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Boosting R&D outcomes in Australia

Vassiliki Koutsogeorgopoulou,

Taejin Park

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ABSTRACT/RÉSUMÉ

Boosting R&D outcomes in Australia

R&D activity can play a central role in raising productivity. Australia compares well in terms of research excellence. However, there is scope for better translation of publicly funded research into commercial outcomes. Strengthening incentives for collaborative research is essential. A simpler funding system for university research that provides sharper and more transparent incentives for research partnerships is important in this regard. Research-business linkages would also be boosted by more effective programmes encouraging business to collaborate, measures promoting greater mobility of researchers between the two sectors, and steps to ensure that intellectual property arrangements are not a barrier to knowledge. In Australia financial support for encouraging business innovation relies mostly on an R&D tax incentive; raising additionality and reducing compliance costs would enhance the effectiveness of the scheme. Maximising the benefits from public investment in research further hinges upon a well-coordinated science, research and innovation system through a "whole-of-government" approach and consolidating certain programmes. Reform initiatives underway, notably those in the National Innovation and Science Agenda, are welcome.

JEL codes: O30, O38, I23
Keywords: Australia, collaboration, commercialisation, co-ordination, evaluation, funding, innovation, intellectual property, R&D, tax incentives

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Améliorer les résultats de la R-D en Australie

Les activités de R-D peuvent jouer un rôle central dans le relèvement de la productivité. Sur le plan de l'excellence de la recherche, l'Australie obtient des résultats flatteurs. Cependant, il est encore possible de parvenir à une meilleure traduction, sur le plan commercial, des travaux de recherche financés par des fonds publics. Il est à cet égard essentiel de renforcer les incitations à la recherche concertée. Les liens entre les milieux de la recherche et les entreprises se trouveraient également renforcés par la mise en place de programmes plus efficaces visant à encourager les entreprises à collaborer, par l'adoption de mesures destinées à favoriser une plus grande mobilité des chercheurs entre ces deux secteurs et par des actions ayant pour objet de garantir que les dispositions relatives à la propriété intellectuelle ne constituent pas un obstacle à la connaissance. En Australie, les aides financières visant à encourager l'innovation dans les entreprises prennent principalement la forme d'une incitation fiscale à la R-D; favoriser une mobilisation accrue de ressources additionnelles et réduire les coûts du respect de la législation permettraient d'accroître l'efficacité du mécanisme. Maximiser les retombées de l'investissement public dans la recherche suppose en outre une bonne coordination des activités scientifiques, de la recherche et de l'innovation, grâce à une approche à l'échelle de l'ensemble de l'administration et au regroupement de certains programmes. Il convient de saluer les initiatives de réforme en cours, notamment celles qui concernent le Programme national pour l'innovation et la science (National Innovation and Science Agenda).

Classification JEL : O30, O38, I23
Mots-clés : Australie, collaboration, commercialisation, coordination, évaluation, financement, innovation, propriété intellectuelle, R-D, incitations fiscaux

TABLE OF CONTENTS

Innovation input is stronger than output 6
Australia can make more out of its R&D spending 6
Weak collaboration between research and business sectors remains a key issue 14
What explains the low level of collaborative research? 14
Policy levers for strengthening collaboration between the research and business sectors 18
Reforming university research funding and monitoring better the broader benefits of research 18
Encouraging business to become more active in collaborative research 21
Ensuring a more effective management of IP by universities 23
Removing barriers to industry-relevant research training and mobility between sectors 24
Achieving greater commercial impact from Australia's public-sector research 25
Tax incentives form the core of Australia's financial support for business R&D 28
There are challenges in making the R&D Tax Incentive more effective 30
Ensuring integrity and containing cost 32
Enhancing administrative efficiency 33
Is there a case of rebalancing the mix of support? 33
Enhancing coherence and co-ordination in the science, research and innovation system 34
A complex system with many players 34
Reforms underway could go further 34
Strengthening the monitoring and evaluation of innovation programmes 35
Recommendations on boosting R&D outcomes 36

REFERENCES 37

Figures

1. There is scope to better match innovation input and output 6
2. Australian Government support for science, research and innovation by sector 7
3. Research quality compares well internationally 8
4. R&D trends and international comparisons 9
5. Decomposition analysis on business R&D intensity 10
6. R&D expenditure by source of funding 11
7. Some critical innovation outcomes are low in international comparison 12
8. Australia's patent performance below average 12
9. Commercialisation outcomes are lagging behind 13
10. Collaborative research in limited 15
11. International collaboration performance is mixed 16
12. Trends in CRC and funding composition of CO2CRC 17
13. Higher education R&D expenditure by source of funding 19
14. University R&D expenditure on engineering and technology is low 21
15. The commercial impact of public-sector research could be strengthened 26
16. Government support for business R&D: trends and international comparisons 29
17. Cost developments of the of R&D Tax Incentive 30

Boxes

1. Australia's research system 7
2. Explaining changes in Australia's R&D, intensity versus composition 10
3. Australia's Cooperative Research Centres programme: an example of strong collaborative research 17
4. The main features of the reform of the higher education research arrangements 20
5. The pros and cons of a "use it or lose it" scheme for publicly funded IP in universities 24
6. CSIRO: Main features 26
7. R&D Tax Incentive: main features 28
8. Innovation and Science Australia 34

BOOSTING R&D OUTCOMES IN AUSTRALIA

By Vassiliki Koutsogeorgopoulou and Taejin Park[1]

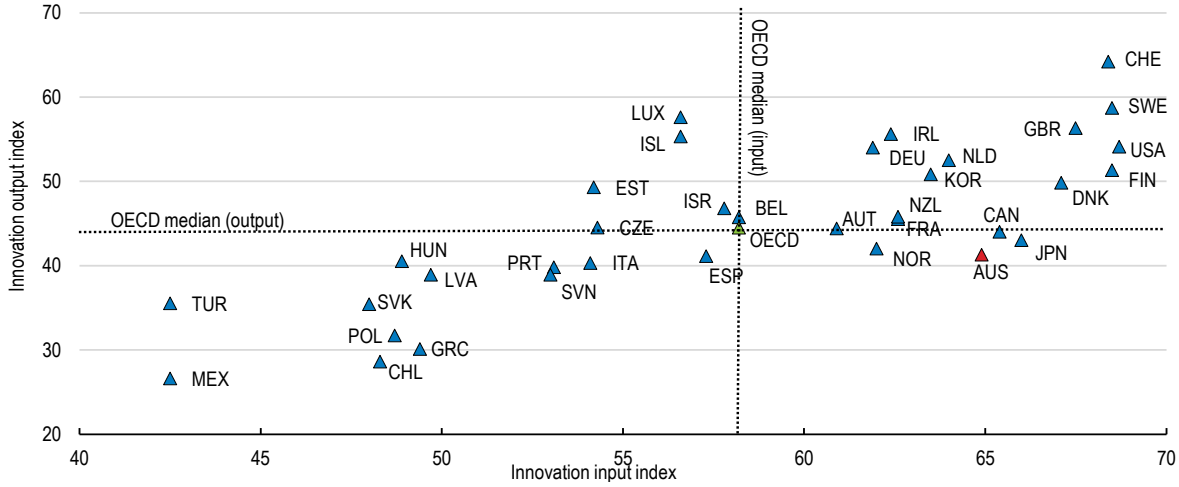
Innovation input is stronger than output

Australia can make more out of its R&D spending

Australia is well above the OECD median in terms of overall innovation "input", according to the *2016 Global Innovation Index* (Figure 1), reflecting a well-developed research system (Box 1), a strong skill base and a supportive institutional framework. Measures of research excellence, such as publications in top international scientific journals and citations, reveal a healthy "academic impact" (Figure 3, Panels A to C). Furthermore, six Australian universities rank among the top 100 on the basis of research-related indicators (Figure 3, Panel D).

Figure 1 **There is scope to better match innovation input and output**

Global Innovation Index: input-output matrix, 2016[1]



1. Innovation input measures include: institutions, human capital and research, infrastructure, market and business sophistication. Output measures include: knowledge and technology outputs and creative outputs. The indicators were normalised into the [0,100] range, with higher scores representing better outcomes.

Source: Cornell University, INSEAD, and WIPO (2016): The Global Innovation Index 2016: Winning with Global Innovation.

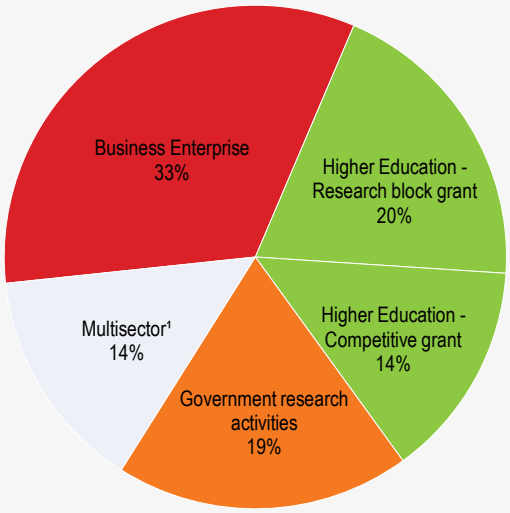
[1] Vassiliki Koutsogeoropoulou is with the OECD Economics Department. Taejin Park was with the Economics Department when this paper was written and is now at the Bank for International Settlements. The authors would like to thank Alvaro Pereira, Robert Ford, Piritta Sorsa, Philip Hemmings (OECD Economics Department), colleagues from the Directorate for Science, Technology and Innovation and other Departments of OECD and experts from the Australian Government for their valuable comments and feedback. Special thanks go to Anthony Bolton (OECD Economics Department) for administrative assistance.

Box 1 **Australia's research system**

Australia's research system consists of universities, public-sector research agencies (PSRAs), businesses, and also an array of smaller organisations and structures (Australian Universities, 2014). In particular:

- There are currently 41 universities (3 of which are private). Higher education absorbs the largest share of Commonwealth support for science and innovation (34% of total in 2016-17) (Figure 2). University research is supported through a "dual" federal funding system of competitive grants and Research Block Grants (RBG) (discussed further below). The competitive grant component is made up of merit-based, peer-reviewed programmes, administrated mainly by the *Australian Research Council* (ARC) and *National Health and Medical Research Council* (NHMRC) (Watt, 2015a,b). These competitive programmes only cover the direct costs of the research projects. RBG are not tied to specific projects and support the indirect costs (e.g. overheads, facilities and equipment) of competitive grant-funded research.

Figure 2 **Australian Government support for science, research and innovation by sector, 2016-17**

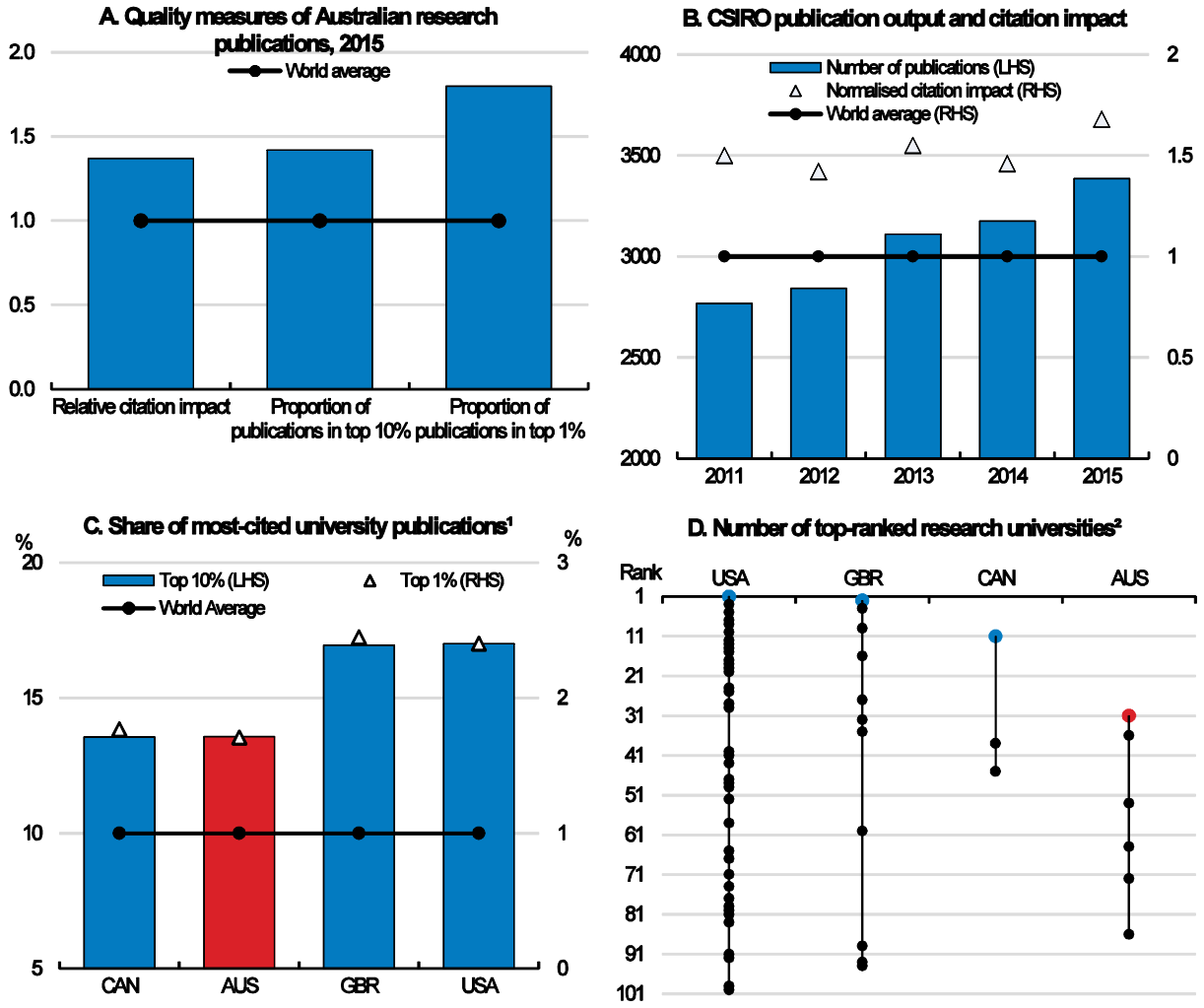


1. Multisector includes R&D expenditure on activities that may be undertaken within more than one of the other sectors (e.g. NHMRC grants are available to universities but also to medical research institutes, government bodies and hospitals).

