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International comparisons of public and private sector expenditure on R&D

2.1 When comparing R&D activity between countries:

> … the most commonly used indicator for comparison purposes is the ratio of expenditure on R&D to Gross Domestic Product (GDP).[1]

2.2 The Organisation for Economic Cooperation and Development (OECD) compiles figures for the R&D / GDP ratio by sector: the business sector, the government sector, the higher eduction sector, and the private non-profit sector. The latter is small in absolute terms. Table 1 lists OECD countries in order of total expenditure on R&D as a percentage of GDP (the far-right column) as well as showing the R&D expenditure / GDP ratio of the business sector, the government sector and the higher education sector. Table 1 shows that Australia has:

- a relatively low business sector expenditure on R&D (BERD)—15th out of the 21 countries listed in the Table;
- a relatively high ratio of government sector R&D expenditure to GDP—equal third out of the 21 countries in the Table; and
- a relatively high ratio of higher education sector expenditure to GDP—equal tenth out of the 21 countries.

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1 Australian Bureau of Statistics (ABS), *Year Book Australia 2002, Science and Innovation, Expenditure on R&D – how does Australia compare internationally?* Cat. No. 1301.0, January 2002, p. 1.

2.3 On the basis of the information in the Table, it appears reasonable to conclude that the public sector in Australia (which includes both the government and most of the higher education sectors) is supporting R&D at an internationally competitive level but that the level of business R&D investment is less competitive. However, there are important qualifications to drawing so blunt a conclusion. These qualifications involve the following factors: problems of collecting international and national R&D data; differences in the structure of national economies; and limitations on what BERD measures. Each of these factors is examined in this chapter.

Problems of collecting international and national R&D data

2.4 Australian data on R&D is collected by the Australian Bureau of Statistics (ABS) which utilises the standard OECD definition of R&D. The ABS defines R&D as comprising creative work undertaken on a systematic basis in order to increase the stock of knowledge (of people, culture and society) and the use of this stock of knowledge to devise new applications. It is important that the work be original and have:

> … investigation as a primary objective, the outcome of which is new knowledge, with or without a specific practical application, or new or improved materials, products, devices, processes or services. R&D ends when work is no longer primarily investigative.[2]

2.5 Key aspects of this definition are the emphasis on 'creative' and 'original' work, the 'systematic' and 'investigative' nature of the activity, its use in 'new applications', and the very wide nature of the activity (it can be about people, culture or society).

2.6 When the R&D definition is used for international comparisons, it has the problem that:

> … the data is compiled from firms [which] are categorising expenditures as meeting the definition and there will be substantial errors and differences between countries. How big they are is really unknown.[3]

2 Australian Bureau of Statistics (ABS), *Australian Standard Research Classification (ASRC) 1998*, Cat. No. 1297.0, pp. 3-4.

3 Dr Ralph Lattimore (Productivity Commission), Transcript, p. 483.

Table 2.1: Expenditure on R&D as a percentage of GDP, OECD countries – 2000-2001

Country	**Business (%)**	**Government (%)**	**Higher education (%)**	**Total** [a] **(%)**
Sweden(b)	2.84	0.13	0.81	3.78
Finland	2.39	0.36	0.60	3.37
Japan	2.11	0.29	0.43	2.98
USA	2.04	0.18	0.38	2.72
Korea	1.96	0.35	0.30	2.65
Switzerland	1.95	0.03	0.60	2.64
Germany	1.75	0.34	0.40	2.49
France	1.37	0.38	0.41	2.18
Denmark(b)	1.32	0.32	0.44	2.09
Netherlands	1.13	0.25	0.57	1.97
Belgium(b)	1.40	0.06	0.47	1.96
United Kingdom	1.21	0.22	0.38	1.85
Canada	1.04	0.21	0.56	1.82
Norway(b)	0.92	0.25	0.47	1.65
Australia	**0.72**	**0.35**	**0.41**	**1.53**
Czech Republic	0.80	0.34	0.19	1.33
Italy	0.54	0.20	0.33	1.07
Spain	0.50	0.15	0.28	0.94
Hungary	0.36	0.21	0.19	0.80
Poland	0.25	0.23	0.22	0.70
Slovak Republic	0.44	0.17	0.06	0.67

