2

Innovation and Commercialisation—Concepts, Definitions and Metrics

2.1 This chapter examines:

- the concept, definition and meaning of innovation and commercialisation;
- the measurement (or metrics[1]) and assessment of Australia's innovation and commercialisation performance, including consideration of the limitations associated with indicators, data and metrics frameworks.

2.2 There were two consensus issues about the concept, definitions and metrics of innovation and commercialisation.

2.3 **Consensus Issue 1**—There are diverse understandings of innovation and commercialisation, resulting in a range of ambiguities. What has emerged is that:

- innovation is a complex non-linear process;
- innovation means different things to different people – this is reflective of the fact that the nature of innovation is different across sectors and industries. Various understandings result in divergences about the spectrum of activities that are considered innovative, the expected and preferred outcomes of innovation, and the range of factors that are seen to drive the innovation process; and

---

1 Metrics are a system of parameters or ways of quantitative assessment of a process that is to be measured, along with the processes to carry out such measurement.

- the meaning of commercialisation varies across sectors as does its significance as an outcome of innovation.

2.4 **Consensus Issue 2**—Measurement and assessment of innovation performance is important to formulating, implementing and evaluating effective innovation policy. There are, however, limitations to innovation and commercialisation metrics frameworks and there is scope for different assessments of the metrics meaning.

What is Innovation?

2.5 The evidence to the inquiry is that innovation is a multi-faceted and complex process that encompasses a broad spectrum of diverse activities and outcomes.

2.6 In its call for submissions to the inquiry, the Committee defined innovation as:

> ... the path of conceiving, developing and implementing ideas through to the generation of products, process and services. It gives economic value to a nation's knowledge.[2]

2.7 In fact, there is no consensus on the meaning of innovation; innovation means different things to different people.[3] For example, Dr Richard Rowe noted:

> To some 'innovation' involves the generation of globally novel ideas, processes or products. To others 'innovation' means the exploitation in Australia of concepts or products well-known elsewhere. To yet others 'innovation' includes the application of methods or products which may have long been known but the impacts of which had been under-appreciated or perhaps unrecognised. Any investigation into 'innovation' must recognise these different concepts, and perhaps others, associated with the term.[4]

---

2 Invitation to make submission, House of Representatives Standing Committee for Science and Innovation, *Pathways to Technological Innovation Inquiry.*

3 For example, see: Coordinating Committee on Science and Technology Working Group on the Metrics of Research Commercialisation, *Submission No. 7*, p. 1; Professors K Smith and J West, *Submission No. 18*, pp. 4-5. Department of Education, Science and Training, *Submission No. 20*, p. 32; Commonwealth Scientific and Industrial Research Organisation (CSIRO), *Submission No. 32*, p. 6; Group of Eight, *Submission No. 62*, p. 2; Mr S Fenton-Jones, *Supplementary Submission No. 78.1*, p. 1.

4 Dr R Rowe, *Submission No. 26*, p. 1.

2.8 In a similar vein, the Department of Education, Science and Training (DEST) has noted that concepts and definitions of innovation are 'evolving and can be somewhat ambiguous' [5], commenting:

> Innovation is a more recently introduced term about which there is, as yet, a less well developed consensus than for science. Various descriptions of innovation have been offered over the years … with a central idea being that innovation describes not merely the creation of new ideas, processes and technologies, but also their uptake, application and use to yield new value.[6]

2.9 As different understandings of innovation have implications for the measurement and assessment of innovation, initiatives have been undertaken to develop international standards. The Organisation of Economic Cooperation and Development (OECD) and Eurostat[7] have taken a lead in this regard through the development of the *Oslo Manual*, a publication that provides guidelines for collecting and interpreting innovation data.[8]

2.10 To date three editions of the *Oslo Manual* have been produced, with the third edition published late in 2005. Notably, the categories and definition of innovation have been modified between editions, reflecting 'changing policy needs'.[9]

2.11 Also of note with regard to the *Oslo Manual* is its intentional focus on the assessment of innovation occurring in the business enterprise sector. In relation to this, the manual states:

> Innovation can occur in any sector of the economy, including government services such as health or education. The Manual's guidelines, however, are essentially designed to deal with innovations in the business enterprise sector alone. This includes manufacturing, primary industries and the services sector.

---

5 Department of Education, Science and Training, *Submission No. 20*, p. 22.

6 Australian Government 2003, *Mapping Australian Science and Innovation: Main Report*, p. 35.

7 Eurostat is the statistical arm of the European Commission, producing data for the European Union and promoting harmonisation of statistical methods across the member states.

8 Organisation of Economic Cooperation and Development (OECD) and Eurostat, *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data,* 3rd Edition, 2005, pp. 46-61.

9 Organisation of Economic Cooperation and Development (OECD) and Eurostat, *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data,* 3rd Edition, 2005, p. 3.

> Innovation is also important for the public sector. However, less is known about innovation processes in non-market-oriented sectors. Much work remains to be done to study innovation and develop a framework for the collection of innovation data in the public sector. Such work could form the basis for a separate manual.[10]

2.12 Innovation in the business enterprise sector is defined in the *Oslo Manual* as:

> ... the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations.[11]

2.13 The *Oslo Manual* also identified and defined the following four categories of innovation:

- **Product innovation**—the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.
- **Process innovation**—the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.
- **Marketing innovation**—the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.
- **Organisational innovation**—the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations.[12]

2.14 As noted previously, the categories and definitions of innovation have been modified between editions of the manual, with previous editions distinguishing between technological and non-technological innovation.

10 Organisation of Economic Cooperation and Development (OECD) and Eurostat *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data,* 3rd Edition, 2005, p. 16.

11 Organisation of Economic Cooperation and Development (OECD) and Eurostat, *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data,* 3rd Edition, 2005, p. 46.

12 Organisation of Economic Cooperation and Development (OECD) and Eurostat, *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data,* 3rd Edition, 2005, pp. 47-52.