Source: Australian Department of Industry, Innovation and Science (2016), The Australian Government's 2016-17 Science, Research and Innovation Budget Tables.

- Australia's most prominent public-sector research agency (PSRA) is the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (discussed further below). Other agencies include, for instance: the Defence Science and Technology Organisation (DSTO), Australian Nuclear Science and Technology Organisation (ANTO), Geoscience Australia, and Australian Institute of Marine Science (AIMS).
- Australia's research system also includes other organisations and structures. The *Cooperative Research Centres* (CRC) programme, for instance, supports end-user driven collaboration among publicly funded researchers, business and the community. The number of CRC programmes has fallen in recent years (there were 33 programmes in 2015-16, compared with 70 in 2006). There are also 15 *Rural Research and Development Corporations* (RDCs) that fund government-industry research projects. Moreover, there are many non-profit research institutes, for instance, over 60 in medical research (Australian Universities, 2014).

Figure 3 **Research quality compares well internationally**



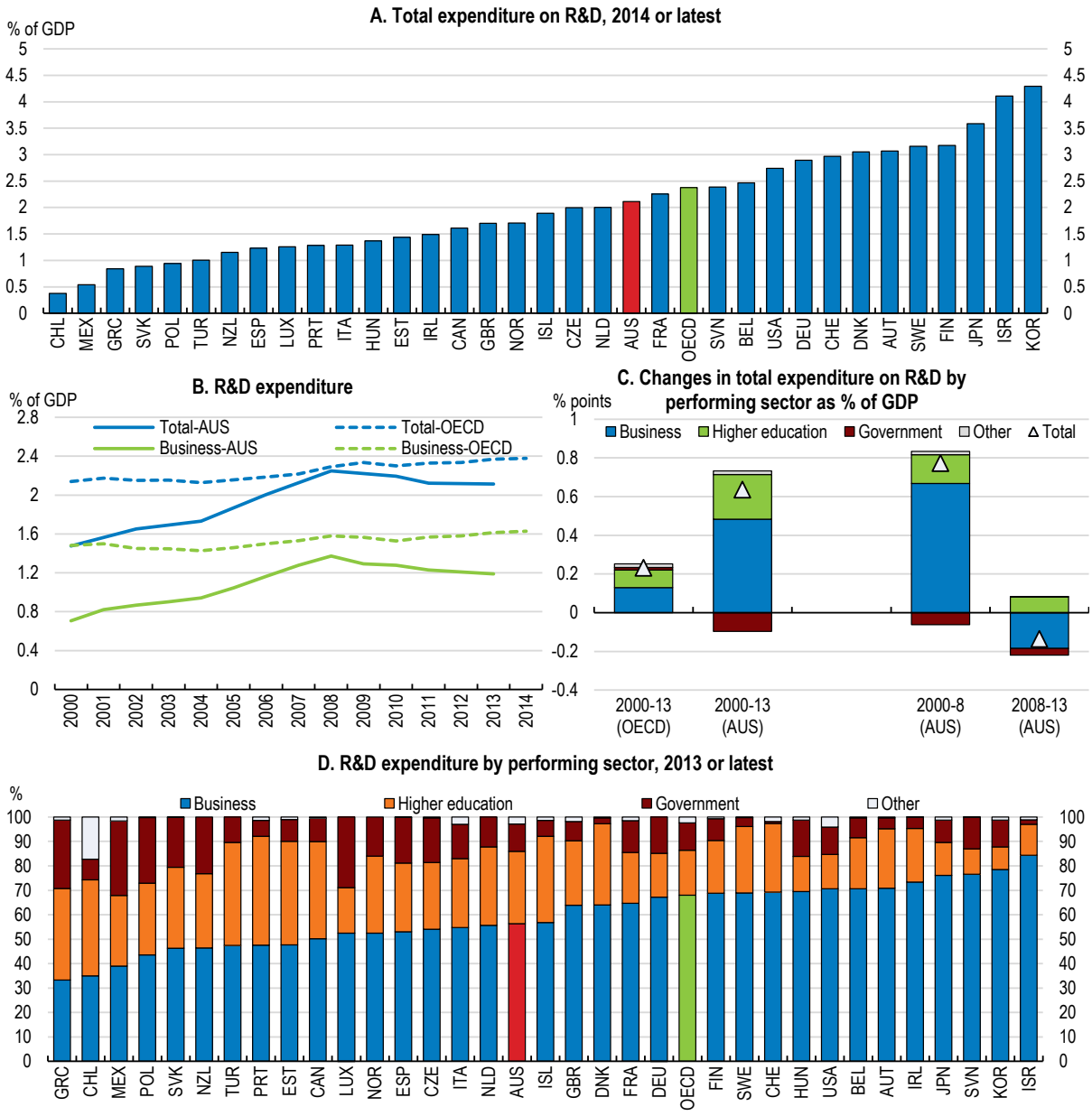
1. Data are based on publications produced during 2011-14. For each country, only universities with at least 5000 publucations during the period are considered.

2. Number of universities in each country that are ranked in the top 100 of Times Higher Education (THE) World University Rankings 2015-16. The ranking of each country is depicted on a line connecting the highest and lowest ranked ones among the world top 100 universities. The research score is calculated as a weighted average of three relevant indicators: research reputation (60%), research income (20%) and research productivity (20%).

Source: Australian Department of Industry, Innovation and Science (2016), Australian Innovation System Report 2016; CSIRO (2016), Annual Report 2015–16; Leiden University (2016), CWTS Leiden Ranking 2016; Times Higher Education (2016), World University Rankings 2015-2016.

Gross expenditure on R&D (GERD) as a percentage of GDP in Australia is middle-ranking (Figure 4, Panel A). This measure of R&D intensity grew rapidly between 2000 and 2008, catching up with the OECD average (weighted), but has fallen in recent years (Figure 4, Panels B and C). This decline mainly reflects trends in the business sector, and in particular a slowdown in mining-related R&D associated with the end of commodity-sector boom (Figure 4 and Box 2). The higher education sector has contributed positively with its share in total R&D exceeding the OECD average in 2013 (Figure 4, Panels C and D). The share of the government-performed R&D fell somewhat between 2000 and 2013; however, this only partially reflects the government's role as it supports R&D in universities and businesses via grants and tax incentives (Figure 6).

Figure 4 **R&D trends and international comparisons**



Source: OECD (2016), OECD Main Science and Technology Indicators (database).

Box 2 **Explaining changes in Australia's R&D, intensity versus composition**

Changes in economy-wide R&D intensity can arise from changing intensities within sectors of the economy but also from changes in industry composition (i.e. structure effects), for example, through rapid growth in R&D-intensive sectors such as pharmaceuticals and ICT equipment. More formally:

$$\text{Business R\&D intenstity} \quad (\text{I}) = \frac{Business\ R\&D\ (RD)}{Business\ VA\ (Q)} = \sum_{i=sector} \frac{Q_i}{Q}\frac{RD_i}{Q_i} = \sum_i S_i I_i = Structure\ effect \times \text{Within} - \text{sector}\ Intensity\ effect$$

Calculations carried out for this *Survey* used the additive Logarithmic Mean Divisia Index method (Ang, 2004):

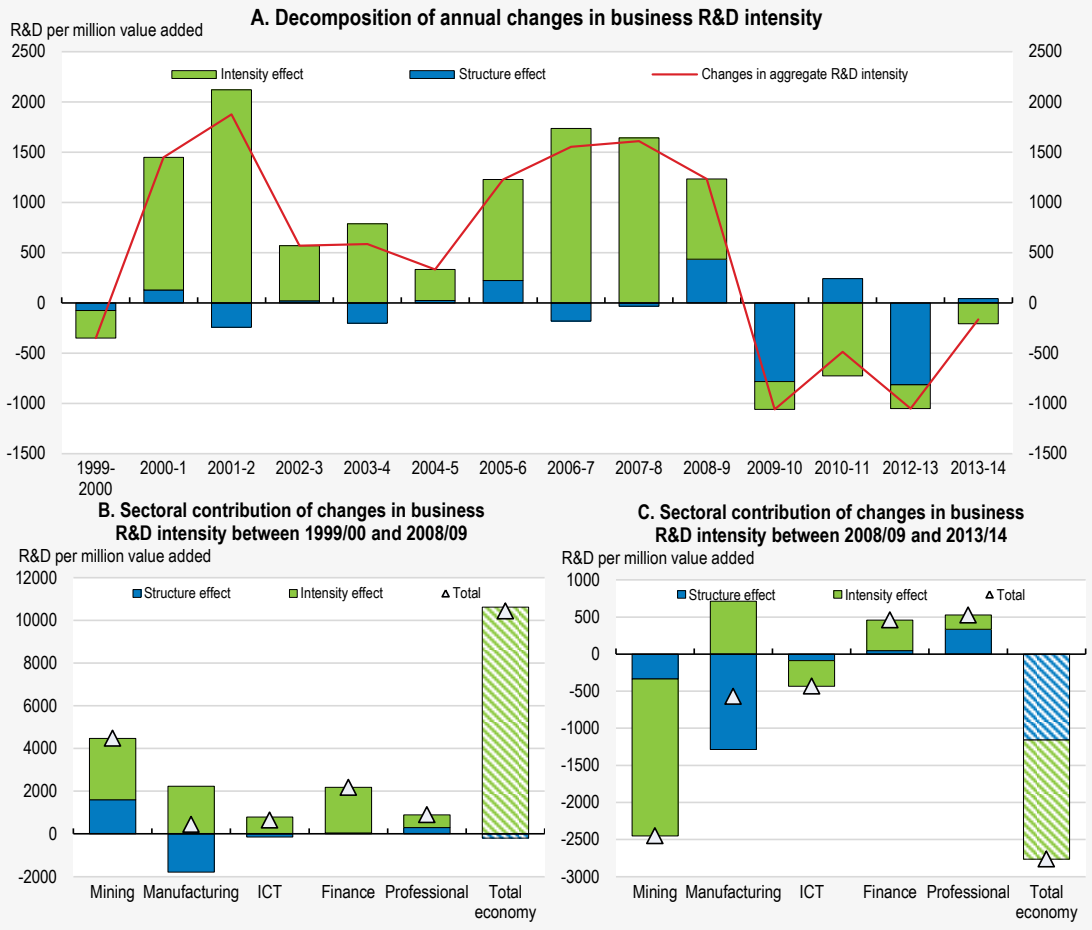
$$\text{Changes in total intensity } (\Delta \text{I}) = I^T - I^0 = \sum_i S_i^T I_i^T - \sum_i S_i^0 I_i^0$$

$$= \sum_i L(\frac{RD_i^T}{Q^T}, \frac{RD_i^0}{Q^0}) \ln(\frac{S_i^T}{S_i^0}) + \sum_i L(\frac{RD_i^T}{Q^T}, \frac{RD_i^0}{Q^0}) \ln(\frac{I_i^T}{I_i^0}) = \Delta I_{structure} + \Delta I_{Intensity}$$

$$where\ L(a,b) = \frac{a-b}{(lna - lnb)} (i.e.\ logarithmic\ mean)$$

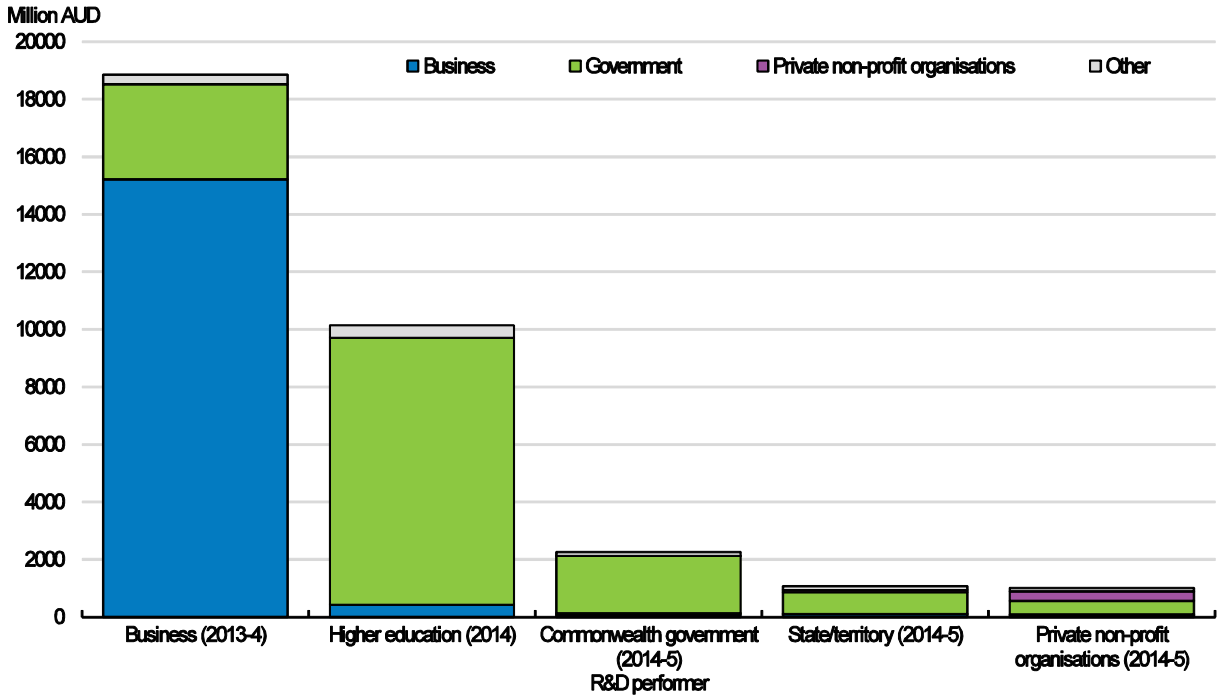
According to the results, the continuous increases in Australia's business R&D intensity between 2000/01 and 2008/09 were largely driven by growth in within-sector intensity. However, the intensity has been falling since the global financial crisis, through both within-sector intensity and structural effects. (Figure 5, Panel A). Examination of specific industries reveals that the post-global financial crisis fall in intensity is mainly due to developments in R&D investment in mining, especially in metal ore mining, and lower output share of manufacturing, the country's most R&D intensive sector (Figure 5, Panels B and C).