(a) Includes private non-profit (b) Data for 1999-2000 only *Source:* ABS *Year Book Australia 2003*, Table 25.*3*

2.7 The cause of the difficulties was outlined by the Australian Bureau of Statistics in the following way:

> - There are difficulties in delineating the point which clearly separates the culmination of R&D investigative work and the beginning of the implementation phase of the innovations or recommendations resulting from R&D. Errors at this point are particularly significant because, although R&D programmes require large outlays of resources, the costs of implementing innovations or recommendations resulting from R&D may also be as high or higher in many instances;
> - Formulating a definition of what constitutes a unit of R&D [is difficult]. From a statistical point of view it is desirable that R&D expenditure be reported in the smallest cluster which can be classified to a single field of research and a single socio-economic objective. The extent to which it is not practicable to provide this detail will reduce the validity and usefulness of the classification, and the resulting R&D statistics; [and]
> - There is also a wide range of scientific and related activities which are not R&D, but which are closely linked with R&D in terms of organisation, resource allocation, institutional affiliation and the use or flow of information. However, activities conducted solely or primarily for the purposes of R&D support are included in R&D.[4]

2.8 These difficulties in compiling international data also apply to the collection of *national* data, as indicated in the Queensland government's submission to the inquiry:

> - There is no agreed conceptual framework governing the collection of data on innovation. As a result, data is often selectively and/or inappropriately used;
> - There is a lack of readily available comparative data on innovation measures available in Australia;
> - When figures are available, their validity and inaccuracy hinders the degree to which they can be used in evidence-based policy development;
> - Historical measures of innovation tend to focus on the manufacturing sector. As such, they provide a less accurate measure of innovative capacity in an economy like Queensland's, where resource and services industries are more dominant. Queensland's high productivity growth and stronger performance in some 'new economy'

4 ABS, *Australian Standard Research Classification (ASRC) 1998, op.cit.*, p. 4.

> indicators suggest that innovation is occurring more broadly across all sectors of the economy.[5]

2.9 Some witnesses told the committee that a further problem of collecting national data on business R&D is that the official statistics may understate business R&D. This could be caused by many SMEs being too busy to fill in survey forms or mistakenly thinking that the questions do not apply to their circumstances.[6] It may also be caused by a narrow definition of R&D that, in the case of the mining sector, has the effect of excluding ore processing, metal production and mining technology services.[7] The committee comes back to this definitional issue in the final chapter of this report.

2.10 The above difficulties in compiling national and international data on R&D activity, even when using a common definition, need to be kept in mind when drawing conclusions from the data.

Differences in the structure of national economies

2.11 The Productivity Commission told the committee that:

> … the lower ratios of BERD that we observe in Australia have more to do with Australia's industry structure being rather less-R&D intensive than the industry structures in some other countries. The services sector in this relatively small economy looks particularly large and, while the service sector does much innovation, not a lot of that is technological R&D, although services are big users of technology.[8]

2.12 The Commonwealth Department of Industry, Tourism and Resources supported the Productivity Commission's view, noting that:

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5 Queensland Government, Submission No. 71, p. 2.

6 Mr Michael Turner, Submission No. 30, p. 1: 'Because SMEs do not register for AusIndustry tax concessions (due to the perceived plethora of paperwork or apply for grants and assistance (again due to the volume of paperwork), Federal agencies are therefore unable to easily ascertain the actual level of SME R&D'; Mr Matt Crellin, Submission No. 1, p. 1: Services-based organisations 'are keen to undertake R&D but do not have the incentive offered to organisations in other sectors to register and obtain government assistance;' Mr Robert Campbell (Precision Metals Pty Ltd), Transcript, p. 582: 'A lot of R&D is being done, but I do not think the government is recording it properly.'

7 Mr Richard Davies (Australian Mineral Industries Research Association International Ltd), Transcript, p. 254: 'The ABS statistics undervalue the total contribution of the [mining and minerals] industry because they adopt a narrow definition which excludes much of manufacturing services'.