2.15 The second edition of the *Oslo Manual* provided the following definition of **technological innovation**:

> Technological product and process (TPP) innovations comprise implemented technologically new products and processes and significant technological improvements in products and processes.[13]

2.16 **Non-technological innovation** was defined as covering:

> ... all innovation activities which are excluded from technological innovation. This means it includes all the innovation activities of firms which do not relate to the introduction of a technologically new or substantially changed good or service or to the use of a technologically new or substantially changed process. The major types of non-technological innovation are likely to be organisational and managerial innovations.[14]

2.17 The word 'technological' was removed from the 2005 definitions of innovation in the third edition of the manual on the basis that:

> ... the word raises a concern that many services sector firms would interpret 'technological' to mean 'using high technology plant and equipment', and thus not applicable to many of their product and process innovations.[15]

2.18 However, in modifying the definitions of innovation between editions of the manual the importance of maintaining continuity with the earlier definitions was acknowledged.[16]

2.19 Essentially, product and process innovation as defined in the third edition of the *Oslo Manual* is equivalent to the earlier definition of technological innovation. Marketing and organisational innovation as defined in the third edition of the *Oslo Manual* is equivalent to the earlier definition of non-technological innovation.[17]

---

13 Organisation of Economic Cooperation and Development (OECD) and Eurostat, *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data,* 2nd Edition, 1997, p. 31.

14 Organisation of Economic Cooperation and Development (OECD) and Eurostat, *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data,* 2nd Edition, 1997, p. 88.

15 Organisation of Economic Cooperation and Development (OECD) and Eurostat, *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data,* 3rd Edition, 2005, p. 17.

16 Organisation of Economic Cooperation and Development (OECD) and Eurostat, *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data,* 3rd Edition, 2005, p. 47.

17 Organisation of Economic Cooperation and Development (OECD) and Eurostat, *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data,* 3rd Edition, 2005, p. 47.

2.20 While not specifically defined in the *Oslo Manual,* several other categories of innovation are commonly recognised. These categories include research and development (R&D)-based versus non-R&D-based innovation, and radical versus incremental innovation.

2.21 As these terms have been used frequently in submissions to the inquiry, the definitions used by DEST in its 2003 *Mapping Australian Science and Innovation Report* are provided:

- **R&D-based innovation** by a firm is most likely to involve applied research and experimental development of product concepts (prototype design, development and testing). Innovation that does not involve R&D may involve identifying new markets, products and technologies, piloting new production facilities, buying in technical information or skills, or investing in equipment or inputs that embody R&D undertaken by others (including from overseas), together with industrial design, which has been established as a highly important innovation activity.
- **Radical versus incremental innovation**—Incremental innovation typically involves relatively small changes in existing products or processes, building on existing technology or practices—fundamentally, it involves continuous improvement. Radical innovation, on the other hand, can involve significant and disruptive changes to products and processes based on new scientific or technological knowledge, or highly novel combinations of existing science and technology.[18]

2.22 While these categories and definitions provide a potentially useful framework for considering innovation, it is recognised that some innovations may have characteristics that span more than one category and that different categories of innovation may be inter-dependent.[19]

18 Australian Government 2003, *Mapping Australian Science and Innovation: Main Report*, pp. 36-37.

19 Organisation of Economic Cooperation and Development (OECD) and Eurostat, *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data,* 3rd Edition, 2005, p. 53.

What is Commercialisation?

2.23 Private sector submissions generally did not discuss the definition of commercialisation in the context of comments on innovation. This reflected an implicit consensus that it was about generating commercial returns.

2.24 The Australian Government described commercialisation in its 2003 *Mapping Australian Science and Innovation Report* as follows:

> **Commercialisation** is 'the process of transforming ideas, knowledge and inventions into greater wealth for individuals, businesses and/or society at large'. Commercialisation is a subset of the broader process of innovation. It is driven by market and profit motives, with firms and others seeking to gain a positive return on investment in research, licensing, product development, and marketing, including through the creation of competitive niche markets.[20]

2.25 Evidence to the inquiry has suggested that the definition of commercialisation and its application in the context of publicly funded research is problematic.[21]

2.26 For Australia's publicly funded research, DEST has provided a separate and specific definition of research commercialisation. Until late 2005, the definition of research commercialisation used by DEST for data collection and statistical purposes was:

> **Research commercialisation** refers to the processes that generate commercial returns through income and capital gains, income from licences and revenue from sales of new products and processes from research conducted.[22]

---

20 Australian Government 2003, *Mapping Australian Science and Innovation: Main Report*, p. 37.

21 See for example Coordinating Committee on Science and Technology Working Group on the Metrics of Research Commercialisation, *Submission No. 7*, attached report *Metrics for Research Commercialisation: A Report to the Coordination Committee on Science and Technology*; Department of Education, Science and Training, *Submission No. 20*, p. 32; Knowledge Commercialisation Australasia (KCA), *Submission No. 27*, pp. 2-3; Group of Eight, *Submission No. 62*, p. 2.

22 Department of Education, Science and Training, *Definitions and Methodological Notes: Statistics on Science and Innovation 2004*, p. 28.

2.27 However, this definition of research commercialisation has been contested. The debate has covered the range of activities encompassed by the term and the impact of the definition on the measurement and assessment of research commercialisation activities in publicly funded research institutions (PFRIs).[23]

2.28 In 2005, a technology transfer and research commercialisation workshop from the Group of Eight, an advocacy group with representation from eight leading Australian universities[24], produced the following question for consideration:

> Does 'commercialisation' refer just to the exploitation for financial gain of Intellectual Property developed within the institution, or does it extend to include the myriad of other ways by which research organisations transfer knowledge for the benefit of the economy?[25]

2.29 This question, and the definition of research commercialisation, has been considered in detail in two recent reports produced for DEST, in the context of assessment of Australia's innovation performance.

