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AUSTRALIA'S POSITION IN THE WORLD OF SCIENCE, TECHNOLOGY & INNOVATION

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How well does Australia's science research and innovation system perform compared to other developed nations? Do we spend more or less on research and development than countries in Europe, Scandinavia and North America? This paper highlights some key results for Australia and other developed nations from the *OECD Science, Technology and Industry Scoreboard 2011*.

Overview

- Australia has a similar percentage of researchers in its workforce compared to North American and European nations, but fewer than Scandinavian countries.
- Australia has a low number of researchers (per cent) working in business enterprises but a relatively high number working in higher education.
- Australia's rate of spending on research and development (R&D) is now greater than that of a range of other countries, but it is significantly less than that of smaller Scandinavian countries. Spending on R&D in the Australian higher education sector is just over half the rates of Sweden and Denmark.
- The level of foreign investment in Australia's business R&D in 2009 was just 1.1 per cent, compared to more than 20 per cent for Austria, the United Kingdom and Ireland.
- If Australia is to further improve its research productivity and innovation capacity, then it may be useful to compare our R&D policy settings with those of smaller developed countries, especially in Scandinavia.

Background

The Organisation for Economic Cooperation and Development (OECD) released the 10th Edition of its *Scoreboard on Science, Technology and Innovation* in September 2011. The report includes statistics on more than 180 indicators from 59 OECD and non-OECD countries. These indicators include such measures as the level and type of spending on R&D activity, the impact of publications, and levels of collaboration.

The 2011 Scoreboard provides a wealth of information that is intended to allow "policy makers and analysts to compare their economies with others of a similar size or with similar structure and monitor their progress towards desired national … policy goals."[i] The purpose of this paper is to highlight some aspects of the relative performance of Australia's R&D system in recent years. The analysis covers eight of the more important indicators for Australia and 12 other countries (see Box 1 for the full list of countries). Each of the selected countries has a developed economy, an internationally respected research culture and a relatively large research workforce. The paper concludes with a discussion of possible implications for Australia's R&D policy.

Box 1: Countries included in this analysis

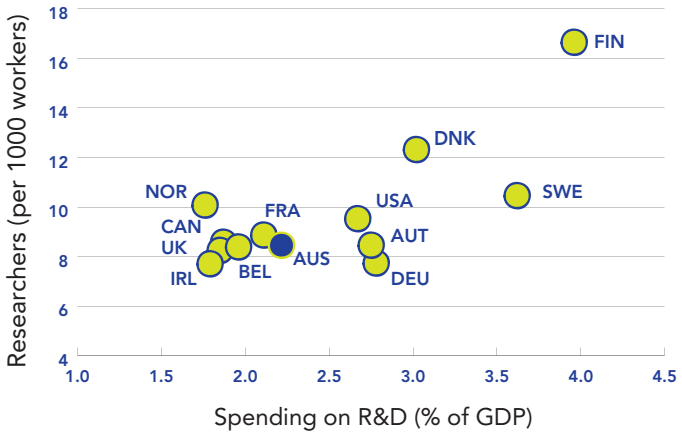
Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Ireland (IRL), Norway (NOR), Sweden (SWE), the United Kingdom (UK), and the United States of America (USA).

R&D expenditure and workforce

The Scoreboard includes two general measures of research activity. One is the size of a country's R&D workforce (the number of researchers per 1000 workers). The other is national expenditure on R&D relative to the size of each country's economy (R&D spending as a percentage of Gross Domestic Product—GDP). Figure 1 shows that most of the countries in this analysis have an R&D workforce (Y axis, vertical) between about 8 and 10 researchers per 1,000 workers. Denmark and Finland stand out on this measure with about 12 and 16 researchers per 1000 workers, respectively.

The rates of R&D spending (X axis, horizontal) for this group of countries vary considerably. Australia's rate of spending on R&D has increased by 51 per cent in recent years and is now greater than that of larger countries such as Canada and the United Kingdom, and of smaller countries such as Belgium, Norway and Ireland. Other smaller countries, namely Denmark, Sweden and Finland, have far higher R&D spending rates, which are consistent with their higher numbers of researchers.