8 Mr Gary Banks (Productivity Commission), Transcript, p. 481.

> Australian industry is characterised by a large number of small firms, the dominance of foreign-owned firms in some industries and few large firms that operate as home-based multinationals. This leads to gaps in the availability of global distribution channels and limited availability of domestic innovators and producers. Australia has a small population and home market especially for specialised products.[9]

2.13 Other witnesses also commented on Australia's industry structure. It was noted that agriculture is 'diminishing in terms of percentage of the economy'[10] and that Australia 'lack[s] the concentration of R&D-intensive industries such as pharmaceutical, chemicals and information technology'.[11]

2.14 The United States was said to have '33% more manufacturing contributing to GDP than we do'[12] and, just in terms of defence activity, the US expenditure on 'defence R&D, as a percentage of GDP, is about eight times higher than in Australia, and around 40 times higher than in Italy'.[13]

2.15 In relation to large and small companies, the committee was told that 'we do not have enough larger companies' which are the ones with the financial capacity to undertake R&D.[14] ABS figures confirm that the larger businesses conduct most of the R&D done in Australia: firms employing more than 1,000 people accounted for 39% of total R&D expenditure in 2000-01; firms employing less than 20 people accounted for just 11% of the R&D expenditure.[15]

2.16 In relation to small companies, witnesses stated that there is a 'predominance of SMEs in the Australian industry structure' and most of these SMEs are not in a position to do R&D.[16] 'They do not have the financial capacity and they cannot take those long-term risks'.[17]

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9 Commonwealth Department of Industry, Tourism and Resources, Submission No. 38, p. 12.

10 Mr John Grace (Council for Knowledge, Innovation, Science & Engineering, Victoria), Transcript, p. 76.

11 Australian Paper Industry Council, Submission No. 44, p. 7.

12 Mr John Grace, *op cit*., p. 73.

13 Commonwealth Department of Industry, Tourism and Resources, *op.cit.*, pp. 7-8.

14 Ms Catherine Livingstone (Australian Business Foundation Ltd), Transcript, p. 295.

15 Australian Bureau of Statistics (ABS), *Research and Experimental Development, Businesses Australia*, Cat. No. 8104.0, July 2002, p. 6.

16 Mr Gary Banks (Productivity Commission), Transcript, p. 482.

17 Ms Catherine Livingstone, *op cit*., p. 283.

2.17 ABS figures confirm the predominance of SMEs. In 1998-99 small private sector businesses (defined by the ABS as those employing less than 20 full-time equivalent people) accounted for 95% of all private sector businesses. These small businesses employed almost 3.4 million people, which is 48% of all private sector employment.[18]

2.18 The overall result of these factors is to render Australia's industry structure less R&D-intensive than some other countries. The structural differences between countries mean that international comparisons of R&D activity should be treated cautiously, even though such comparisons 'will nevertheless continue to form a part of the wider information base on which judgements about the appropriateness of national investment in R&D will be made'.[19] The structural differences:

> … make international comparisons of relative expenditure on R&D by business and/or by governments difficult to interpret and of limited value on their own.[20] [Further,] Australia is far from being a typical OECD country and so comparisons with economies of OECD countries may be quite inappropriate.[21]

Limitations on what BERD measures

2.19 The limitations on what BERD measures are of two broad kinds. Both relate to what BERD is *not*. It is *not* a measure of productivity, and it is not necessarily a good measure of innovative capacity or achievement.

BERD is *not* a measure of productivity

2.20 BERD is a measure of what businesses spend on R&D; hence, it is an output measure and 'a poor indicator of the value that accrues to

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18 Australian Bureau of Statistics (ABS), *Small Business in Australia 1999*, Cat. No. 1321.0. The ABS defines a 'large business' (excluding those in the agriculture sector) as one employing 200 or more people. The ABS defines a 'medium business' as one employing 20 to 199 people. The ABS does not utilise an employment-size definition of an agricultural business because of difficulties in defining small business on this criterion. For this sector, the ABS utilises a measure called the 'estimated value of agricultural operations' (EVAO). A small agricultural business is defined as one having an EVAO of between $22,500 and $400,000.