2.30 The first of these reports, *The Emerging Business of Knowledge Transfer*[26], released in March 2005 and known as the Howard report, stated:

> Research commercialisation is a term that is used widely and diversely within research organisations, industry, and government. In application, it has slightly different interpretations and meanings.[27]

---

23 See for example Coordinating Committee on Science and Technology Working Group on the Metrics of Research Commercialisation, *Submission No. 7*, attached report *Metrics for Research Commercialisation: A Report to the Coordination Committee on Science and Technology*; Department of Education, Science and Training, *Submission No. 20*, p. 32; Knowledge Commercialisation Australasia, *Submission No. 27*, pp. 2-3; Group of Eight, *Submission No. 62*, p. 2.

24 Group of Eight membership consists of the vice-chancellors (presidents) of: the University of Adelaide; the Australian National University; the University of Melbourne; Monash University; the University of New South Wales; the University of Queensland; the University of Sydney; and the University of Western Australia.

25 Group of Eight, accessed 12 October 2005, *Report on Outcomes of the Technology Transfer and Research Commercialisation Workshop held on 8 July 2005 in Canberra,* <go8.edu.au>.

26 Howard Partners 2005, *The Emerging Business of Knowledge Transfer: Creating Value from Intellectual Property and Services.*

27 Howard Partners 2005, *The Emerging Business of Knowledge Transfer: Creating Value from Intellectual Property and Services,* p. 11.

2.31 The Howard report identified four types of knowledge transfer that extend beyond the traditional understanding of commercialisation as the selling or licensing of research and intellectual property:

- **Knowledge production**—sees transfer as the sale of 'knowledge products' embedded in intellectual property (IP) and other explicit or codified formats, and manifested in sale and or licensing of intellectual property rights to new businesses (spin-outs) or existing businesses which may be in the public or private sector.
- **Knowledge diffusion**—approaches transfer from the perspective of encouraging broad industry adoption of the results of research; it emphasises communication and adoption of research results.
- **Knowledge relationship**—sees transfer as the provision of services to businesses based on a broadly defined intellectual property platform, including trade secrets, know-how and other forms of tacit knowledge; it emphasises collaboration, partnership and joint ventures.
- **Knowledge engagement**—sees transfer as a by-product of a convergence of interests between science and society and in particular, the interests of higher education, industry, and government.[28]

2.32 The Howard report suggested that these types of knowledge transfer might better encompass the range of different processes and interactions involved in commercialising research emerging from Australia's PFRIs.[29] DEST also noted that while the term research commercialisation was initially limited to the knowledge production model (i.e. idea—patent—licence—spin-off), it was evolving:

> ... to encompass the notion of commercial 'benefits' of publicly funded research, whether those benefits accrue to the research institution or not. This means that the term is now often applied to other modes and activities, such as 'diffusion' (e.g. through publications, conferences, information seminars etc), research contracts and consultancies, the training of research graduates for employment in industry, and various forms of joint venture and partnership.[30]

---

28 Department of Education, Science and Training, *Submission No. 20*, p. 7.

29 Howard Partners 2005, *The Emerging Business of Knowledge Transfer: Creating Value from Intellectual Property and Services*, p. 22.

30 Department of Education, Science and Training, *Submission No. 20*, p. 22.

2.33 The second report, *The Metrics for Research Commercialisation*[31], stated that 'there is considerable complexity in defining what research commercialisation means, and should mean, in Australia'.[32]

2.34 It concluded that the DEST definition for research commercialisation 'is somewhat narrow'.[33] This resulted in the Coordinating Committee on Science and Technology (CCST) Metrics Working Group's first recommendation:

> That for Australia's publicly funded research, 'research commercialisation' be defined as the means by which universities' and PFRAs [publicly funded research agencies]' research generates commercial benefit, thereby contributing to Australia's economic, social and environmental well-being. This is achieved through developing intellectual property, ideas, know-how and research-based skills resulting in new and improved products, services and business processes transferable to the private sector.[34]

2.35 In December 2005 DEST broadened its definition of research commercialisation, adopting the definition recommended by the CCST Metrics Working Group.[35]

---

31 This report was produced by Department of Education, Science and Training's Coordinating Committee on Science and Technology Working Group on the Metrics of Research Commercialisation.

32 Coordinating Committee on Science and Technology Working Group on the Metrics of Research Commercialisation, *Submission No. 7*, attached report *Metrics for Research Commercialisation: A Report to the Coordination Committee on Science and Technology*, p. 12.

33 Coordinating Committee on Science and Technology Working Group on the Metrics of Research Commercialisation, *Submission No. 7*, attached report *Metrics for Research Commercialisation: A Report to the Coordination Committee on Science and Technology*, p. 11.

34 Coordinating Committee on Science and Technology Working Group on the Metrics of Research Commercialisation, *Submission No. 7*, Attached report *Metrics for Research Commercialisation: A Report to the Coordination Committee on Science and Technology*, p. 12.

35 Department of Education, Science and Training, *Definitions and Methodological Notes: Statistics on Science and Innovation 2005*, p. 44.

Outcomes of Innovation

2.36 Evidence to the inquiry has emphasised that commercialisation is not the only outcome of innovation. Specifically, a number of submissions have identified the implementation of innovation via technology transfer[36] and its broad uptake to achieve financial, social and/or environmental outcomes as critical components of the innovation process.[37]

2.37 Innovation can be made publicly available to promote industry-wide economic growth, or provide environmental and social benefits for the community rather than sold commercially to generate direct economic benefits. The non-commercial mechanisms by which new products or processes are disseminated and applied are referred to as **adoption** or **utilisation**. Evidence to the inquiry has indicated that those sectors with a strong 'public good'[38] focus (e.g. agriculture, health and environment) frequently consider adoption to be the most appropriate means of innovation implementation. [39]

2.38 In its submission to the inquiry, the Rural Research and Development Corporation (RDC) Chairs Committee noted that its focus on promoting the adoption of innovation stemmed from:

> ... the nature of rural product markets...and the consequent need to keep enabling producers to be strategically placed at the frontiers of technological innovation and global competitiveness. In many instances research is directed at problems unique to Australia and/or the size of the

36 Technology transfer is the sharing of knowledge and facilities among industries, universities, governments and other institutions to ensure that scientific and technological developments are accessible to a range of users who can then further develop the technology into new products, processes, materials or services.

