australia, and the Australian Academy of Technology and Engineering.

The Australian Academy of the Humanities (www.humanities.org.au) 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. It 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 program, and provides authoritative and independent advice to governments, industry, the media and the public on matters concerning the humanities.

The Australian Academy of Science (www.science.org.au) was established by Royal Charter in 1954 to provide independent, authoritative and influential advice, to build public awareness and understanding of science, to promote international scientific engagement and to champion, celebrate and support excellence in Australian science. The Academy comprises more than 500 of Australia's leading scientists, each of whom is elected for their outstanding contributions to science. The Academy represents Australian science internationally through membership of international unions and councils, and through exchanges, events and meetings. The Academy also promotes science and mathematics education in schools through its widely used inquiry-based education programs.

The Academy of the Social Sciences in Australia (www.assa.edu.au) 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, promotes national and international scholarly cooperation across disciplines and sectors, comments on national needs and priorities in the social sciences and provides 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 some 600 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.

The Australian Academy of Technology and Engineering (ATSE, www.atse.org.au) advocates 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 most intellectually and experimentally able in technological sciences and engineering in Australia. Through engagement by

its Fellows, the Academy provides robust, independent and trusted evidence-based advice on technological issues of national importance. It does 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 inquiry-based learning, teaching quality and career promotion. ATSE fosters national and international collaboration and encourages technology transfer for economic, social and environmental benefit.

By linking more than 2000 of Australia's most eminent researchers, scholars and practitioners from these four academies, ACOLA enables interdisciplinary thinking to help solve complex societal issues for the benefit of Australia's social, cultural, economic and environmental wellbeing. ACOLA's strength is in pulling together interdisciplinary perspectives from across the HASS and STEM disciplines, bringing different expertise and methodologies to some of the most complex issues and questions facing the nation. It is this strength that enabled the delivery of the Securing Australia's Future program and allowed ACOLA's reports to provide a rich understanding of the opportunities and challenges in Australia.