Figure 5 **Decomposition analysis on business R&D intensity**



Source: OECD calculations based on ABS (2015), 8104.0 - Research and Experimental Development, Businesses and 5204.0 - Australian System of National Accounts, 2015-16.

Figure 6 R&D expenditure by source of funding



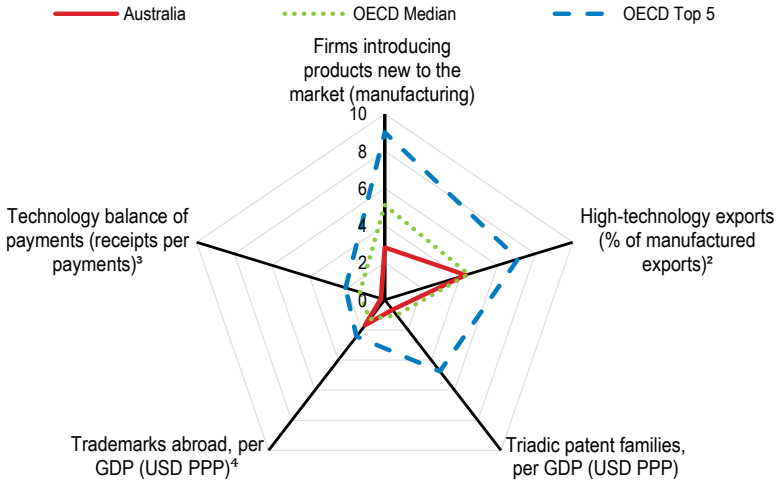
Source: ABS, 8104.0 - Research and Experimental Development, Businesses, Australia, 2013-14; 8109.0 - Research and Experimental Development, Government and Private Non-Profit Organisations, Australia, 2014-15; 8111.0 - Research and Experimental Development, Higher Education Organisations, Australia, 2014.

While the inputs of Australia's innovation system rank high among OECD countries, output indicators are less impressive. Innovation output is, of course, difficult to measure. According to the *Global Innovation Index*, Australia's output is only around the median (Figure 1), and specific indicators, such as triadic patents and "new-to-market" innovations, compare unfavourably internationally (Figure 7). To an extent, the low rates of "creative" innovation can be explained by the importance of "imported" innovation in Australia (see Chapter 1 of *the 2017 Economic Survey of Australia* (OECD, 2017)). The large weight of the mining sector in the Australian economy may be an additional reason for the relatively weak innovation outcomes as the sector has a comparatively low patent intensity (OFHIM, 2013). However, even compared with other advanced resource-rich countries, Australia ranks low in terms of patent-based measures (Figure 8). It also performs poorly in translating publicly funded research into commercial outcomes. Patenting revenue and other measures of knowledge flow and commercialisation, including the impact of publicly funded research on patents and start-up companies formed, lag behind those in OECD peers (Figure 9).

The remainder of this paper examines avenues for improving Australia's translation of its research knowledge into commercial outcomes focusing on four areas: collaboration between research and business sectors, public-sector research agencies, R&D tax incentives and governance and monitoring of the innovation system.

Figure 7 **Some critical innovation outcomes are low in international comparison**

Innovation output indicators[1]

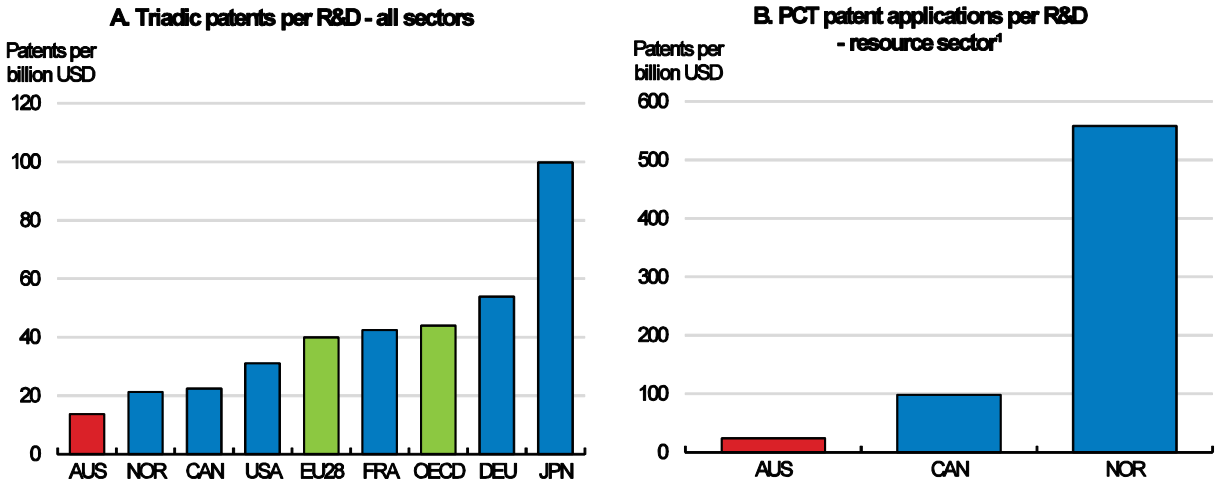


1. Indicators are normalised by re-scaling to be from 0 (worst) to 10 (best).
2. High-technology exports are R&D-intensity products, such as aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.
3. This measure consists of money paid, or received, for the use of IP and technical services (including technical assistance) and for industrial R&D carried out abroad, etc.
4. Trademarks abroad correspond to the number of applications filed at the United States, EU and Japan, by application date and country of residence of the applicant. For the United States, EU members and Japan, counts exclude applications in their domestic market. Counts are rescaled by taking into account the relative average propensity of other countries to file in these three offices.

Source: OECD (2015), OECD Science, Technology and Industry Scoreboard 2015; World Bank (2016), World Development Indicators (database); OECD (2014), OECD Science, Technology and Industry Outlook 2014; OECD, Main Science and Technology Indicators (database).

Figure 8. **Australia's patent performance is below average**

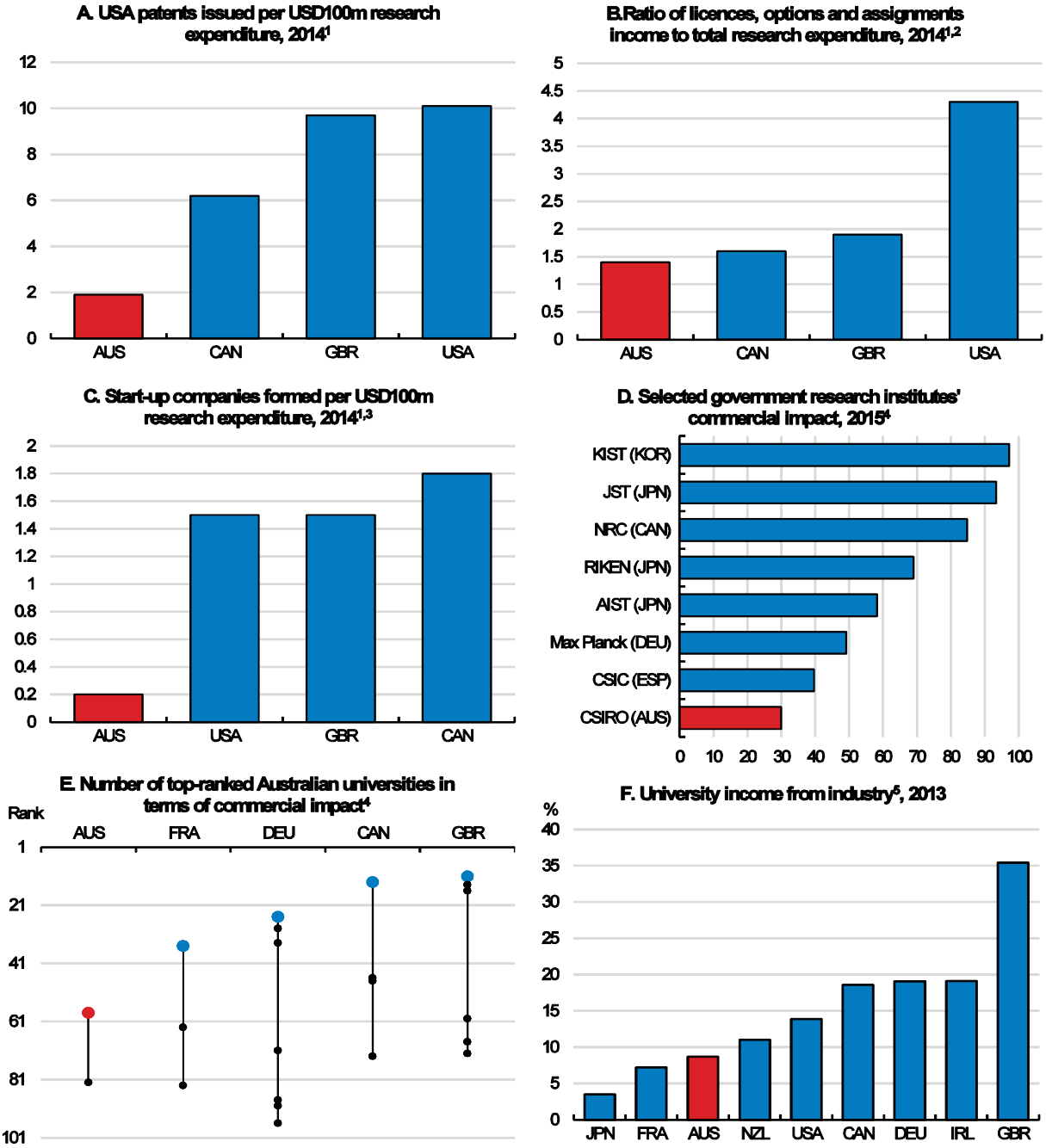
Patent intensity, 2013



1. Patent application for resource sector is defined according to International Patent Classification E21 (earth or rock drilling; mining).

Source: OECD (2016), OECD Main Science and Technology Indicators.

Figure 9 **Commercialisation outcomes are lagging behind**



1. Data for publicly funded research organisations, which include universities, publicly funded research agencies and medical research institutes.
2. A licence agreement formalises the transfer of technology between two parties. An option agreement grants the potential licensee a period to evaluate the technology and negotiate a licence agreement. An assignment agreement conveys all rights, titles and interests in the licenced subject matter to the named assignee.
3. Start-up companies that are partially or entirely dependent on the licensing or assignment of an institution's technology for initiation.
4. "Commercial impact" indicates how often basic research originating at an institution has influenced commercial R&D activity, as measured by academic papers cited in patent filings. The selection of institutes is based on comparable annual budget size.
5. Includes funds from business enterprises, private non-profit and abroad.

Source: Australian Department of Industry, Innovation and Science (2016), National Survey of Research Commercialisation (NSRC); Reuters (2016), Top 25 Global Innovators – Government; Scimago Lab (2016), Scimago Institutions Rankings; OECD (2015), OECD Science, Technology and Industry Scoreboard 2015.

Weak collaboration between research and business sectors remains a key issue

Australia's difficulty in commercialising publicly funded research reflects a low level of collaborative research, which is an increasingly recognised channel of knowledge transfer (OECD, 2013; OECD, 2015a). Australia ranks last among 26 OECD countries with respect to the proportion of businesses collaborating with higher education or public-sector research agencies on innovation (Figure 10, Panel A). Only 3% of Australian innovation-active firms source their ideas from the research sector, while 60% of ideas come from sources within the firm, though the results vary somewhat across sectors and with the size of firm (Figure 10, Panels B and C).

Australia also has a low incidence of co-authored publications between industry and the research sector and a comparatively low concentration of researchers in the business sector, suggesting low mobility between the two sectors (Figure 10, Panels D and E). Evidence on international linkages is more mixed: co-operation on publications and patenting is below the OECD average, but international mobility of scientific authors is relatively high (Figure 11).

There are undoubtedly good examples of research-industry collaboration in Australia such as the Cooperative Research Centre for Green House Gas (Box 3) and the partnership between the University of New South Wales and Onesteel for the development of specific technologies (Watt, 2015a). However, it is clear that, in broad terms, there is room for improvement on this front.