37 Department of Education, Science and Training, *Submission No. 20*, p. 24; Commonwealth Scientific and Industrial Research Organisation (CSIRO), *Submission No. 32*, p.6; Dr J Yencken and Professor Emeritus M Gillin, *Submission No. 41*, Attached paper, p. 12.

38 'Public good' is characterised by outcomes or products that are not supply limited and are freely or readily available to benefit communities.

39 See for example Meat and Livestock Australia, *Submission No. 4*, p. 4; Dr R Rowe, *Submission No. 26*, p. 1; Rural Research and Development Corporation Chairs Committee, *Submission No. 54*, pp. 9-10; Australian Cotton Cooperative Research Centre, *Submission No. 57*, pp. 1-2; Department of Agriculture, Fisheries and Forestry, *Submission No. 90*, p. 2; Land and Water Australia, *Submission No. 96*, p. 2; Professor P Høj (Australian Research Council), *Transcript of Evidence*, 5 December 2005, p. 9.

> Australian market dictates a limit to commercialisation opportunities.[40]

2.39 The RDC Chairs Committee explained further:

> Additionally there is a view that [rural] producers, where they are the main target for adoption of a new technology, have in effect already contributed to the products from research and should not be required to make further payment. This is in recognition of the contribution [to the R&D that] they make through compulsory levies and the benefits they receive from government matching contributions, which in part, are perceived as an alternative to government incentives to businesses in other sectors, such as through 125per cent tax deductibility.[41]

2.40 While innovation adoption does not generally result in direct economic benefits for the originators and developers, it may result in economic benefits realised through positive social and environmental outcomes.

2.41 For example, Professor Alan Pettigrew of the National Health and Medical Research Council (NHMRC), the Australian Government's principal health and medical research funding body, emphasised the potential economic benefits arising from the translation (i.e. adoption) of improved health practice and policy as a result of health and medical research outcomes, stating:

> ...the translation of research discovery into improved health practice and health policy, which goes beyond just commercialisation, and it may not involve commercialisation at all...can have significant economic benefit to the community and Australia generally.[42]

2.42 In contrast to those sectors and organisations with a public good focus, profit related imperatives (i.e. increased revenues, reduced business costs or improved productivity) were the most frequently reported drivers of innovation for businesses.[43]

---

40 Rural Research and Development Corporation Chairs Committee, *Submission No. 54*, p. 9.

41 Rural Research and Development Corporation Chairs Committee, *Submission No. 54*, p. 9.

42 Professor A Pettigrew (National Health and Medical Research Council), *Transcript of Evidence*, 12 September 2005, p. 1.

43 Australian Bureau of Statistics, *2003 Innovation in Australian Business (ABS 81580)*, p. 28.

Measurement and Assessment of Innovation Performance and Outcomes

2.43 Reliable data on the national innovation system[44] provides an essential foundation for policy formulation to support Australia's economic growth, social and environmental development. Innovation indicators that assess the system in terms of its inputs, outputs and outcomes can be used to identify national innovation strengths and weaknesses.

2.44 Evidence to the inquiry has underscored the importance of reliable data. It has also questioned the adequacy of existing measurement frameworks, highlighting some of the limitations associated with innovation indicators, data sets, analyses and interpretations.[45]

2.45 Due to the complexity of innovation systems, there is no single indicator that is capable of assessing all elements of innovation. Instead an array of measures is needed. The major role in developing international standardised guidelines for assessing innovation has fallen to the OECD.

2.46 These guidelines are disseminated through a series of methodological manuals which, in conjunction with other international and national standard classifications, define the indicators and data collection methodologies for use when assessing innovation systems.[46]

2.47 These international standard measurement frameworks enable comparisons of innovation to be made between countries, and analysis of national and international trends that could impact on the capacity of innovation systems to meet current and projected needs.

2.48 Nonetheless, assessment of innovation remains difficult, particularly as the associations between innovation inputs, outputs and outcomes are complex and multi-dimensional.

---

44 The national innovation system is defined as the body of policies, regulations, institutional and infrastructural arrangements and activities concerned with the creation, acquisition, dissemination and use of scientific and technological knowledge.

45 For example see Science Industry Action Agenda, *Submission No. 61*, p. 11; Australian Geoscience Council, *Submission No. 71*, p. 12; Department of Industry, Tourism and Resources, *Submission No. 82*, p. 3; Mr D Scott-Kemmis, *Submission No. 99*, p. 2.

46 Organisation of Economic Cooperation and Development (OECD) methodological manuals include the *Frascati Manual* for research and development, the *Patent Manual*, the *Canberra Manual* for human resources in science and technology, the *Manual for Technology Balance of Payments*, the *Oslo Manual* for innovation and the *Productivity Manual*.

2.49 One significant limitation of current innovation measurement frameworks is that the majority of the key innovation indicators necessarily rely on empirical evidence that is indicative of correlations between resource inputs and innovation outputs and outcomes.