Figure 1: Researchers (per 1000 workers) vs. spending on R&D (per cent of GDP)



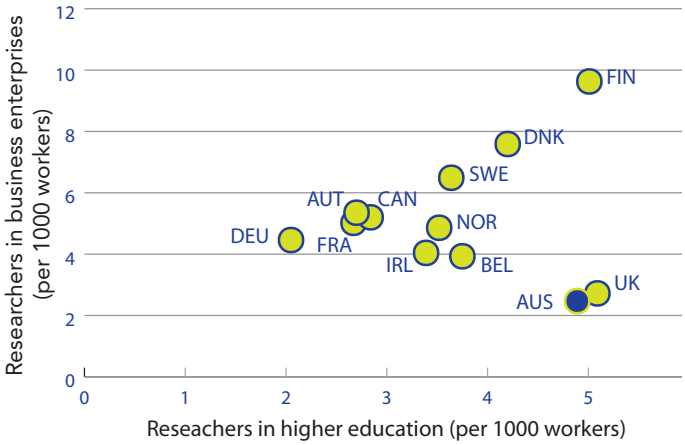
There are four main sectors where R&D takes place: higher education (mainly universities), business enterprises, government agencies and private not-for-profit organisations (e.g. independent medical research institutes). In Figure 2, the number of R&D researchers per 1,000 workers is shown for the two largest sectors: business enterprises (Y axis) and higher education (X axis).

All countries shown here have greater proportions of R&D workers in business enterprises than the United Kingdom and Australia. The proportions in the smaller countries of Sweden, Denmark and Finland are more than three times that of Australia.

The R&D effort in the United Kingdom and Australia is clearly concentrated in the higher education sector. Denmark and Finland, on the other hand, have strong R&D workforce numbers in both the higher education and business sectors.

Other more detailed OECD indicators show that the number of researchers in the manufacturing and service sectors in Australia (3.1 per 1000 employed in industry, 2009) was less than a third of the average figure for the four Scandinavian countries (10.0) and the United States (10.5). These figures reveal a critical lack of investment in, and a significant disadvantage for, innovation in Australia's industry sectors.

Figure 2: Researchers in business enterprises vs. researchers in higher education (per 1000 workers, data for USA not available)



Given that 60 per cent of Australian Government spending on R&D occurs in the higher education sector,[ii] it is relevant to compare recent growth in this spending across the group of countries. For most countries the increase in spending over the period 1999–2009 has been in the order of 13 to 45 per cent (36 per cent in Australia). However, spending on higher education R&D in Ireland and Denmark more than doubled in this period. The rates of higher education R&D expenditure in Canada and Finland are now 1.4 times greater than Australia's. The rates in Sweden and Denmark are 1.7 times greater than Australia's[a]. Each of these four countries also has more researchers working in the business sector (see Figure 2).

The relatively low level of R&D activity in the Australian business sector is also reflected in the low percentage of Australian business R&D that was supported by funds from abroad[b]. The level of business R&D funding from abroad was highest in Austria (23%), the United Kingdom (22%) and Ireland (21%). In these countries there is a strong presence of foreign multinationals in the economy and in the domestic production of technology[iii]. Across Canada and the selected Scandinavian and European countries, the average was about 10%. In contrast, Australia's level of business R&D funding from abroad was only 1.1%. This level was exceeded in 32 other countries in the full OECD report.

The low level of overseas business investment in Australian R&D is consistent with Australia's relatively low levels of business

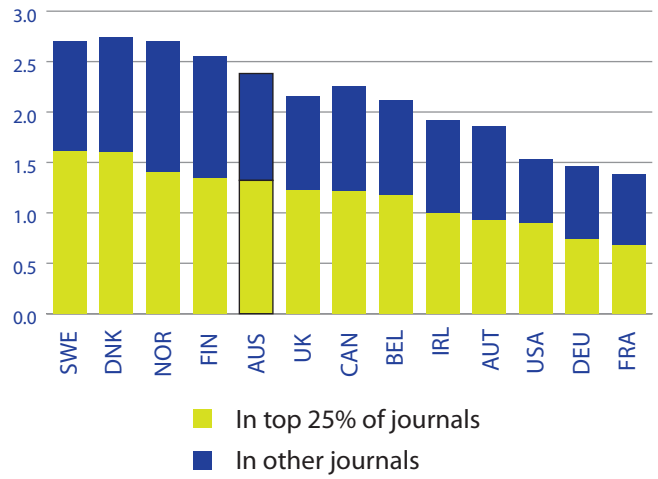
R&D and manufacturing and exports of goods and services as a proportion of GDP[iv]. Australia relies less on manufacturing and R&D in that sector because it has relatively high levels of natural resource rents[v] and 'natural capital'[vi] as a percentage of GDP compared to most of the countries included here. This is in contrast to Norway which also has very high 'natural capital' but which has more than double the level of R&D workforce in business enterprises than Australia and more than 10 times the level of international funding of business R&D.