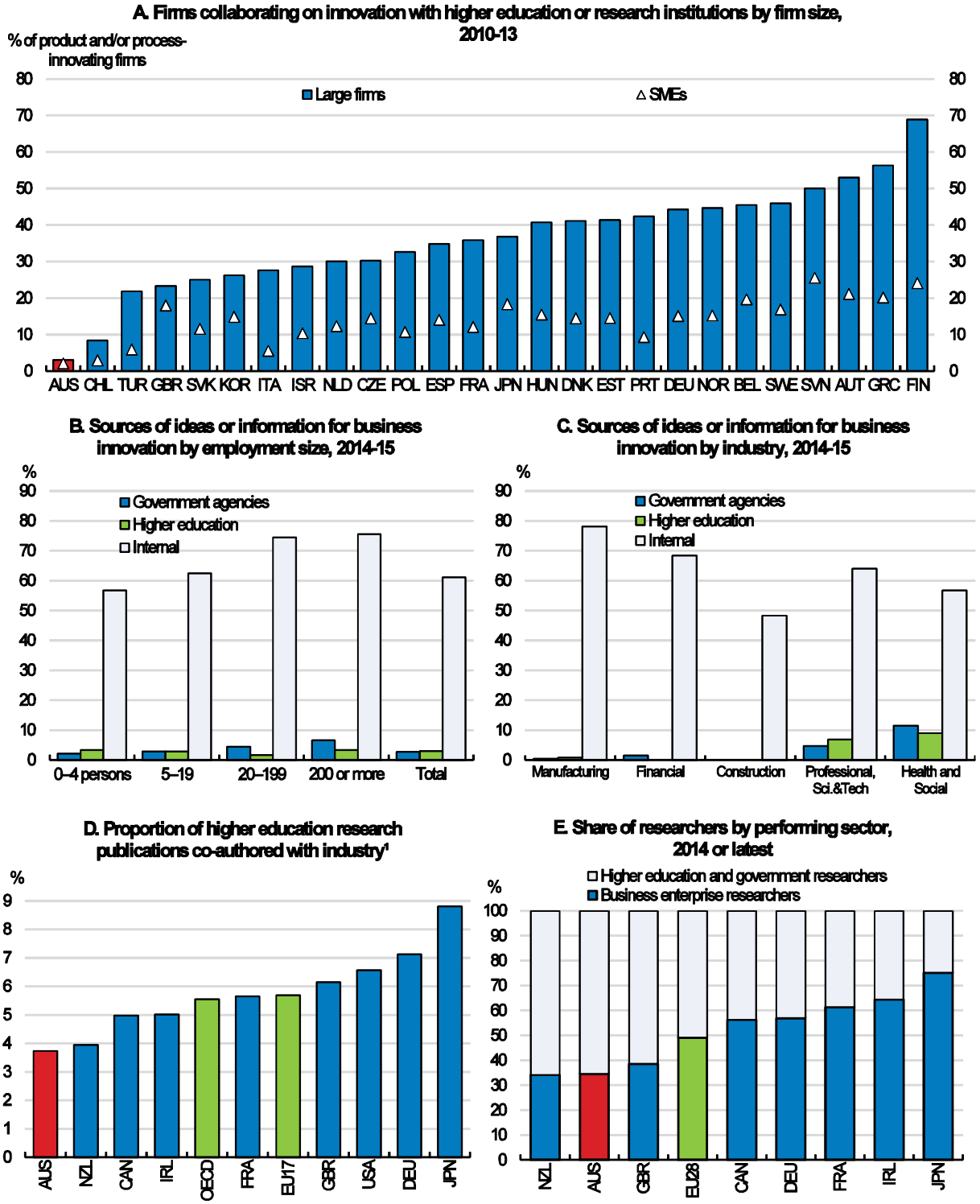
What explains the low level of collaborative research?

Differing priorities and cultures of universities and firms, reflecting differences in objectives, and structural factors, such as the importance of "imported" innovation, partly explain the low level of collaboration (PwC et al., 2015; The Senate, 2015; Ferris et al., 2016).

As highlighted in the *2012 Survey* (OECD, 2012), one specific driver of Australia's low level of collaborative research is that the tight linkage between promotion opportunities and publication outcomes in higher education is likely reducing researchers' incentives to engage with industry. Universities place a high value on research excellence, as this is key in determining their international ranking and reputation (Australian Government, 2014a; PwC et al., 2015). Moreover, research excellence is important in determining federal-government transfers to universities (though its importance has fallen under current reforms, see below). Long administrative procedures for competitive grants (see below) add to the obstacles for collaborative research. Furthermore, a recent review stressed the dissuasive effect of charges imposed by university administrations on commissioned research or consultancy, especially as regards small-scale projects (The Senate, 2015).

The relatively low proportion of researchers employed in industry can be another barrier to collaborative research (Figure 10, Panel E). This is reflected in the early career paths of research graduates. For example, survey data show that in 2012 only a quarter of Masters/PhD graduates were working in the private sector in that year (Australian Government, 2014b). The relatively limited in scale and scope industry placement programmes and low levels of mobility between research and business sectors explain, to a large extent, these patterns (PwC et al., 2015; McGagh, et al.,2016). Both universities and industry need to be more open to collaborative opportunities and to sharing expertise. A recent government report on the innovation system highlights the importance of the science and research skills that are found in academia and public research organisations for "new-to-market" innovations (Australian Government, 2014c).

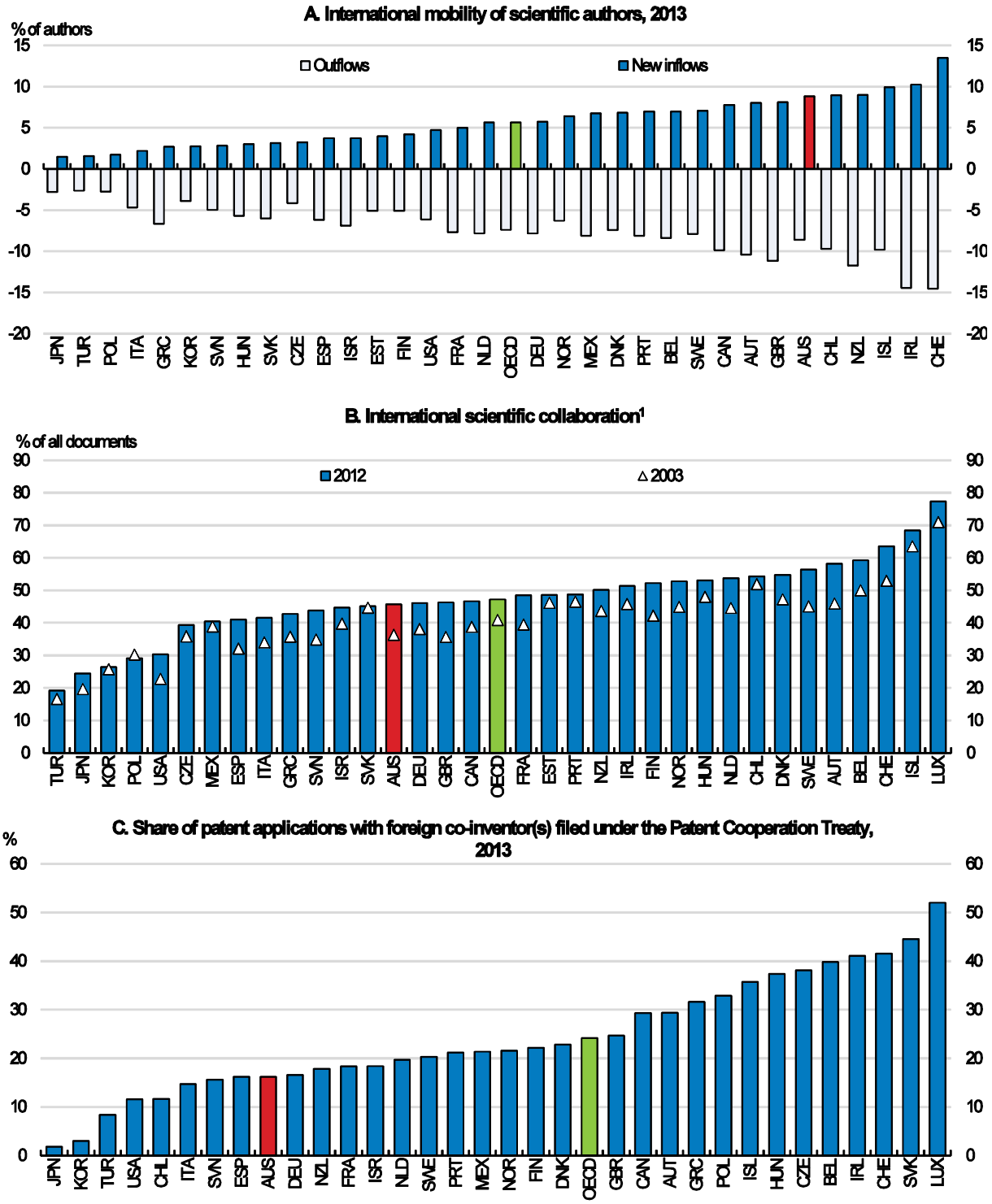
Figure 10 **Collaborative research in limited**



1. Includes universities having produced more than 5000 publications during 2010-13.

Source: OECD (2014, 2015), OECD Science, Technology and Industry Scoreboard; Australian Department of Industry, Innovation and Science (2016), Australian Innovation System Report; ABS, 8158.0 - Innovation in Australian Business, 2014-15; Leiden University (2016), CWTS Leiden Ranking 2016; OECD (2015), Main Science and Technology Indicators: Volume 2015/2.

Figure 11 **International collaboration performance is mixed**



1. Publications co-authored among institutions in different countries.

Source: OECD (2015), OECD Science, Technology and Industry Scoreboard 2015; OECD (2016), OECD Patent Statistics (database).

Box 3 **Australia's Cooperative Research Centres programme: an example of strong collaborative research**

Since the *Cooperative Research Centres programme* (Box 1) began in the early 1990s, government has provided over AUD 4 billion in support and other stakeholders have contributed a further AUD 12.3 billion (Australian Government, 2016a). It is estimated the economy-wide benefit has been more than triple the value of government support, adding about 0.03 percentage points to annual GDP growth (Allen Consulting Group, 2012). Government spending on the programme has been reduced to 1.5% of total government support for science, research and innovation in 2015-6, from its peak level of 3.9% in 1997-8 (Figure 12, Panel A).

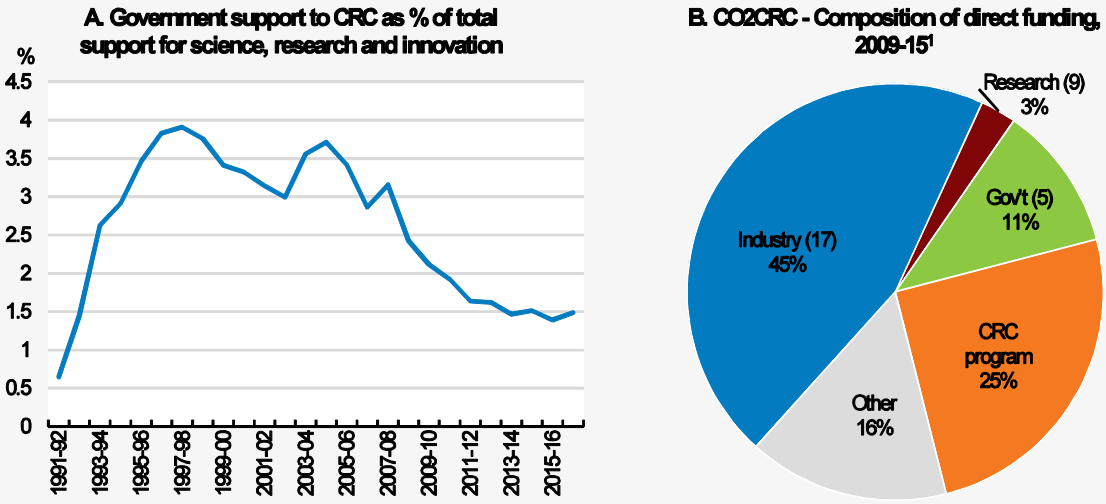
Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) – Green innovation

The CO2CRC is a Centre based in the University of Melbourne, which specialises in research on Carbon Capture and Storage (CCS). After 11 years of funding CO2CRC exited the program in 2014 and continues to operate with the support of other programmes including the Government CCS Flagships Program (*CarbonNet project*), funded by the Education Investment Fund (CO2CRC, 2015).

CO2CRC has successfully developed the country's first deep geological CO_2 storage process (*Otway Project*). The Project completed end-to-end demonstration of CCS technologies on the largest scale globally to date. It has provided valuable new data for the development of government policy and global energy market development (State Government of Victoria, 2016).

A key feature of CO2CRC is its extensive collaboration of industry, research organisations, government and international partners. As of 2013-14, 33 domestic and foreign organisations were participating in the Centre either through providing staff or funding. This diverse base of support is a key factor to the success of the Centre (Figure 12, Panel B).

Figure 12 **Trends in CRC and funding composition of CO2CRC**



1. () refers to the number of participating organisations in each sector.

Source: Australian Department of Industry, Innovation and Science (2016), The Australian Government's 2016-17 Science, Research and Innovation Budget Tables; CO2CRC (2015), Annual Report 2014.

The universities' systems for managing intellectual property (IP) are also potentially problematic for industry-university collaboration and knowledge diffusion. The Productivity Commission highlighted, for instance, dissuasive transaction costs, especially for small and medium-sized enterprises (SMEs), in accessing university IP due to the large variety of IP arrangements across universities (and often within them too) (PC, 2007). An inquiry in 2012 concluded that delays in IP negotiations are a "major obstacle" to collaboration between industry and publicly funded research organisations (ACIP, 2012). According to this report, it takes typically 10 months to negotiate IP contracts, with delays commonly relating to agreement over the ownership of IP created in the process of collaboration, publication rights and accurate valuation of the IP. Furthermore, a recent review of university research funding (discussed below) highlights concerns raised by industry groups about overvaluation of IP by some universities and shortages of academic staff with sufficient prior commercialisation experience (Watt, 2015b). A lack of clarity on IP ownership for students on industry placements is seen by industry groups as a further obstacle to collaboration.

Policy levers for strengthening collaboration between the research and business sectors

Boosting collaborative research is closely related to encouraging universities and business to engage, with research funding arrangements and business-focused collaboration programmes being obvious levers. Effective management of IP created by university research and increased mobility between research and business sectors are also important for enhancing knowledge flow. All these areas are discussed below.

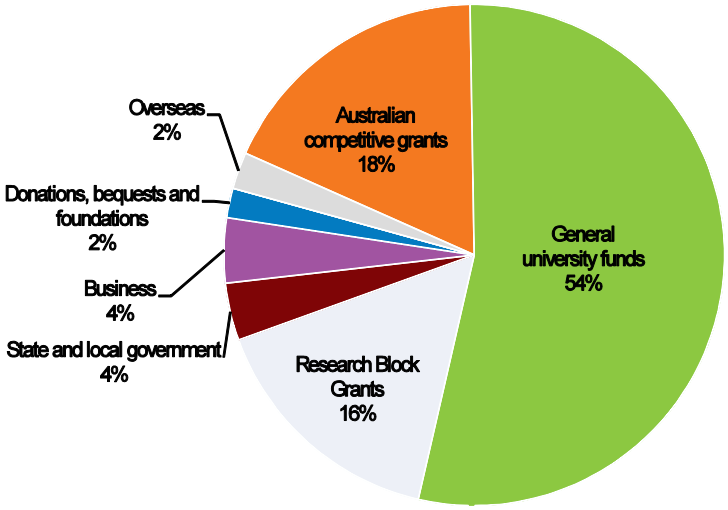
Strengthening collaboration does not imply a need for reduced attention to basic research. Indeed, there are good reasons for continuing support for such research. The *OECD Innovation Imperative* (OECD, 2015a) stresses the significantly larger knowledge spillovers generated by basic research compared to applied research, while also making applied research more productive. Moreover, basic research facilitates access to international knowledge (OECD, 2015b).