2.50 Urging caution with regard to the interpretation of innovation metrics, the *Australian Government's Innovation Report 2004–05* stated:

> ... it should be kept in mind that an increase in any one of the various indicators may not necessarily be a better outcome for the economy. This is true especially for input type indicators such as those in the knowledge creation and human resources categories, as it is difficult to prove a direct relationship between increased expenditure and subsequent increases in innovation output.[47]

2.51 In some cases, the limitations associated with the indirect nature of innovation indicators are exacerbated by deficiencies in data sets. These deficiencies can include gaps in the data where there has been no ongoing collection, and incompatibilities between data sets collected and compiled in different countries.[48]

2.52 Particularly challenging is the assessment of public sector innovation.[49] Evidence to the inquiry has also highlighted the absence of standard guidelines for data collection and analyses to assess the impact of innovation adoption. In addition, a 'triple bottom line' assessment requires measures of the social and environmental benefits of innovation, as well as economic outcomes.

2.53 Meat and Livestock Australia (MLA), one of the 14 RDCs, noted that its success can only be assessed through the measurement of outcomes that take account of 'key areas of adoption impact' including:

- Triple bottom line assessment, looking at economic, social and environment benefits.
- Direct cost-benefit analysis at both an industry and enterprise level.
- Identification of the adoption rate of technologies by industry stakeholders.

47 *Australian Government's Innovation Report 2004-05: Real Results Real Jobs*, p. 5.

48 Department of Industry, Tourism and Resources, *Submission No. 82*, p. 3.

49 Organisation of Economic Cooperation and Development (OECD) and Eurostat, *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data,* 3rd Edition, 2005, p. 16.

- Satisfaction of stakeholders, providing a qualitative measure of the outcomes of technology adoption where appropriate.
- Where possible, measurement of direct realised benefit at an enterprise level.[50]

Assessing National Innovation Performance

2.54 The existing metrics give an insight into:

- Australia’s national comparative innovation overall in both the public and private sectors;
- innovation and commercialisation in the business sector; and
- research commercialisation in the public/not-for profit sector.

Australia’s Innovation Performance Relative to OECD Countries

2.55 Table 2.1 shows Australia’s comparative innovation under 15 indicators grouped in six categories.

2.56 Overall Australia performed at or above the OECD average on 10 of the 15 indicators. The Innovation Scorecard indicated that Australia is strong in the percentage of the labour force that has a tertiary education, the number of science and engineering graduates in the labour force and internet usage. These indicators imply that Australia’s labour force is highly skilled and able to participate in the innovation process.

2.57 Table 2.1 shows that Australia is performing at 50 per cent or more above the OECD average in three of the 15 indicators. These indicators are:

- scientific and technical articles per capita;
- foreign affiliates in manufacturing R&D; and
- multi-factor productivity[51] growth for 1997 to 2001.

50 Meat and Livestock Australia, *Submission No. 4*, p. 4.

51 A nation's productivity is the volume of goods and services it produces (its output) for a given volume of inputs (such as labour and capital). Much, but not all, of Australia's output growth can be accounted for by increases in the inputs to production. The amount by which output growth exceeds input growth is the productivity improvement. Multifactor productivity represents that part of the growth in output that cannot be explained by growth in labour and capital inputs.

Table 2.1 Australia's Innovation Scorecard 2004

Category	Indicator	2004 rank*	2002 rank	Relative to OECD average (per cent difference)	Available data
Knowledge creation (the ability to generate new ideas and technologies)	R&D expenditure in government and higher education sectors % GDP[52]	6	7	+ 18	2002
	Scientific and technical articles per million population	9	8	+ 66	2003
	Number US patents per million population	18	18	- 66	2003
	Business sector R&D Expenditure % GDP	19	19	- 48	2002
Human resources	Percentage of workforce with tertiary education	6	5	+ 30	2002
	Number of science graduates per 10 000 persons in labour force	6	6	+ 40	2001
	Researchers per 10 000 in labour force	8	7	+ 18	2002
Finance	Investment in venture capital % GDP	7	18	< 1	2001
Knowledge diffusion	Investment in ICT % of business sector gross fixed capital	6	3	- 5	2001
	Internet users per 1 000 population	6	10	+ 36	2003
	Investment in new equipment - investment in machinery & equipment % GDP	10	12	+ 11	2002
Collaboration	Share of foreign affiliates in manufacturing R&D	4	3	+ 135	2001
	Breadth of international science and engineering collaboration	12	8	+ 10	2001
Market outcomes	Average annual growth in multi-factor productivity between 1997 and 2001	4	4	+ 126	2001
	Expenditure on innovation as share of total sales in manufacturing %	N/A	16	- 42	1996-97

** Australia's current ranking is from a field of 27–30 OECD countries with the exception of: Investment in venture capital as a percentage of gross domestic product (GDP) (25), Investment in ICT as a percentage of business sector gross fixed capital formation (18), Share of foreign affiliates in manufacturing R&D (19), Growth in multi-factor productivity between 1997 and 2001 (17), and Expenditure on innovation as a share of total sales in manufacturing (19)—number in parentheses represents the number of OECD countries. A 'top ten' performance is considered to be within the top third of available OECD countries.*

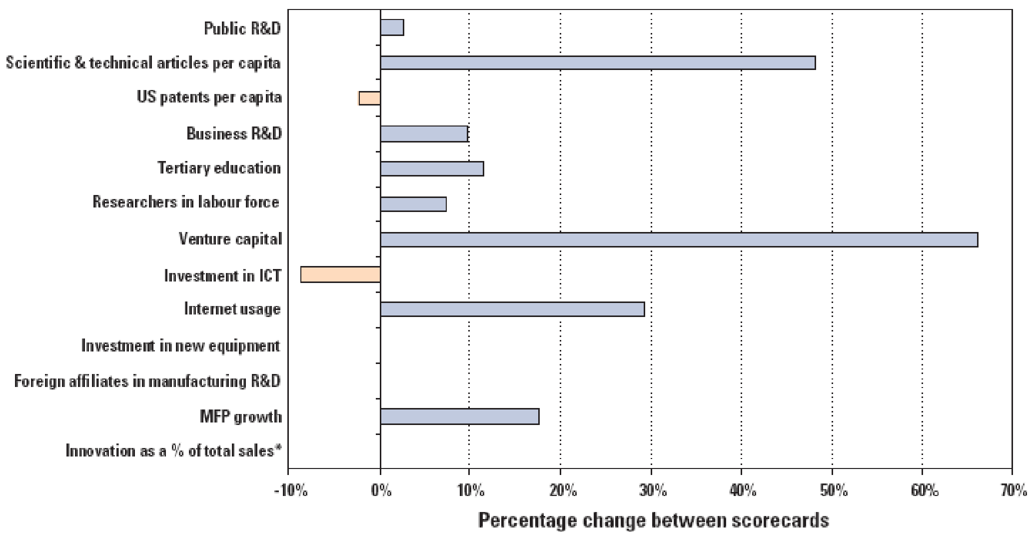
Source *Based on data from* The Australian Government's Innovation Report 2004–05: Real Results Real Jobs, *p. 6.*