19 Commonwealth Department of Industry, Tourism and Resources, *op.cit.*

20 *ibid.*, pp. 7-8.

21 Australian Academy of Technological Sciences and Engineering, Submission No. 48, p. 1.

productivity and export performance in the commercialisation of R&D'.[22]

2.21 While international comparisons focus on the BERD / GDP ratio, it is the *inverse* ratio which gives some indication of productivity, that is, the ratio of GDP to BERD. The Productivity Commission stated that, on this ratio, Australia scores well, meaning that our R&D productivity is high compared to many other countries that are hailed as a model: 'Australia has a high R&D productivity [which means that] we get a lot of output for less R&D'.[23]

BERD is not necessarily a good measure of innovative capacity or achievement

2.22 Australia does not yet have statistical studies on innovative activity (with the exception of two surveys of the manufacturing sector conducted by the Australian Bureau of Statistics in 1993-94 and 1996-97).[24] This gap in the data on innovation is of concern to the ABS, which is developing a broader innovation survey for use in late-2003. The concern of the ABS is reflected in the following comment:

> Conspicuously absent from the data presently available for Australia are recent measures of innovation outputs (that is, new products and processes that are being implemented). Such "output" data provide an informative and direct way to measure the degree to which Australia is innovating and can be obtained through industry-wide business surveys… [Such surveys would] ascertain what proportion and types of businesses are innovating (that is, introducing new products and processes), what types of innovations are occurring and what impact they are having on the output and productivity of the businesses concerned.[25]

2.23 The new survey being developed by the ABS will be compatible with OECD guidelines 'although it would probably also include non-technological (organisational and managerial) innovation'.[26] The

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22 Mr Richard Davies (Australian Mineral Industries Research Association International Ltd), Transcript, p. 254.

23 Mr Gary Banks (Productivity Commission), Transcript, p. 488 and discussion on p. 492.

24 Australian Bureau of Statistics (ABS), *Innovation in Manufacturing (1996-97), Cat.* No. 8116.0, June 1998. Also see ABS, *Year Book Australia 2003 - Science and Innovation, Innovation Statistics*, Cat No. 1301.0, January 2003.

25 Australian Bureau of Statistics (ABS), *Newsletters: Science and Technology Statistics Update*, Bulletin No. 7, December 2002, p. 10.

26 *ibid.*

importance of including information about non-technological innovation was stressed by the Productivity Commission and the Australian Business Foundation:

> Technological R&D is often less valuable as perceived by SMEs than other forms of innovation: organisational innovation, innovation in terms of the relationships with their customers and so on.[27]
>
> There is a lot of innovative activity going on where R&D investment is not central to it… for example [there are] new competitive strategies going on in Australia where both manufacturing and service firms are linking and selling products and services together in innovative ways… They are doing things like prototyping, help desks, maintenance services, training, technical upgrades and even putting together packages of sutures and surgical instruments for any given surgical procedure and for a number of surgical supply companies. This has been found to be widespread.
>
> A new competitive dynamism… [is] going on in that respect. New skills, new alliances and new capabilities are being fostered as a result of that, in response to tough, crowded and saturated markets, low-cost competition and so on. *Mostly this does not involve business R&D investment*… There is a new dynamic going on and a new competitiveness is happening because companies see the need to do so—to retain customers, to share risks, to add new value to customers…
>
> [But the important point is that] while it [business R&D] is quite crucial to Australia's innovation, it is not necessarily the full story.[28]

2.24 In the absence of Australian-derived statistical data on innovative activity, it is useful to examine material in the *World Competitiveness Yearbook* of the Institute for Management Development. The *Yearbook* compares 75 countries against 174 indicators. On global competitiveness in relation to innovative activity, the Institute found that 'Australia has dropped to 14th position in the overall rankings for 2002, from 11th position in 2001'.[29] This assessment took account