Reforming university research funding and monitoring better the broader benefits of research

Federal-government funding of higher education research comprises a "dual" system of Research Block Grants (RBG) and competitive grants (Box 1). RBG are allocated to universities through programme-specific, performance-based formulae, which reward the institutions for the research income they attract, publications, and higher degree student load and completions. The weights attached to each funding driver differ across the RBG schemes (Watt, 2015a,b). Prior to changes in early 2017 (Box 4), the university research income from Australian competitive research grants ("Category 1") had a larger weight in determining RBG funding than research income from other sources, including from industry ("Category 2-4").

The RBG cover a relatively small proportion of total university research expenditure, around 16% in 2014 (Figure 13). Other sources, notably "general university funds", which include Commonwealth funding not specifically targeted at research, play a greater role. But RBG account for a large proportion of government support under the dual funding system for university research. In addition, they entail schemes that support the indirect costs of research, research training, as well as collaborative efforts (Watt, 2015 a,b). However, the Research Block Grant system has been judged as "unnecessarily complex", and as failing to provide clear incentives regarding collaboration with business and other end-users (Watt, 2015b).

Figure 13 **Higher education R&D expenditure by source of funding, 2014**



Source: ABS (2016), 8111.0 - Research and Experimental Development, Higher Education Organisations, Australia, 2014.

The reforms underway to the funding system for university research (Box 4) go in the right direction and should be implemented as envisaged. A simpler allocation formula for block funding, along with a more balanced weighting between the role of university research income from competitive grants and income from other sources (mainly business), provide sharper and more transparent incentives for collaborative research. Changes in the competitive grants processes, notably the introduction of continuous *Australian Research Council (ARC) Linkage Projects* grant rounds and fast track decision-making (Box 4), are also expected to increase incentives for collaborative research and commercialisation, as they allow both researchers and industry partners to take a greater advantage of emerging innovation opportunities (Watt, 2015b; Australian Government, 2015a).

Inadequate support for indirect research costs (e.g. overheads, facilities and equipment) is seen by some universities as constraining resources (including staff time and funding) for collaboration and commercialisation of research (Go8, 2015; The University of Sydney, 2015). Currently, the indirect costs of research projects funded by the Australian competitive grants are met by the RBG (Box 1). However, some argue that the block grants fail to do this adequately (see for example, Williams, 2016). In addition, it has been argued that the lack of an integrated mechanism for funding the direct and indirect costs of research makes it difficult to obtain a consistent and full funding of research projects (AAMRI, 2006). The Watt Review concluded that, in spite of concerns, the present level of support for the indirect costs of research has not affected the quality of research to date, though it did call for monitoring to ensure that this will remain the case (Watt, 2015b).

Box 4 **The main features of the reform of the higher education research arrangements**

A government-commissioned review on research policy and funding of higher education (Watt Review) in 2015 identified several avenues to increase the returns from public investment in universities (Watt, 2015b). The review notably recommended a new funding system for university research that is less complex and provides greater incentives for collaboration and research commercialisation. It also recommended a comprehensive approach to assessing the wider benefits of publicly funded research. Reforms are underway in response to the review's recommendations. In particular:

Research funding arrangements

- A new model for Research Block Grants (RBG), announced as part of the recent *National Innovation and Science Agenda* (NISA), began operating in early 2017. The new arrangements are combining the six existing RBG schemes into two: a *Research Support Programme* (RSP) and a *Research Training Programme* (RTP). Block grants for the RSP are now allocated exclusively on the basis of research income, with an increase in the weight attached to the income from business and other end-users ("Category 2-4"). This income category is now given equal weight to income from Australian competitive grants ("Category 1") (Watt, 2015b; Williams, 2016). This means that publications and higher degree student load no longer feature in the RSP funding formulae (Australian Government, 2016b). Publications are also removed from the RTP funding formulae. Student completions and research income across Categories 1-4 are retained as drivers for research training funding, each with equal weight.

- In addition, changes to the competitive grant programmes are underway, aiming to increase their responsiveness to applicants' needs and boost collaborative research. Notably, the *Australian Research Council (ARC) Linkage Projects* – designed to support research partnerships between universities and businesses and other end-users – have moved to a continuous application and assessment process (rather than one round per year as was previously the case), accompanied by a fast-track decision-making process; grant decisions were taking up to 9 months under the annual selection process (Watt, 2015b). In addition, measures will be taken to facilitate assessment and prioritisation of proposals with commercialisation and business collaboration potential.

Impact assessment

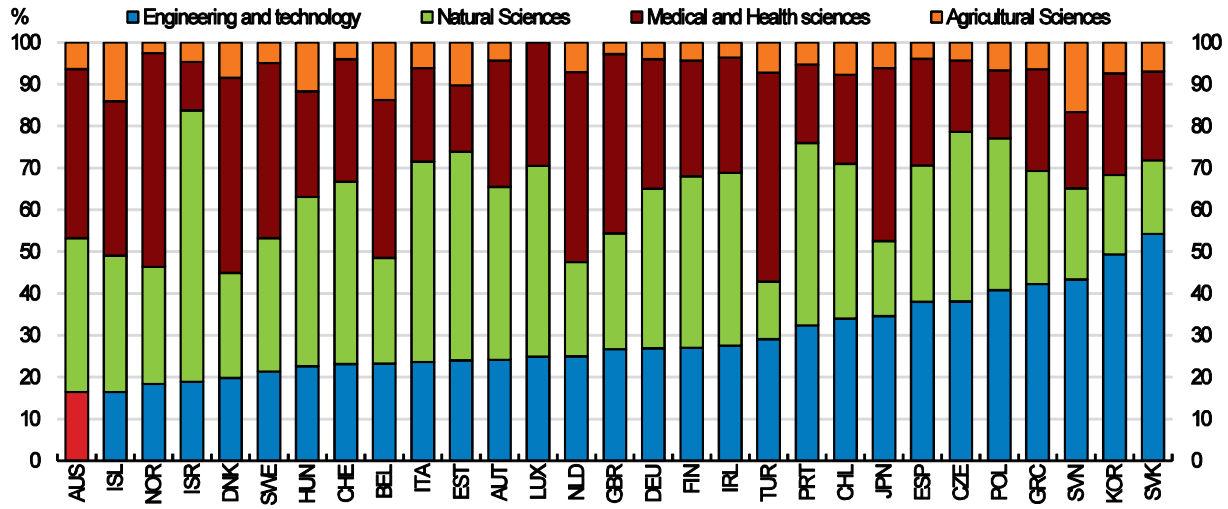
- A new framework for assessing the "impact" of university research is being developed (Australian Government, 2016b). Currently, the quality of university research is gauged by the *Excellence in Research for Australia* (ERA) – a national evaluation framework (Australian Government, 2011). ERA is based on expert review informed by a range of indicators including citation profiles and peer review of a sample of research outputs. The ratings against national and international benchmarks are determined by committees of researchers, drawn from Australia and overseas (ARC, 2016). The framework under development intends to compliment the ERA with new measures – qualitative and quantitative – that enable assessment of university research performance in terms of non-academic impact and end-user engagement (Australian Government, 2015a; 2016b). The government plans to implement the new framework in 2018, following a pilot project in 2017.

Consideration could also be given to introducing incentives in the university funding system for R&D expenditure in fields with the greatest potential gains from collaborative activity, such as engineering and technology, and information technology (Williams, 2016). Australian institutions rank poorly internationally with regards to the R&D expenditure in these fields (Figure 14).

The government should also proceed with the development of the new "impact assessment" model, taking into account the lessons from the pilot in 2017 (Box 4). As noted in Box 4, Australia has a national evaluation framework for the quality of the university research, but an impact and engagement framework that would allow an assessment of the economic and social benefits of such research is missing. The challenges of developing the new impact assessment model should not be underestimated. Transparent, well-designed, evidence-supported, monetary and non-monetary indicators are important in this regard (Jensen and Webster, 2016; Go8, 2015). These would help to monitor better how well (or otherwise) the universities are translating their research outcomes into wider impacts, which would increase accountability with regard to the value of publicly funded research and facilitate better-informed funding decisions (Penfield et al., 2014). Moreover, the new model is expected to provide universities impetus for increased engagement with industry and other end-users of research, enhancing knowledge transfer.

Figure 14 **University R&D expenditure on engineering and technology is low**

Share of higher education R&D expenditure by field of science, 2013 or latest



Source: OECD (2016), Research and Development Statistics (database).

Encouraging business to become more active in collaborative research

Boosting collaboration also requires effective incentives to stimulate industry to seek research partnerships. The federal government supports a number of business-focused collaboration programmes. These include: the *Rural Research and Development Corporations* **(**Box 1); the *Cooperative Research Centres* (Box 1); and the *ARC Linkage* schemes. In addition, there are programmes (such as *Innovation Connections*, discussed below) that assist firms, mainly SMEs, to connect with research institutions. According to the information cited by the Watt Review, around 1 800 businesses were involved in government-funded collaboration programmes in 2013-14 (excluding those administrated by the Department of Agriculture), which corresponds to only 13% of the firms registered under the *R&D Tax Incentive* scheme (Watt, 2015b).

Recent initiatives under the *National Innovation and Science Agenda* (NISA) go in the right direction towards boosting business-led research partnerships. The move of the *ARC Linkage Projects* scheme to a continuous application round, along with the introduction of a fast-track decision-making (Box 4), will allow firms to decide promptly which research project to support, removing an important barrier to collaboration (Universities Australia, 2016a; Watt, 2015b). Firms with fewer than 20 employees will also be exempted from the requirement to provide cash contributions under the *Linkage Projects* scheme (Australian Government, 2016b). This is expected to stimulate smaller firms to apply for the programme. Industry-research collaboration is particularly important to small- and medium-sized firms (making up the majority of businesses in Australia), as it is difficult for such firms to fund internal investment in innovation (PwC et al., 2015).

NISA has also revamped the *Research Connections* programme that was introduced in 2014 to equip SMEs with the skills and capacities to collaborate with the research sector (Australian Government, 2014d). The scheme provided facilitation/intermediary services through a network of 13 Research Facilitators, who assess firms' research needs and direct them to research expertise (Watt, 2015b). It also provided matched funding for research. The new programme, *Innovation Connections* (launched in early 2016), expands the support. There will be eight new Innovation Facilitators and two new grant components. The latter extend the support for placements, notably of graduate or post-graduate researchers in businesses and of business researchers in a publicly funded research organisation (Australian Government, 2015a). *Innovation Connections* is part of the broader *Entrepreneurs' Programme* which provides practical support for businesses, researchers and entrepreneurs.

The *Innovation Connections* programme can assist more SMEs to "reach into" institutions that have the skills to address their research needs, particularly in regional Australia. Evidence suggests that such types of programmes can encourage partnerships between SMEs and research institutions which are likely to continue after the completion of the grant project (Watt, 2015b). A close monitoring of the revamped scheme is necessary in view of the relatively low take-up rates of the government-funded business-focused collaboration programmes. The evaluation results should be published for transparency. Simple and flexible governance and management arrangements are also important, helping to avoid unnecessary delays in the negotiation and formalisation of agreements for collaborative research (OECD, 2012). The success of collaboration-enhancing schemes further hinges upon the stability in the programmes offered, as frequent changes in the design and naming can reduce effectiveness.

An effective and efficient system of business-focused collaboration programmes also requires co-ordination among different levels of government. At present, broadly similar schemes to *Innovation Connections* (a national programme) are operated by some state governments, for instance *Technovouchers* in New South Wales and the *Innovation Vouchers Programme* in Western Australia (Watt, 2015b). This increases the risk of overlap and increased administrative costs. The new framework (discussed below) developed by the Department of Industry, Innovation and Science for the evaluation and measurement of programmes and policies (Australian Government, 2015b) is a welcome step towards an effective management and better co-ordination.

These initiatives need to be complemented by reforms in the *R&D Tax Incentive* scheme, providing financial support for business R&D, to better incentivise industry to collaborate with the research sector (see below).

Ensuring a more effective management of IP by universities

Universities have introduced simplified IP licencing processes in recent years to promote collaborative research. Seven universities are currently members of *Easy Access IP* – an international network offering a free licence to a specific technology, using a simple, non-negotiable one-page agreement (Eggington et al., 2015; Watt, 2015a,b). *Easy Access IP* allows companies (or individuals) to evaluate and commercialise university research output quickly. Business must pay for the patenting costs and acknowledge the university as the source of the IP. If not commercialised within three years, the IP reverts back to the university. Irrespective, the universities can use the IP for research and teaching purposes (Watt, 2015b; PC, 2016). Also, all universities have signed up to use *Source IP*, a central platform aiming to provide information to business about public sector IP. Finally, the government has developed the *IP Toolkit* (launched in September 2015) to simplify and improve the management and use of IP in partnerships between businesses and researchers (Australian Government, 2015c). The Toolkit offers guidance about potential collaborators and contract negotiations and also provides the tools (including a model contract) necessary for streamlining the process of collaborative IP arrangements.

Furthermore, the funding arrangements for Australian competitive grants are to be amended in 2017, as was recommended by the Watt Review, requiring universities to list their patents generated by publicly funded research on *Source IP* and offer, and use, if requested by the collaborative partners, simplified contracting arrangements (in particular, the *IP Toolkit* model contract) (Watt, 2015b; Australian Government, 2016b). The government will also require all future applications and progress reports for the *ARC Linkage Projects* scheme – designed for collaborative research – to identify the actual and potential IP arising from the project and planned management arrangements.