52 R&D expenditure in the government and higher education sectors is defined as the expenditure of R&D performed by government research agencies (both federal and state governments) and universities. It includes all capital expenditure, labour expenditure and other current expenditure (such as materials, fuels, rent, hiring, repairs, maintenance and data processing, and the proportion of expenditure on general services and overheads) which are attributable to R&D activities.

2.58 Table 2.1 also indicates that Australia's business expenditure on R&D (BERD), levels of patenting in the United States (US) and innovations as a percentage of total sales were assessed as substantially below the OECD average. Australia also performed below the OECD average for investment in information and communication technology (ICT), although this indicator was less than 10 per cent below the OECD average.

2.59 The Innovation Scorecard also enables a review of innovation trends over time within Australia. The change in Australia's innovation performance between the 2002 and 2004 Innovation Scorecards is shown in Figure 2.1.

Figure 2.1 Percentage Change in Australian Indicator Values for the 2004 Innovation Scorecard Relative to the 2002 Scorecard



** Innovation as a percentage of total sales was not updated from the 2002 Scorecard due to a lack of new data*

Source ` The Australian Government's Innovation Report 2004–05: Real Results Real Jobs, *p. 7.*

2.60 Since 2002, Australia's Scorecard performance has improved on most innovation indicators, with investment in venture capital, scientific and technical articles, and internet usage all increasing significantly.

2.61 However, there has been a decline in patenting levels in the US and investment in ICT. These are both areas where Australia's performance is also below the OECD average.

2.62 In summary, Australia is above average with regard to science participation and workforce education, but is less successful in innovation and commercialisation of new ideas or patents.

2.63 This is consistent with concerns raised in some submissions regarding patent costs and ICT industry support.[53] Submissions also raised concerns regarding the projected supply of skilled science and engineering graduates which may impact on future Scorecard outcomes.[54] These issues are considered in more detail in subsequent chapters of the report.

Innovation in the Business Sector

2.64 In 2005, the Australian Bureau of Statistics (ABS) released the results of its third Australian business innovation survey. The survey was conducted in accordance with the OECD's *Oslo Manual* guidelines, and assessed both technological and non-technological innovation occurring in Australian businesses over the period 2001-03.[55]

2.65 Internationally comparative key findings of the ABS business innovation survey included:

- 34.8 per cent of Australian businesses innovate, with the most common type of innovation being process innovation, implemented by 22.9 per cent of businesses. Product or services innovation was implemented by 16.6 per cent of businesses.
- The proportion of firms innovating rises as the size of the firm increases, both in terms of employee numbers and business income.
- The main driver of business innovation is increased company revenue achieved through either increased productivity or meeting market demand.

---

53 For example see Australian Computer Society, *Submission No. 38*, p. 1; Proteome Systems, *Submission No. 55*, p. 1; Australian Information Industry Association, *Submission No. 60*, p. 4; DSTC Pty Ltd, *Submission No. 69*, p. 2; Australian Geoscience Council, *Submission No. 71*, p. 9.

54 For example see Australian Academy of Technological Sciences and Engineering, *Submission No. 49*, p. 8; Science Industry Australia, *Submission No. 61*, Attachment 1, p. 53; GBC Scientific Equipment, *Submission No. 76*, pp. 4-5.

55 Australian Bureau of Statistics, *2003 Innovation in Australian Business (ABS 8158.0).*

- The major barriers to innovation include the cost and associated economic risks, and market related barriers (e.g. market domination by a competitor or lack of customer demand).
- Businesses with more than 50 per cent foreign ownership were more likely to innovate.
- 27 per cent of innovating businesses were involved in some form of active collaboration, with 25 per cent of businesses reporting collaboration with suppliers, clients, competitors and consultants. This compared to only 6.5 per cent collaborating with universities, government and research institutes.
- The majority of innovating businesses acquire innovation ideas, knowledge or abilities from within 100 kilometres of the business location.
- The majority of innovation reported by businesses comprised the introduction of goods, services or processes (33.9 per cent) that were 'new to Australia' rather than 'new to the world' (11.7 per cent).[56]

2.66 International comparisons revealed that the total proportion of businesses innovating in Australia is slightly higher than that of the European Union as a whole.[57]

Commercialisation in the Public Sector

2.67 The most recent *National Survey on Research Commercialisation* was released in 2004.[58] The *National Survey* provided information on a number of measures of commercialisation activities conducted by

56 Australian Bureau of Statistics, *2003 Innovation in Australian Business (ABS 8158.0).*

57 Australian Bureau of Statistics, *2003 Innovation in Australian Business (ABS 8158.0),* p. 11.

58 The National Survey was commissioned by Department of Education, Science and Training, and conducted by the Australian Institute of Commercialisation based on the methodology used in the annual licensing survey conducted in the US and Canada by the Association of University Technology Managers.

PFRAs[59], universities, medical research institutes (MRIs) and Cooperative Research Centres (CRCs) during 2001 and 2002.[60]

2.68 Specifically, the survey provided information on gross income derived from licences and start-up company formation and levels of patenting. The survey also enabled comparisons with similar data collected for the year 2000 and international comparisons.