27 Mr Gary Banks (Productivity Commission), Transcript, p. 482.

28 Ms Narelle Kennedy (Australian Business Foundation Ltd), Transcript, p. 293 (emphasis added).

29 Institute for Management Development, *World Competitiveness Yearbook*, June 2002, quoted in Submission No. 29 (Council for Knowledge, Innovation, Science & Engineering, Victoria).

of economic performance, government efficiency, business efficiency, infrastructure, the nature of research and innovation (whether oriented to basic research or not),[30] the number of patents issued, the number of personnel engaged in research, and international prizes won. Some of the relevant R&D indicators used in making the global assessment, and Australia's ranking on these indicators, are shown in Table 2.2.

2.25 The detailed information in the global assessment of innovative activity led the non-Ministerial members of the Victorian Council for Knowledge, Innovation, Science and Engineering to conclude that:

> The total number of Australian patents in force is relatively high (12th rank) but other countries are catching up (32nd rank for change in patents granted to residents).
>
> Business expenditure on R&D (17th rank) lags total spending on R&D (14th rank). Likewise, the total number of R&D personnel in business enterprises (19th) lags the total number of R&D personnel nationwide (13th). This indicates that government is currently investing more significantly in R&D than business.[31]

2.26 Further insights into Australia's innovative capacity and achievement are available from the measures of 'current competitiveness' prepared by the World Economic Forum. This shows Australia as ranked ninth in 2001-02, up from 15th in 1998-99.[32] The 'current competitiveness indicator' has two elements: 'company operations and strategy', and

30 'Basic research' is defined by the ABS as being 'experimental and theoretical work undertaken primarily to acquire new knowledge without a specific application in view'. It contrasts to 'applied research' which is defined as 'original work undertaken in order to acquire new knowledge with a specific application in view'. A further category mentioned in this report is 'experimental development' which is defined as 'systematic work, using existing knowledge gained from research or practical experience for the purposes of creating new or improved products / processes' (ABS, *Research and Experimental Development: Higher Education Organisations Australia, 2002*, Cat. No. 8111.0, Glossary, p. 20).

31 Council for Knowledge, Innovation, Science and Engineering, Victoria, Submission No. 29 (Non-Ministerial members of the Victorian Council for Knowledge, Innovation, Science and Engineering), Attachment A, quoting from the Institute for Management Development, *World Competitiveness Yearbook*, June 2002.

32 'The Current Competitiveness Index [CCI] examines the microeconomic bases of a nation's GDP per capita and provides insights into the level of GDP per capita that is sustainable into the medium term. Unless firms are fundamentally improving their operations and strategies and competition is moving to a higher level, growth will be snuffed out. The CCI is a bottom-up type of indicator that is attuned to the corporate base rather than macro measures of performance and is based on survey data rather than hard data.' World Economic Forum, quoted in Submission No. 29 (Council for Knowledge, Innovation, Science and Engineering, Victoria), Attachment A, p. 2.

'quality of the national business environment'. The Forum found that in 2001/2002, Australia's business environment was ranked in seventh position ahead of company practice in 24th position. The specifically R&D factors used by the Forum are listed in Table 2.3.

Table 2.2: R&D indicators in relation to global assessment of innovative activity in 75 countries

R&D indicators	Australia's rank
Patent and copyright protection	10
Basic research	11
Scientific articles	11
Total R&D personnel nationwide per capita	12
Number of patents in force	12
Nobel prizes	13
Nobel prizes per capita	13
Total R&D personnel nationwide	13
Total expenditure on R&D	14
Securing patents abroad	16
Business expenditure on R&D	17
Patents granted to residents	17
Patent productivity	18
Total expenditure on R&D per capita	19
Total R&D personnel in business enterprises	19
Total expenditure on R&D%GDP	21
Business expenditure on R&D per capita	21
Total R&D personnel in business per capita	21

Source: Institute for Management Development, *World Competitiveness Yearbook*, June 2002, quoted in Submission No. 29 (Non-Ministerial members of the Victorian Council for Knowledge, Innovation, Science and Engineering), Attachment A, p. 1.