These initiatives go in the right direction. Further development and wider use of simplified contracts, such as those incorporated in the *IP Toolkit* and *Easy Access IP*, is critical for knowledge exchange and collaboration on the exploitation of IP. For instance, an assessment of the *Easy Access IP* scheme in the United Kingdom for the period 2012-15 found that it has resulted in savings in staff time and legal costs (Eggington et al., 2015). The Watt Review's assessment of *Easy Access IP* also concluded that it usefully supports the commercialisation of university research and that the broader application of *Easy Access IP*, or similar arrangements, should be investigated (Watt, 2015b).

Open access publishing is also being strengthened. In 2013, Australia introduced limited open access policies, aiming to improve access to publications arising from research supported by public funding (through the *Australian Research Council* and the *National Health and Medical Research Council*, see Box 1) (Watt, 2015b). In line with the recommendation of the Watt Review, reporting arrangements for universities will consider the relative share of research output made available through publication or open source repositories. Some countries further include "use it or lose it" provisions for IP in research funding arrangements, which allow public funders to appropriate IP if its owner is not exploiting it, although the Productivity Commission did not find supporting evidence for the introduction of such provisions in universities (PC, 2016) (Box 5).

Box 5 **The pros and cons of a "use it or lose it" scheme for publicly funded IP in universities**

The *2015 Review of Research Policy and Funding Arrangements* (Watt Review) recommended the authorities examine the feasibility of a "use it or lose it" scheme (Watt, 2015b). Such provisions would require a university to free up the IP arising from publicly funded projects if commercialisation does not begin within a specific time frame.

In principle, a "use it or lose it" scheme could strengthen access to IP; however, there are design and enforcement issues. Choosing an appropriate time deadline is challenging as the "reasonable" time frame for commercialisation will vary widely across research projects. A "use it or lose it" scheme also increases complexity in reporting arrangements (Watt, 2015b). Moreover, the compulsory licence arrangements for patents in Australia, which also apply to publicly funded organisations, imply already de facto "use it or lose it" arrangement for patents owned by such organisations, weakening the rational for additional provisions (PC, 2016). On balance, the Productivity Commission found a lack of evidence for more interventionist approaches of IP arising from publicly funded research, advocating instead that existing measures such as *Easy Access IP* and *Source IP*, which are still at a preliminary stage, should be given time to work before additional measures are considered.

The steps to strengthen open access publishing are welcome. Several studies show that open access publishing improves the impact of scientific papers (OECD, 2015a), although challenges remain, including the risk of dissemination of lower-quality scientific results and the need to make it more sustainable through market mechanisms, as most open-access journals rely on subsidies or funding from universities and government (OECD, 2015a). In its recent study on IP arrangements, the Productivity Commission recommends that the federal and state governments provide free access through an open access repository for all publicly funded publications, within 12 months of publication (PC, 2016). This would facilitate further knowledge exchange.

Australia's Technology Transfer Offices (TTOs) are specialised in the creation, management and enforcement of IP rights (PC, 2016). Some Australian TTOs have been successful, but there is scope for improvement. TTO's managerial capacities have been criticised, including a lack of "genuine" support for commercialisation efforts and limited skills in the management of IP and licensing and start-ups (Harman, 2010). More recently, Jensen and Webster (2016) have underscored the importance of legal teams specialised in unconventional outputs, such as databases, algorithms and apps that are neither patentable nor can be clearly protected by copyright. Overall, therefore there appears room for TTOs to become more effective.

Removing barriers to industry-relevant research training and mobility between sectors

Industry experience, especially for young researchers, is an important channel for linking universities and businesses (PwC et al., 2015). According to a recent review by the Australian Council of Learned Academies (ACOLA), several factors dissuade the creation of industry placements for higher degree research students, including inflexibilities in rules governing the scholarship schemes for post-graduate students and high financial and administrative costs of placements for business (McGagh et al., 2016).

Moreover, Australia lacks a co-ordinated approach to industry placements for higher degree research students, and so the proposal by the ACOLA review for a nationally consistent approach is welcome. This would reduce complexity and red-tape burden on universities and industry partners and allow researchers to obtain better information about appropriate placement opportunities. It would also increase accountability (McGagh, et al., 2016). Besides boosting collaboration, industry-relevant research experience could improve employment opportunities beyond academia. Furthermore, innovation-relevant skills and university-business linkages can be strengthened through encouraging students to take "entrepreneurship" courses as part of their degrees. In the Netherlands, for example, nearly all Universities and Universities of Applied Sciences are offering entrepreneurship units in degree courses (see Chapter 1 of the *2017 Economic Survey of Australia* (OECD, 2017)).

Plans to revise, through engagement with universities, the appointment and promotion arrangements for academics, so that time spent in business is given greater recognition, go in the right direction (Australian Government, 2016b). This would lessen the link between promotion opportunities and publication outcomes, promoting mobility between the research and industry sectors. It is important that the new appointment and promotion policies are carefully designed, entailing "engagement" criteria that attach high weights to industry experience with large potential for facilitating knowledge flow.

More information on research outcomes and expertise would also facilitate mobility between business and research sectors. Ongoing development of an online access point to connect businesses with commercially-relevant research and potential research partners is welcome (Watt, 2015b). Last, but not least, policy changes need to be accompanied by a shift in academic culture, which conventionally recognises only publications and teaching as "worthy" activities for career advancements (Jensen and Webster, 2016). The reform underway in funding arrangements for university research (Box 4) aims to prompt such change. At the same time, the businesses sector also needs to be open in offering work experience to researchers (PwC et al., 2015).

The need for an integrated approach across research, innovation and education (the so-called "knowledge triangle") is well recognised by the OECD countries, given the systemic nature of innovation and the role – and relationship – of the different players in the innovation system. Research hubs, such as the Waterloo knowledge triangle in Canada (see OECD, 2016 for further discussion), can provide useful examples for Australia.

Achieving greater commercial impact from Australia's public-sector research

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) (Box 6) is the largest public-sector (non-defence) research agency in Australia. It undertakes multidisciplinary in-house research and collaboration with other research partners, including universities and industries, as well as international partners (PC, 2007). Overall, CSIRO performs well, meeting expectations and targets in performance indicators for its main programmes. Various evaluations have concluded that, overall, CSIRO brings net benefit (see for instance, ACIL Tasman, 2010 and ACIL Allen, 2014). Moreover, programmes administrated by CSIRO, such as the *SME Engagement Centre*, connecting business to expertise and government programmes, seem to be working well. Existing data suggest that, since 2008, the programme has helped more than 100 SMEs to grow and become more competitive (Watt, 2015b).

Box 6 **CSIRO: Main features**

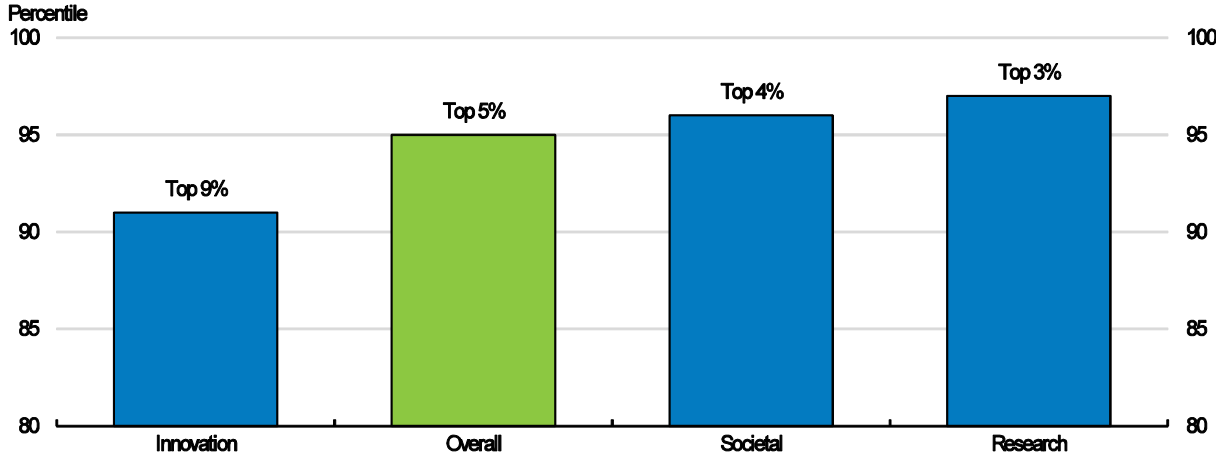
The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is an independent statutory body and the leading public sector research agency in Australia. It is a "mission directed" organisation with a primary remit to conduct research for the public good and assist Australian industry (OECD, 2011). CSIRO's remit also notably includes a responsibility to encourage the application or utilisation of the results of its research. Secondary functions include international scientific liaison, training of research workers, publication of research results, technology transfer of other research, provision of scientific services and dissemination of information about science and technology. CSIRO undertakes research across many areas, employing around 5000 employees (full-time equivalent), located in over 50 locations (CSIRO, 2015a, 2016). The wide variety of research projects and large scale of the agency provides considerable scope for multidisciplinary research to be carried in-house, reinforced through collaborative research (PC, 2007).

In 2015-16 CSIRO received over 40% of the federal funding to public-sector research agencies (PSRAs) and close to 8% of the government's total support for science and innovation (Australian Government, 2016c). Around 62% of the agency's operating revenues in that year came through the federal budget, with the rest from external sources, including consulting and royalty and license revenues (CSIRO, 2016). CSIRO allocates its public funding using multiple criteria and with guidance from the *National Science and Research Priorities*. As of 2013, CSIRO has a statutory requirement to develop a *Corporate Plan* (a rolling 4-year plan) each year and submit an annual P*ortfolio Budget Statement* (CSIRO, 2015b). Performance is assessed in *CSIRO's Annual Report*. Performance criteria (as from 2016-17 and beyond) include evidence of economic, social and environmental impacts, customer and user satisfaction, level of external revenue and improvement of innovation capacity. The performance of the *CSIRO Innovation Fund* (see below) is also assessed with regard to investments in science-based technology in industry sectors that have been identified as growth sectors for the Australian economy (Australian Government, 2016d).

There is scope, however, for further improving CSIRO's effectiveness in terms of commercialisation of its research and knowledge transfer, while ensuring that this does not come at the cost of excellence in research or societal impacts. The agency ranks among the world's top 25 government research organisations on the basis of the Reuter's ranking of innovative capacity and achievement, and it also fares well in terms of "academic impact" (Figure 3, Panel B). However, it lags behind comparable institutes in other countries in terms of "commercial impact", as proxied by the citation of its academic papers in patent filings (Figure 9, Panel D). This finding is supported by indicators showing that CSIRO's innovation outcomes fall behind its research excellence (Figure 15).

Figure 15. **The commercial impact of public-sector research could be strengthened**

Ranking of CSIRO among world research institutions[1]



1. The "innovation" measure consists of innovative knowledge (scientific publication output from an institution cited in patents) and technological impact (percentage of the scientific publication output cited in patents). The "societal" measure consists of web size and domain's inbound links. The "research" measure consists of output, collaboration, research excellence, leadership and talent pool.

Source: Scimago Lab (2016), Scimago Institutions Rankings.

CSIRO has implemented in recent years a framework to plan, monitor and evaluate the impact of its research (CSIRO, 2014). This system tracks the translation of research into benefits ("pathways to impact") and is based on the "Triple Bottom Line" (TBL) approach. TBL is an internationally recognised impact assessment framework with three dimensions: environmental, social, and economic. CSIRO uses both cost-benefit analysis (usually for economic impacts), in addition to more qualitative methods (CSIRO, 2015c). Evaluations are based on internal or external assessments, or a mix of the two types. The framework includes both planning (ex-ante) and evaluation (retrospective).

The move to a more comprehensive and consistent impact evaluation approach is welcome. The new framework can help CSIRO better plan and measure the impact of its research. In addition, the new approach will enable improved aggregation and comparison of outcomes/impact across the organisation. However, so far, the impact evaluation has been retrospective. Progress needs to be made towards future impact planning as well. This is particularly important in view of the larger focus given, compared to the past, on the commercial outcomes of research under CSIRO's new long-term strategy (CSIRO, 2015d; The Senate, 2015). It is welcome that CSIRO is releasing a new training programme focusing on impact pathways. It is important that planning and evaluation processes assess the wider impact of commercialisation, including the effect on research excellence and societal outcomes.

A new fund (the *CSIRO Innovation Fund*), announced as part of NISA, was launched at end-2016 by the government to support early stage commercialisation of research from CSIRO, other research institutions and universities (Australian Government, 2015a). The fund has two components: *i)* an early stage innovation fund of AUD 200 million to support co-investment in new spin-off and start-up companies created by research institutions; and, *ii)* a AUD 20 million strengthening of CSIRO's "accelerator programme" which assists preparation for commercial adoption. The early stage innovation fund will be co-funded by the government (AUD 70 million over 10 years), CSIRO and the private sector.

The establishment of the *CSIRO Innovation Fund* is a positive step given the important role of capital at the early stages of the commercialisation process, especially for start-ups. It will also foster greater research-industry collaboration. Investments by the *CSIRO Innovation Fund* need to carefully target projects with large commercialisation and productivity-enhancing potential. The new performance criteria for CSIRO (Box 6) are a welcome step forward. As the fund is still at its initial phase, a close follow up of outcomes would be advisable.

Effectiveness and efficiency of public-sector research should be improved further by the ongoing implementation of the *Public Governance, Performance and Accountability Act 2013* (PGPA Act) under which public-sector research entities are required to measure and assess their performance. The Act introduces obligations for annual performance statements (to be tabled in Parliament) and a *Corporate Plan*, as is currently the practice by CSIRO (Box 6). A common approach to assessing the outcomes and impacts of research of PSRAs will bring more accurate measurement of the benefits of public funding for research (CSIRO 2015c), also helping to improve Australia's commercialisation and innovation outcomes. Ensuring a swift transition by PSRAs to the new arrangements is important.