2.69 In summary, Australian universities generated about 59 per cent of total licence income in 2002, compared with MRIs (22 per cent), Commonwealth Scientific and Industrial Research Organisation (CSIRO) (13 per cent), CRCs (five per cent) and the remaining PFRAs (one per cent).[61]

2.70 Other key changes from 2000 to 2004 included:

- increases in the stock of income-yielding licences, the active stock of start-up companies and the overall value of equity held by Australia's PFRAs;
- increases in employment of commercialisation and commercialisation support staff;
- a stable level of income earned from licences[62]; and
- a decline in the number of new patents applied for and issued.[63]

2.71 Taking into account differences in levels of research expenditure and countries' gross domestic product (GDP), international comparisons revealed that Australia's universities:

- have fewer US patents issued to them than universities in the US or Canada;

---

59 Publicly funded research agencies included in the survey are the Australian Institute of Marine Sciences, the Australian Nuclear Science and Technology Organisation, Commonwealth Scientific and Industrial Research Organisation and the Defence Science and Technology Organisation.

60 Department of Education, Science and Training 2004, *National Survey of Research Commercialisation Years 2001 and 2002: Selected Measures of Commercialisation Activity in Universities and Publicly Funded Research Agencies*.

61 Department of Education, Science and Training 2004, *National Survey of Research Commercialisation Years 2001 and 2002: Selected Measures of Commercialisation Activity in Universities and Publicly Funded Research Agencies*, p. xvii.

62 Figures were adjusted to take in to account a single, very large transaction reported in the 2000 survey which inflated the figure reported for that year.

63 Department of Education, Science and Training 2004, *National Survey of Research Commercialisation Years 2001 and 2002: Selected Measures of Commercialisation Activity in Universities and Publicly Funded Research Agencies*, p. xvii.

- execute fewer licences than those in the US, Canada and the United Kingdom (UK);
- earn income from licences at a rate which is greater than those in the UK, roughly comparable to Canada but less than the US; and
- form more start-up companies than those in the US, but fewer than those in Canada or the UK.[64]

2.72 As noted previously in this report, the definition and metrics of research commercialisation in Australia has been reviewed recently by DEST.[65] While this has resulted in the adoption of a broader definition of research commercialisation and development of a revised metrics framework, the framework has yet to be implemented and evaluated.

2.73 While noting that further work is needed to develop commercialisation metrics, the *National Survey* acknowledged the work of DEST's CCST Metrics Working Group.[66] In summary, based on the analysis of research, commercialisation metrics used in Australia and overseas, the CCST Metrics Working Group has recommended the use of 14 core metrics grouped under three categories:

- intellectual property;
- research contracts and consultancies; and
- skills development and transfer.[67]

---

64 Department of Education, Science and Training 2004, *National Survey of Research Commercialisation Years 2001 and 2002: Selected Measures of Commercialisation Activity in Universities and Publicly Funded Research Agencies*, p. xvii.

65 Howard Partners 2005, *The Emerging Business of Knowledge Transfer: Creating Value from Intellectual Property and Services*; Coordinating Committee on Science and Technology Working Group on the Metrics of Research Commercialisation, *Submission No. 7*, Attached report *Metrics for Research Commercialisation: A Report to the Coordination Committee on Science and Technology*.

66 Department of Education, Science and Training 2004, *National Survey of Research Commercialisation Years 2001 and 2002: Selected Measures of Commercialisation Activity in Universities and Publicly Funded Research Agencies*, Summary, p. xi.

67 Coordinating Committee on Science and Technology Working Group on the Metrics of Research Commercialisation, *Submission No. 7*, attached report *Metrics for Research Commercialisation: A Report to the Coordination Committee on Science and Technology*, 2005, p. 17.

2.74 In addition, the CCST Metrics Working Group also recommended the development of a comprehensive data collection strategy for research commercialisation which should:

- maintain the existing time series data for the core indicators developed through the National Survey of Research Commercialisation;
- address any deficiencies in data quality so as to improve data timeliness, availability and/or reliability; and
- whenever possible, draw upon existing and reliable third-party data to reduce the burden on respondents and to ensure consistency.[68]

Committee Comment

2.75 The Committee recognises that, despite the inquiry's terms of reference specifying technological innovation, it is not always possible to restrict innovation to the technological arena.

2.76 Additionally, commercialisation should not be regarded as the sole objective or outcome of innovation. The implications of innovation should encompass a range of diverse activities, mechanisms of implementation and outcomes.

2.77 The Committee notes that the debate regarding the definition of research commercialisation is indicative of the challenges faced by PFRIs as they undergo a process of adaptation and change.

2.78 Traditionally centres of teaching and research, there is a growing expectation from the government that PRFIs will also contribute to the global knowledge-based economy through the active transfer of knowledge, skills and innovation, specifically via increased commercialisation.

2.79 DEST's adoption of a broader definition to encompass the various ways in which PFRIs may contribute to Australia's economic, social and environmental wellbeing, significantly impacts on the range of commercialisation activities that PFRIs can report on and subsequently the level of commercialisation 'success' that PFRIs can demonstrate.

68 Coordinating Committee on Science and Technology Working Group on the Metrics of Research Commercialisation, *Submission No. 7*, attached report *Metrics for Research Commercialisation: A Report to the Coordination Committee on Science and Technology*, 2005, p. 9.

2.80 The Committee is encouraged to note national and international activities directed toward developing enhanced and standardised conceptual and metrics frameworks to facilitate objective and comparable assessments of innovation and commercialisation.

2.81 The Committee acknowledges the importance of monitoring innovation performance over time, and does not underestimate the challenges associated with developing and implementing robust metrics frameworks.

2.82 The innovation measurement frameworks reviewed in this chapter show their potential contribution to assessing the strengths and weaknesses of Australia's innovation system. Some of the challenges that can be encountered in implementing innovation measurement frameworks in a dynamic environment are also demonstrated.