Research outcomes

Counts of research publications and how often publications are cited by others are common measures of research outcomes. By sheer volume of publications, the United States is the most prolific, followed now by China[vii]. A different picture emerges if we look only at publications in the top journals. On this measure, the United Kingdom is in second place behind the United States. When the size of each country is also taken into account, the story is again different. Figure 3 shows the number of publications in two categories per 1,000 population—those in the top 25 per cent of journals (green bars) and those in other journals (blue bars)[vii].

On these measures, Australia compares favourably with the United Kingdom, Canada, United States, Germany and France. It is of interest that the smaller Scandinavian countries perform best among this group.

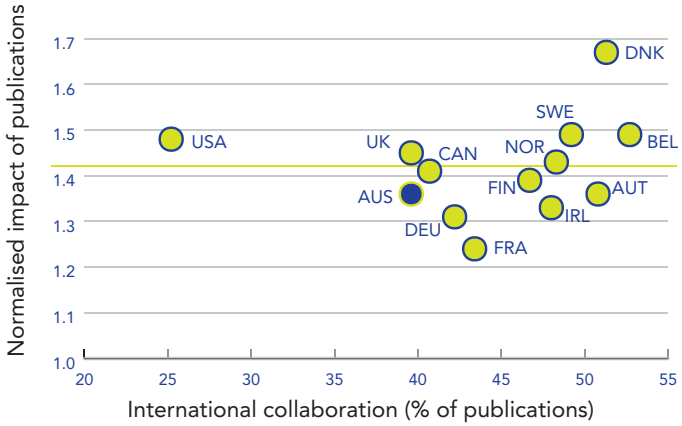
Figure 3: 2009 publications per 1000 population, by journal quality



Of increasing interest and importance is the level of collaboration between researchers. Collaboration is where researchers from different institutions—either within the same country or in different countries—work on and publish research together. Researchers collaborate because the challenges of modern R&D often require the sharing of expertise and infrastructure. The OECD also provides a measure of publication quality called the 'normalised impact'. The more times a publication is cited by other researchers, the higher the 'impact' it is said to have. The OECD has developed an average impact score for each country for all of each country's publications from 2003 to 2009[viii]. These scores were then normalised to the world average (an impact score of 1 means a country's publications were cited at the world average rate). Figure 4 shows each country's average impact score (Y axis) against their rate of international collaboration (per cent of publications; X axis).

For the group of countries included here the average impact score is 1.42 (Figure 4, green line, range 1.24 to 1.67). This means that publications from these countries have been cited, on average, 42 per cent more than the world average. Apart from France and Denmark, each country shown sits in a narrow band of impact scores ranging from 1.3 to 1.5. On the other hand, the level of international collaboration is much more variable (Figure 4).

Figure 4: Normalised impact of publications[viii] vs. international collaboration levels



The United States has the lowest level of international collaboration at 25 per cent of publications and Belgium has the highest at 53 per cent. The standout country on both measures shown here is Denmark, which has the second highest score for international collaboration (51 per cent) and the highest score for publication impact (1.67).

Research collaboration seems to play different roles in different countries. The relatively high impact of research in the United States apparently does not depend on collaboration with international partners. On the other hand, the high impact of research in smaller countries in this group is associated with high levels of international collaboration. Piecing this together, it appears that in smaller developed nations (particularly in Scandinavia) high levels of R&D support (Figure 1) go hand-in-hand with international collaboration and result in high impact research results. The impact of research from these countries is as good as or better than for larger countries such as the United States, France, Germany and Canada. The larger nations have lower levels of international collaboration than smaller nations of Europe and Scandinavia.