Tax incentives form the core of Australia's financial support for business R&D

Most financial support for business innovation in Australia comes via the *R&D Tax Incentive* (hereafter, Incentive) (Box 7). In 2014-15, the Incentive, which replaced the long-lived *R&D Tax Concession* scheme in 2011, accounted for around 30% of the government's total expenditure in science, research and innovation, and for over 90% of the support for business research and innovation (Figure 16, Panel A), which is high in international comparison (Figure 16, Panel B). The tax incentives for SMEs are more generous than for larger firms (Box 7). Participation in the Incentive has increased rapidly since its introduction, particularly for SMEs, with the fiscal costs of the programme exceeding forecasts (Figure 17, Panels A to C). The refundable component of the programme (Box 7) has been the main cost driver (Figure 17, Panel D). Business R&D intensity data have so far not echoed this development (Figure 17, Panel B). This possibly reflects other influences, especially the end of the mining boom (Box 2). Regardless, this trend needs to be closely monitored, and included in assessments of the programme's effectiveness in encouraging additional business R&D.

Box 7 **R&D Tax Incentive: main features**

The *R&D Tax Incentive* (Incentive), introduced in 2011, provides tax offsets to incorporated companies for R&D activity, including foreign companies that are tax resident in Australia (Ferris et al., 2016). Trusts are generally not eligible to claim the Incentive.

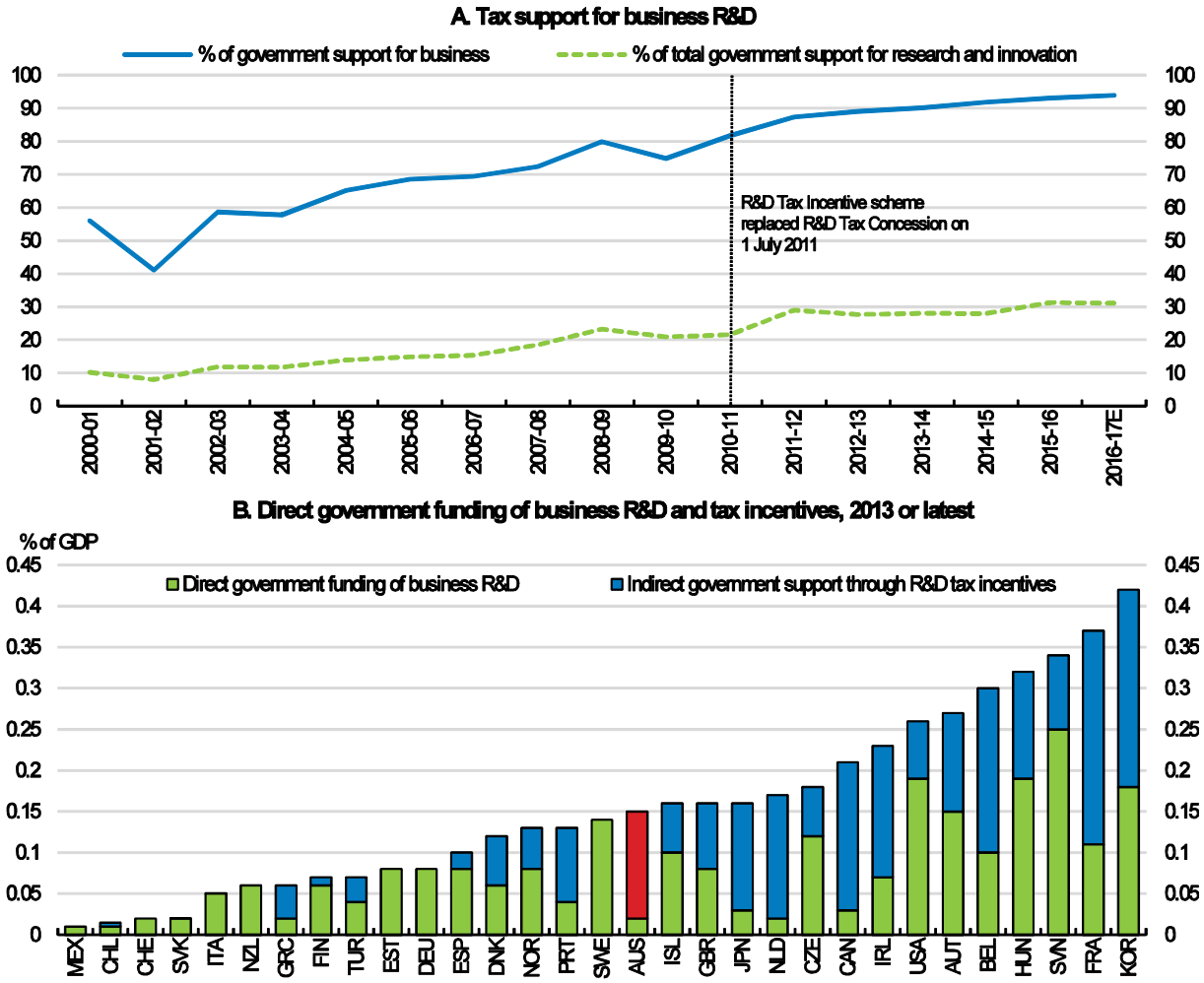
The programme is jointly administrated by AusIndustry (on behalf of Innovation and Science Australia) and the Australian Taxation Office (ATO). In broad terms, AusIndustry manages the registration of companies accessing the Incentive and determines the eligibility of R&D activities, while ATO determines the eligibility of companies applying for the scheme and the eligibility of their claimed R&D expenditure (Australian Government, 2015d; Ferris et al., 2016). The Incentive is a self-assessment programme, the ATO and AusIndustry undertake compliance activities as part of their administration of the Incentive.

The Incentive has two components:

- a 43.5 % refundable tax credit (offset) (45% prior to July 2016) for eligible companies with an aggregated turnover of less than AUD 20 million per annum. The refundable element of the scheme means that, where a company's tax liability is smaller than the value of the R&D tax offset, they receive an immediate refund, rather than carrying forward the offsets;
- a non-refundable 38.5% tax credit (offset) (40% prior to July 2016) for eligible companies with an aggregated turnover of AUD 20 million or more per annum.

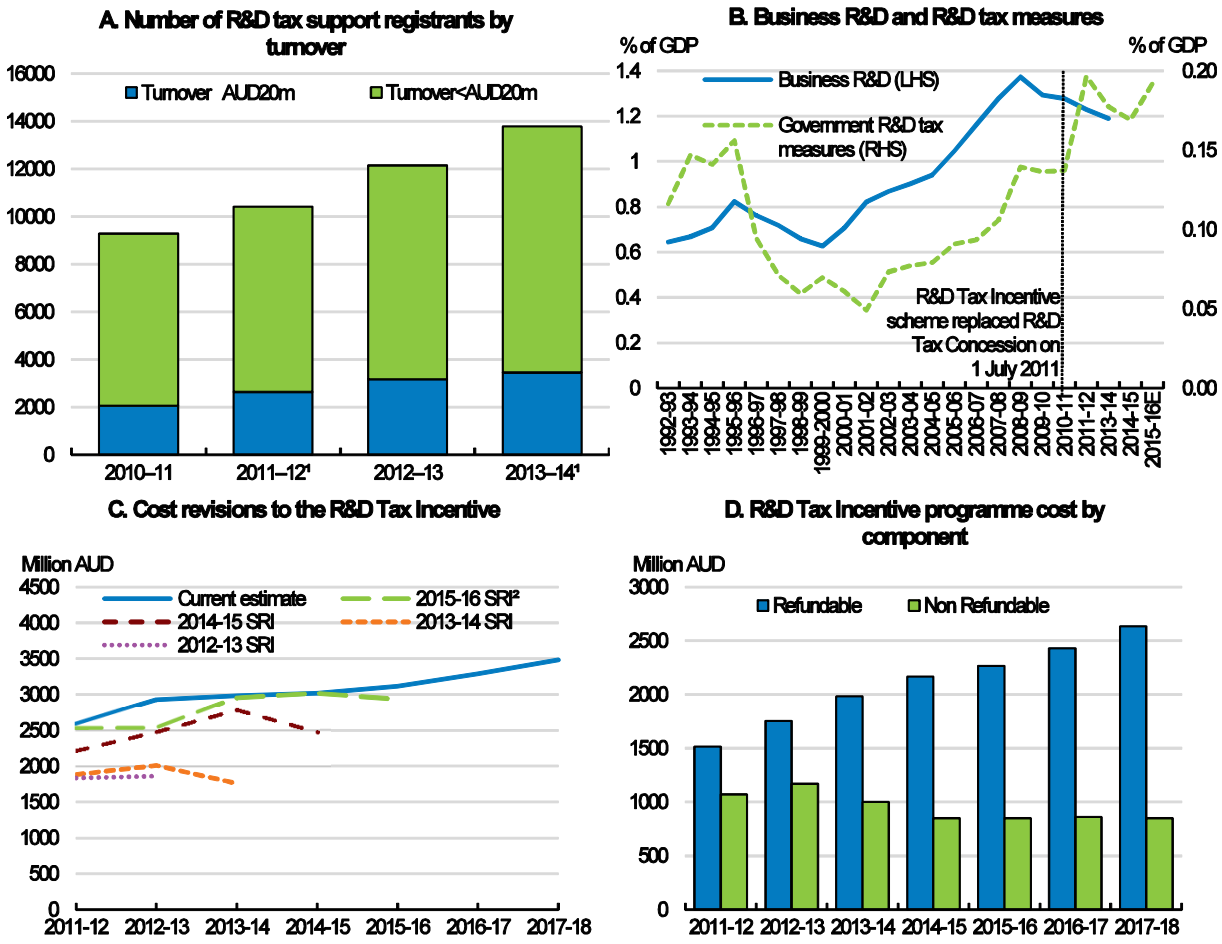
An annual AUD 100 million R&D expenditure threshold was introduced 2015. Firms with eligible R&D above the threshold receive, from July 2014, a tax credit at the prevailing company tax rate (30%) rather than the Incentive rate (Australian Government, 2016e).

Figure 16 **Government support for business R&D: trends and international comparisons**



Source: Australian Department of Industry, Innovation and Science (2016), Science, Research and Innovation Budget Tables; OECD (2015), OECD Science, Technology and Industry Scoreboard 2015, Chapter 4.

Figure 17. **Cost developments of the of R&D Tax Incentive**



1. 2011-12 was a transitional year in which some firms accessed the R&D Tax Concession while others accessed the R&D Tax Incentive and 2013-14 data are not complete.

2. Australian Government's Science, Research and Innovation (SRI) budget.

Source: Ferris et al. (2016), Review of the R&D Tax Incentive; Department of Industry, Innovation and Science (2015), Innovation Australia: Annual Report 2014-15; ABS (2015), 8104.0 - Research and Experimental Development, Businesses, Australia, 2013-14.

There are challenges in making the R&D Tax Incentive more effective

A key measure of effectiveness of public support to R&D is "additionality": the extent to which the support prompts R&D over-and-above the amount which would be undertaken without it. Evidence suggests that only around 10-20% of the total R&D registered under the Incentive is additional, a similar result to that found in other countries (Australian Government, 2016e). An assessment of the Incentive (Ferris et al., 2016), as part of a government-initiated review, concluded that the programme "falls short of its stated objectives of additionality and spillovers".

Strengthening additionality may be difficult. By design, volume-based (i.e. applying to all qualified R&D expenditure) tax instruments, such as the Incentive, not only subsidise the additional R&D but also support the activities which would have been conducted in the absence of tax incentives (Appelt et al., 2016; Ferris et al., 2016). This puts limits on the additionality that can be achieved. Furthermore, measures that endeavour to raise additionality (such as, more sophisticated eligibility criteria) can increase complexity, and consequently, compliance and administrative costs. Among the reform options, one

possibility would be to grant a part of the refundable R&D incentive (see Box 7) under more stringent criteria for additionality (see for example, KPMG, 2016). While of merit, designing (and implementing) the additional criteria may be challenging and may add to the high administrative burden.

Another reform option to sharpen focus on additional R&D activity is to introduce an intensity threshold. Ferris et al. (2016), for instance, recommend only applying the tax credit to R&D spending that exceeds 1-2% of total business expenses for the recipients of the non-refundable component (larger companies) of the Incentive. If well implemented, such a reform could make the Incentive more targeted, increasing its effectiveness. Evaluation and, if needed, adjustment will be important as experience is gained. Complementing this recommendation, Ferris et al. suggest doubling the existing expenditure threshold (from AUD 100 million to AUD 200 million) in order for large R&D-intensive firms to retain an incentive to undertake additional R&D.

Making the *R&D Tax Incentive* a more effective instrument for collaborative research between businesses and publicly funded research institutions is also important, given that such research is more likely to generate spillovers (Appelt et al., 2016). Indeed, recent firm-level evidence suggests that Australian firms that innovate and source their ideas from research organisations are 34% more productive than those that do not (ACOLA, 2014). Currently, the Incentive does not focus on encouraging collaboration; in 2013-14 only 9.5% of projects under the programme were involved in collaboration with another organisation (Australian Government, 2016e). The government could consider introducing an R&D tax-credit premium for business expenditure on collaborative research with publicly funded research organisations, or add criteria relating to collaboration in the eligibility criteria for the current programme. Various analyses (see for example, PwC et al., 2015; ATN, 2016; Ferris et al., 2016; Universities Australia, 2016b), favour an R&D tax-credit premium option for Australia. Ferris et al. specifically recommend an additional premium rate of tax credit of up to 20% above the current non-refundable tax credit rate where R&D expenditure involves collaboration with publicly funded research organisations. Several other OECD countries use R&D tax incentives to promote collaboration (Appelt et al., 2016). For example, in Japan, the tax credit rate is increased to 30% for joint R&D activity with a university or public research institutions (the standard credit is 12% for SMEs and 8-10% for large firms) (OECD, 2015c). In Canada, eligible corporations in Ontario can claim a 20% (capped) refundable tax credit for research performed under contract with eligible research institutes (Ontario Ministry of Finance, 2014).