2.83 For example, the capacity to make direct historical and cross-country comparisons of some innovation indicators included in the Innovation Scorecard and the ABS survey of business innovation is restricted due to gaps in data sets, changes in the data collected over time and differences in innovation data collected between countries.

2.84 Adding to the challenges associated with data collection is the scope for differential interpretation of innovation metrics. In this regard, the Committee notes the comment made by Science Industry Australia (SIA) in its submission:

> Data in publications from DEST are very useful, but it appears that for every conclusion that could be drawn from the data, it was also possible to find contradictory data from which an opposite view could be expressed.[69]

2.85 A key element to emerge with regard to the interpretation of innovation metrics was the need to take into account the unique context of a nation's economic structure, geographical opportunities and historical influences.

2.86 By way of example, the Committee notes evidence presented with regard to interpretation of the significance of Australia's comparatively low level of BERD. When taken at face value the low level of BERD might be interpreted to indicate a lack of innovative activity occurring in Australian businesses. However, it has also been argued that it may reflect the structure of Australian industry, with its high level of dependence on medium-to-low technology industries

69 Science Industry Australia, *Submission No. 61*, p. 11.

(e.g. agriculture, mining etc) and a predominance of SMEs, both of which tend to have a low reliance on in-house R&D to achieve innovation.[70]

2.87 Elaborating on the scope for different interpretations of innovation performance data with regard to Australia's low level of BERD and its high levels of GDP per capita, economic growth and dependence on primary product exports, Mr Scott-Kemmis submitted:

> Debate about the innovation policy implications of this situation has tended to centre around three positions concerning the facts above:
>
> - The low levels of BERD and international patenting signals weaknesses in the 'national innovation system' that will ultimately lead to diminishing competitiveness and living standards. Consequently, it is essential to stimulate industry to increase R&D investment.
> - The high and sustained rates of productivity growth signal the essential strength of the 'national innovation system' and the correctness of the policy settings of the past two decades. There is no persuasive or urgent case for major change in innovation policy, and there is perhaps even some over-investment in public sector research—as there is little evidence that this investment has been a major driver of productivity growth.
> - The low levels of BERD and patenting are simply reflections of our industrial structure. These low levels may nevertheless be quite consistent with high rates of innovation in sectors where R&D is not a dominant driver of innovation. However, Australia may well risk losing future degrees of freedom if its current level of specialisation narrows even further and major new firms and industries do not develop.[71]

2.88 Clearly, the alternate interpretations of the same innovation data would have significantly different implications and paths of action for innovation policy makers.

2.89 Generally, submissions made to the inquiry by those Australian Government departments with responsibility for innovation policy formulation and implementation have demonstrated a good

---

70 Professors K Smith and J West, *Submission No. 18*, pp. 6-8; Mr D Scott-Kemmis, *Submission No. 99*, p. 2; Ms T Berman (Department of Industry, Tourism and Resources), *Transcript of Evidence,* 28 November 2005, p. 10; Ms P Kelly (Department of Industry, Tourism and Resources), *Transcript of Evidence*, 28 November 2005, p. 10.

71 Mr D Scott-Kemmis, *Submission No. 99*, p. 2.

awareness of innovation performance measurement frameworks, including their limitations and the potential for differential interpretation of innovation data. [72]

2.90 In addition, the Committee endorses the broader definition of innovation and commercialisation. However, evidence suggests that assessing the impact of innovation adoption, including its economic value and other benefits to the wider community, will be difficult and will require the development of a more robust measurement framework.

2.91 While there are challenges associated with the development of a quantitative framework to assess the broader impact of innovation, the Committee notes progress under DEST's **Research Quality Framework** (RQF) initiative. The RQF is intended to form the basis for an improved assessment of the quality and impact of publicly funded research, including assessment of the full economic, social and environmental impacts. Once implemented the RQF will provide the Australian Government with the basis for redistributing research funding to ensure that areas of the highest quality of research are rewarded.

2.92 In May 2006, following a consultation process with key stakeholders including universities, DEST released its advice on the preferred RQF model. During the consultation, a number of concerns were raised relating to the design and implementation of the RQF. These include concerns regarding the cost effectiveness of the RQF exercise, the potential for duplication of existing competitive peer-review processes and an underestimation of the impact of basic research due to the time lag between the initiation of the research and the realisation of research outcomes.[73]

2.93 In a private briefing to the Committee, DEST indicated that it was aware of these concerns and sought to address them through continuing consultation with key stakeholders with regard to the development of a detailed RQF implementation plan. In early 2006, an RQF Implementation Group was established to oversee further consultation. The Australian Government's 2006 budget also

72 For example see Department of Education, Science and Training, *Submission No. 20*; Department of Industry, Tourism and Resources, *Submission No. 82*; Department of Communications, Information Technology and the Arts, *Submission No. 87*.

73 L Shewan and A Coats, 'The Research Quality Framework and its Implications for Health and Medical Research: Time to Take Stock?', *Medical Journal of Australia*, vol. 184 (9), 2006, pp. 463-66.

announced $3 million to finalise the development of the RQF.[74] The Committee anticipates that concerns expressed in relation to the RQF will be addressed during the next phase of consultations.

2.94 In addition, the Committee notes that the Treasurer and the Minister for Education, Science and Training have requested the Productivity Commission to undertake a research study into the economic, social and environmental returns of public support for science and innovation in Australia.[75]

2.95 The Committee expects that such an inquiry will consider appropriate metrics for measuring these broad impacts. The Productivity Commission will report by March 2007.

74 Australian Government, 2006, *Budget 2005-06, Budget Paper No. 2*, p. 164.

75 The Treasurer, accessed 31 March 2006, *Productivity Commission to Review Public Support for Science and Innovation* (Press Release), <treasurer.gov.au>.