In Australia's case, with one of the lowest levels of international collaboration among this group of countries, research impact is nevertheless close to the average. For the United States, while its impact score is matched by some smaller countries, its global dominance in R&D is underpinned by the sheer volume of its research activity.

Discussion

The bulk of Australia's world-class R&D takes place in its universities. Through this effort, Australia produces 2.6 per cent of the OECD nations' total number of science and engineering graduates at doctorate level[ix]. The low level of researcher employment in Australian businesses indicates, however, that this research training primarily results in employment in higher education, rather than in industry. Other data from 2006 show that just 4 per cent of Australia's doctorate-holders are employed in manufacturing[x]. Low levels of researcher employment in industry may partly explain our relatively low level of doctorate holders overall. Australia has 8 doctorate holders per 1000 workers, less than the 11 per 1000 in the United States and much less than in Germany, which has 20 doctorate-holders per 1000 workers[xi].

The relatively low level of R&D activity in business in Australia is consistent with Australia's economy being heavily based on the export of natural resources, especially coal and iron ore. Manufacturing and the export of goods and services, which depend on R&D and innovation for their competitive advantage, contribute less to Australia's income in comparison to many other developed countries. It's possible that the future demand for, and revenue from, Australia's natural resources could decline because of declining international demand or volatile commodity prices. The need could then arise to change the balance of Australia's economy more towards innovation-led productivity. Strategies would be required to build business R&D and innovation. This would be challenging, given the low base from which business R&D must increase, and the time it takes to develop R&D capacity and capability.

Australia may also need to consider whether its current levels of R&D investment in universities and government agencies such as CSIRO is adequate when compared to other small nations, particularly in Scandinavia. Discussion needs to be raised as to what strategies should be introduced to boost R&D and innovation in all sectors, their cost and how they could be resourced. Australia is indeed fortunate to have a strong research base in its universities, government agencies and its not-for-profit research institutes. How best to capitalise on this base in order to build more R&D in industry and a more innovation-led economy is a challenge that lies ahead.

Conclusions

The data indicate that some nations with less than half the population of Australia, particularly in Scandinavia, achieve significant impact in their R&D through a number of different avenues. They have higher rates of R&D spending overall and in higher education; greater employment of researchers in business, manufacturing and services; higher levels of collaboration in R&D; and they attract more foreign investment to support their R&D activity. This poses the question: what can Australia learn from these countries to improve the overall level and impact of its R&D effort? Critical factors may include the level of investment in R&D, barriers to international mobility and collaboration of R&D personnel, the availability of research infrastructure and the attractiveness of the industry R&D environment.

This limited review of the OECD Scoreboard for 2011 shows the need for continued national debate about Australia's R&D effort and our position on the world stage. Future debate will be prompted and informed by the detailed analysis of the strengths and gaps in Australian science currently being prepared by Australia's Chief Scientist (see Further Reading). The debate should aim to ensure that Australia's policies for research and innovation support a national economy that can thrive and adapt to challenges as global economic circumstances change.

Further reading

OECD (2011), OECD Science, Technology and Industry Scoreboard 2011, OECD Publishing.

Australia's Chief Scientist, Professor Ian Chubb AC, will launch the Health of Australian Science report on 23 May 2012. The report will be available at: chiefscientist.gov.au

Notes

a) Australia's rate is for 2008, whereas the data for the other four countries was for 2009; Australia's rate in 2009 would be higher than in 2008.

b) Data are for 2009 except for Austria and Belgium (2007), and for Australia, France and Germany (2008). Data for the United States are not available.

References

i) OECD Scoreboard 2011, Page 3. See: Further Reading
ii) Australian Key Innovation Figures, accessed 25 April 2012
iii) OECD Scoreboard 2011, Page 92
iv) World Bank online data, accessed 18 March 2012
v) OECD online data, accessed 16 March 2012
vi) Natural capital as defined by worldbank.org, accessed 24 April 2012
vii) OECD Scoreboard 2011, Page 94
viii) OECD Scoreboard 2011, Page 47
ix) OECD Scoreboard 2011, Page 69
x) Edwards, D et al (2009) Supply, Demand and Characteristics of the Higher Degree by Research Population in Australia. ACER
xi) Auriol, L. (2007), Labour Market Characteristics and International Mobility of Doctorate Holders, OECD

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