An R&D tax-credit premium could also increase mobility between the industry and research sectors, if eligibility for the premium included exchange of staff between the industry and research partners (ATN, 2016; Universities Australia, 2016b), and/or R&D tax incentives were strengthened for firms employing PhD graduates for a specific period after graduation (PwC et al., 2015; Ferris et al., 2016). Ferris et al. recommend, for instance, that the collaboration premium of up to 20% for the non-refundable tax credit (see above) also applies to the cost of employing recent PhD, or equivalent, graduates in science, technology, engineering or maths (STEM) in their first three years of employment. Mechanisms aiming to increase employment of researchers in industry operate elsewhere. For instance, in France wage expenditures of researchers with a PhD or equivalent degree are considered twice for R&D credit purposes during the first 24 months following their first recruitment (OECD, 2015c). Other mechanisms for R&D business support, such as grants, could also be used to encourage collaboration, complementing the R*&D Tax Incentive* (Deloitte, 2016). The exchange of staff, for instance, can also be directly supported.

In view of the importance of the *R&D Tax Incentive* in Australia's innovation policy, and the significant budgetary costs involved, comprehensive analyses are required for assessing additionality. This could include, without underestimating the measurement difficulties, an evaluation not only of "input" but also "output" additionality (the outputs from R&D activities which would not have been achieved without public support), accompanied by estimates of wider economic and social benefits (Appelt et al., 2016). Publishing the results of such analyses would increase transparency regarding the performance of the *R&D Tax Incentive*, making it easier to communicate any policy changes. Evaluations should also look at the possible trade-off between increasing additionality and complexity. The OECD has launched a project to evaluate R&D tax credit systems across countries using micro-data (Appelt et al., 2016).

Ensuring integrity and containing cost

Efficiency and effectiveness of the R&D tax break system further hinges upon ensuring high standards of integrity in the use of funds. Both AusIndustry and ATO undertake compliance activities as part of their administration of the Incentive (Box 7). AusIndustry's risk review activities focus on the risk of non-compliance of registered R&D activities at the pre-registration or post-registration stages. In the case of ATO, compliance activities are concentrated primarily on expenditure and the behaviour of specialist tax advisers (Ferris et al., 2016). The findings of AusIndustry's and the ATO's compliance activities suggest that most participants in the Incentive programme are acting in accordance with the programme's rules. Specific delivery risks have been identified, however. Incorrectly identifying activities as research and development and/or incorrectly attributing expenditure against activities is one of the major risks to the integrity of the programme. This issue needs to be monitored closely, introducing, if necessary, tighter compliance measures that are well-targeted. Developing comprehensive data sets that help gauge the extent of the abuse is also important.

The introduction of the *R&D Tax Incentive* in 2011 brought new definitions of core and supporting R&D activity, which are welcome as they aim at increasing clarity (Australian Government, 2016e). The R&D eligibility conditions reflect the principles in the *OECD Frascati Manual* (OECD, 2015d), used by several countries as a basis for identifying R&D activity and expenditure. The eligibility conditions essentially require the development of new knowledge, a purpose and systematic approach to develop such knowledge, and an element of technical risk regarding the success of the approach (Ferris et al., 2016). The Incentive's eligibility criteria are principle-based, providing flexibility for changing R&D activities over time. However, such an approach can be open to misinterpretation and possible "boundary pushing" of eligibility (Australian Government, 2016e). The *2012 Survey* (OECD, 2012) highlighted the need for clear and consistent interpretation by those processing applications of the eligibility criteria and frequent evaluation of outcomes. The recent assessment of the Incentive by Ferris et al. specifically recommends the development of new guidance (including plain-language summaries and case studies) to increase clarity about the scope of eligible activities and expenses.

The upward risks to the costs of the Incentive could be further managed by strengthening provisions for the existing expenditure cap, applying it to "connected entities", and/or by introducing additional caps (BDO, 2016). For instance, a cap on the refundable component of the Incentive (applicable to smaller firms) could be considered, with any amounts above the cap to be retained by the firm as a carried-forward non-refundable tax credit (see, BDO, 2016 and Ferris et al., 2016). In placing a cap on refundability it is important to assess carefully its potential trade-off with additionality, especially as there is some evidence that SMEs are more responsive than large firms to fiscal incentives (Australian Government, 2016e).

Enhancing administrative efficiency

There is also scope for improving the administrative efficiency of the Incentive programme. Compliance costs for the participating firms are relatively high as a percentage of the financial support provided, standing, on average, at 23% for small firms and 8% for large companies (Ferris et al., 2016). Such costs include time and resources to complete the application process and to keep records for the justification of activities and respond to audits. The fees paid by participating firms to consultants (specialist advisers), according to available information, account for almost half of the total compliance costs. This may reflect issues with the clarity or complexity of the Incentive, prompting the need for specialist advisers to help optimise companies' returns from the Incentive. In a review of the programme in 2015, stakeholders stressed the scope for reducing compliance costs by streamlining the application process (Australian Government, 2016e). Currently, companies first register the R&D activities they have self-assessed and then make the claim for tax return. As a reform option, the government could consider adopting a single application process for accessing the *R&D Tax Incentive*, as was also suggested by Ferris et al. Further benefits could be derived by developing a combined database by the two agencies (see Box 7) administrating the programme (Ferris et al., 2016).

The process for registering an R&D activity raises additional issues. Under present arrangements, the tax support is claimed *ex post*, i.e. after the R&D spending has taken place. Specifically, a firm has 10 months after the end of an income year to register R&D activities (Australian Government, 2016e). Some argue that this encourages claims for "business-as-usual" costs that do not represent the type of R&D targeted by the Incentive. A pre-registration process for R&D activity could lessen this problem, as it would require firms to identify specific projects that they would later make a claim for (ATSE, 2016); but such process could also add to the administrative burden on firms, and could be complex to be administrated if firms had to change their planning (Deloitte, 2016).

The review of the *R&D Tax Incentive* provided an opportunity to consider reforms that would maximise the returns of public investment in business R&D, including through a better co-ordination of the Incentive with other initiatives in the innovation agenda. However, reform also needs to take account of the importance of stability, so that businesses can plan R&D spending without having to accommodate regulatory risk. The *OECD Innovation Imperative* (OECD, 2015a) cites evidence suggesting that frequent R&D policy changes undermine the effectiveness of R&D tax credits (Westmore, 2013). The review of the Incentive sensibly proposes fine-tuning the system rather than wholesale change. At the same time, a systematic evaluation of the programme is essential to assess whether or not it remains relevant and to identify corrective measures.

Is there a case of rebalancing the mix of support?

A shift in the balance between indirect (tax incentives) and direct support (grants) for business R&D could also be considered. R&D tax incentives do not have the "picking winners" problem associated with direct grants and require fewer administrative resources to operate compared to grants (OECD, 2015e). However, as discussed above, the evidence suggests that tax incentives are not hugely efficient in terms of additionality, although this depends on design (Appelt et al., 2016). Grants or other forms of direct support can be more efficient, as these can be focussed on areas that might have particularly high additionality. Recent OECD analysis also suggests direct support measures may be more effective in inducing R&D than previously considered, especially in the case of young firms where lack of upfront funds for an innovative project is often a barrier. Furthermore, whereas R&D tax incentives are also more likely to stimulate short-term applied research and boost incremental innovation, direct subsidies are more targeted towards long-term research and radical innovations. However, the fund allocation process must be based on rigorous and transparent criteria, while the selection process should ensure efficiency and avoid rent-seeking activities and adverse selection problems (OECD, 2015a).

Enhancing coherence and co-ordination in the science, research and innovation system

A complex system with many players

Several government departments at the federal level and numerous councils, committees and boards are involved in the science, research and innovation system (Green, 2015). State governments are also involved in policy development and programme design. Federal government investment in research and innovation is spread across 15 portfolios, with their own research and innovation programmes and multiple agencies delivering such programmes (Cutler, 2008). Major research agencies, namely the *Australian Research Council* (ARC) and the *National Health and Medical Research Council* (NHMRC), do not directly conduct research but they influence the national research programme through the funding they provide to universities and medical research institutes.

A more co-ordinated approach would be welcome. A recent inquiry stressed the need for a more integrated, "whole-of-government", approach to science, research and innovation (The Senate, 2015). The consultation report highlights fragmentation in decision-making and resource allocation between many government departments and research funding agencies, as well as frequent changes in the functions and structure of departments and a lack of regular, independent evaluations. It calls for the establishment of strategic goals in key areas, eliminating duplication and overlap and ensuring continuity and outcome-orientation in policies and programmes across the whole of government.

Reforms underway could go further

A new independent board, *Innovation and Science Australia* (ISA), was established in 2016 that has roles: *i)* to provide strategic whole-of-government advice on the government's investment in science, research and innovation; and, *ii)* to oversee the operational delivery of a number of programs (Box 8; Australian Government, 2015a). Through the provision of coordinated data and advice, this new board will assist government to make better informed decisions about investment in science, research and innovation, and help plan such investment in light of national priorities (Australian Government, 2015a). ISA will conduct comprehensive audits and regular reviews of the innovation system, which can help identify possible gaps in and/or misalignment of strategic objectives. The 15-year plan for the government's investment in science, research and innovation that ISA is required to develop, will usefully help prioritise major research projects and reform initiatives.

Box 8 **Innovation and Science Australia**

A new statutory independent board, *Innovation and Science Australia* (ISA), was announced in December 2015, as part of the NISA, with responsibility for "strategic whole-of-government advice on all science, research and innovation matters" (Australian Government, 2015a). The relevant legislation for its establishment became effective in July 2016. The aim is for ISA to have a broader role than its predecessor, *Innovation Australia*. Notably, it will work across government and interact directly with stakeholders; audit and review regularly the innovation system to assess its performance and make recommendations to align government strategic priorities; and, develop a 15-year national plan for investment in science, research and innovation (Parliament of Australia, 2016). ISA will also continue to perform the work of its predecessor, including the administration, monitoring, oversight and operation of programmes such as the *R&D Tax Incentive* and the *Cooperative Research Centres* (CRC) programme. It will complement the *Commonwealth Science Council*, established in 2014 to advise the government on all aspects of science and technology in Australia.

Although is too early to assess the effectiveness of ISA, this reform holds promise in paving the way for a whole-of-government approach to science, research and innovation. ISA also has the potential for promoting collaboration, given that the new body will be working directly with the industry and community sectors. Such an engagement could in turn increase stakeholders' support for the government's innovation policies, and hence their successful implementation (OECD, 2015a). ISA's progress on these fronts needs to be closely monitored and evaluated. It is important to ensure that greater coordination does not come at the expense of the diversity of innovation activities, constraining the responsiveness of the science, research and innovation system to evolving needs (Cutler, 2008).

Steps towards a more coordinated and coherent system could further include abolishing or consolidating certain research programmes. The *National Commission of Audit* refers, for example, to the numerous (around 150) research funding programmes and agreements, many of which, in its view, are not well targeted or appear to have negligible positive spillovers (NCOA, 2014). Such programmes are spread across the various government agencies and departments. The Commission also saw scope for reducing administrative costs, proposing, for instance, a better aligning of ARC and NHMRC grant processes (but keeping the medical research funding pool separate).

Strengthening the monitoring and evaluation of innovation programmes

As mentioned in various places throughout this paper, high quality evaluation and performance measurement is a precondition for effective innovation policy, as they are the basis for changes if outcomes are not in line with intentions. The difficulties in developing effective measures and key performance indicators should not be underestimated, especially when the outcomes of the publicly funded research appear only in the longer term. Good practice principles underscore that evaluations should be based on independent and transparent assessment; their findings are made public; and that they are accompanied by effective mechanisms for policy learning to ensure that the findings of evaluation are guiding future decision making (OECD, 2015a). The system should incorporate both *ex-post* and *ex-ante* evaluations (Appelt et al., 2016; OECD, 2014).

Recent steps towards improving evaluation performance, including the development of the new impact assessment for university research and the transitioning of public-sector research agencies and other Commonwealth entities to a common approach to assessing the outcomes and impact of research under the *Public Governance, Performance and Accountability Act 2013* (discussed above) are welcome. Notably, the *Evaluation Strategy 2015-19* of the Department of Industry, Innovation and Science, provides a framework to guide evaluation and performance measurement of its programmes and policies (Australian Government, 2015b). The strategy incorporates evaluation across a programme's lifecycle and envisages both prospective and retrospective evaluations. A core goal of the framework is to improve the data available to assess programmes' outcomes and impacts, an essential element for ensuring policy effectiveness.

Recommendations on boosting R&D outcomes

Strengthening the links between research and business sectors

- Put a greater weight, as envisaged, on collaboration in university funding, including increasing the role of income derived from research partnerships in determining research grants. Implement university funding reforms that introduce simplified arrangements for block funding.
- Develop a more coordinated approach to industry placements for higher degree research students.
- Encourage a greater weight for industry experience in the university appointment and promotion system.
- Increase the take-up rate of programmes that encourage business to collaborate by implementing simple and flexible governance arrangements and providing greater stability in the range of programmes.
- Improve the management of Intellectual Property (IP) created by university research, particularly by further developing simplified IP contracts and continuing to promote open access publishing.

Achieving greater commercial impact from public-sector research

- Implement a common approach across public-sector research agencies for assessing research outcomes and impacts.
- Ensure that investments by the *CSIRO Innovation Fund* target projects with large commercialisation and productivity-enhancing potential.

Enhancing the effectiveness and efficiency of the R&D Tax Incentive

- Make the Incentive more effective by adjusting its parameters, for example by:
  - Combining an eligibility threshold with an increase in the expenditure cap for recipients of non-refundable component of the Incentive (larger companies), as suggested in the recent review.
  - Granting a part of the refundable Incentive under more stringent criteria for additionality.
  - Consider introducing an R&D tax premium for business expenditure on collaborative research with publicly funded research institutions.
- To better manage the fiscal cost of the Incentive, consider placing a cap on the refundable component, with any amounts above the cap to be carried forward.
- Adopt a single application process for accessing the Incentive to lower compliance costs.

Reducing complexity in the governance of the science, research and innovation system

- Develop a more integrated, “whole-of-government”, approach to science, research and innovation and consolidate innovation support programmes.
- Evaluate at an early stage the progress achieved towards greater co-ordination under the new innovation body, *Innovation and Science Australia*.

Improving evaluation performance and monitoring

- Strengthen the monitoring and evaluation of innovation programmes, in particular through the development of more comprehensive databases that provide input to the monitoring processes.

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