2.27 On the basis of these figures, the Victorian non-Ministerial Council for Knowledge, Innovation, Science and Engineering concluded that:

- Much of the supporting infrastructure for R&D in Australia is in place with world-class tax credits (sixth rank) and subsidies (eighth rank) for firm-level research

and development as well as high-quality scientific research institutions (ninth rank);

- Business enterprises, however, are not taking full advantage of the supporting infrastructure. Firm-level innovation is very low (35th rank) as is company spending on R&D (23rd rank);
- There is room to improve the linkages between universities and industry (14th rank) and the technology transfer resulting from foreign direct investment (21st rank) in order to facilitate R&D and improve Australia's technological sophistication (16th rank).[33]

Table 2.3: R&D indicators used by the World Economic Forum to rank the current competitiveness of 75 countries

R&D indicators	Australia's rank
Tax credits for firm-level R&D	6
Subsidies for firm-level R&D	8
Quality of scientific research institutions	9
Firm-level technology absorption	13
University/industry research collaboration	14
Technological sophistication	16
Foreign direct investment and technology transfer	21
Company spending on R&D	23
Availability of scientists and engineers	24
Firm-level innovation	35

Source: Institute for Management, *Development World Competitiveness Yearbook,* June 2002, quoted in Submission No. 29 (Non-ministerial Council for Knowledge, Innovation, Science and Engineering), Attachment A, p. 2.

2.28 The information in the *World Competitiveness Yearbook* indicates that Australia's overall innovation performance compares well to other countries, particularly when it is realised that the most recent data on business expenditure on R&D 'precedes the commencement of *Backing Australia's Ability* which includes a number of initiatives aimed at increasing BERD'.[34] These initiatives are described in the following chapter.

2.29 The Commonwealth Department of Industry, Tourism and Resources concluded that:

33 Council for Knowledge, Innovation, Science and Engineering, Victoria, Submission No. 29, Attachment A, p. 2.

34 Commonwealth Department of Education, Science and Training, Submission No. 64, p. 11.

> Australia's innovation performance based on internationally comparable data is consistently high—in the top ten of the 30 OECD member countries... [This is due to] the relative strength of our skills base, the competitive cost of labour, and the capacity of Australian businesses to transfer technology throughout the economy.[35]

2.30 The Department of Industry, Tourism and Resources added:

> Australia has the highest number of domestic and international strategic alliances for the size of its economy. Further, Australian businesses have one of the strongest relative capacities to integrate technology into their operations - the number of young science technology graduates in the labour force is 42% higher than the OECD average.
>
> Research by the United States-based Economist Intelligence Unit has rated Australia second only to the US in its provision of an environment conducive to the development of e-business opportunities. This is critical to Australia maximising its position in the emerging information economy.[36]

2.31 The Chief Scientist added his support for Australia's improved, and impressive, innovation performance when he stated that the 'most recent data' shows:

> 16 start-up companies per one billion dollars of research expenditure in the year 2000—this is a survey undertaken, with a fair amount of rigour, of the medical research institutes, the government-funded research agencies and the universities, so it is fairly comprehensive—versus 13.8 in the US and 37.5 in Canada. You can look at this and say we are on track for the sort of target that I had proposed to the Prime Minister's Science, Engineering and Innovation Council a year or so ago of creating 250 start-up companies from our public investment in R&D within five years, with an expectation that this will add $20 billion per annum… to our exports… [This] is telling us that we are now getting the settings more right than we have in the past.[37]

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35 Commonwealth Department of Industry, Tourism and Resources, *op.cit.*, p. 12.

36 *ibid.*

37 Dr Robin Batterham (Chief Scientist), Transcript, p. 467.

Conclusion

2.32 On the basis of the information outlined in this chapter, the committee concludes that Australia's level of BERD is relatively low, but increasing, when compared to OECD countries. However, our general productivity, innovative activity and the national competitiveness of the Australian economy in recent years gives the Committee cause for confidence. Nonetheless, every effort should be made to increase the level of BERD for reasons that are explained in the following chapters