**SUBMISSION OF THE DEPARTMENT OF EDUCATION, SCIENCE AND TRAINING**

**TO THE**

**HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON SCIENCE AND INNOVATION**

**INQUIRY INTO BUSINESS COMMITMENT TO R&D IN AUSTRALIA**

## Relevant responsibilities of the Education, Science and Training Portfolio

The Portfolio takes a national leadership role in education, science and training. It works with various stakeholders (including industry groups), State and Territory governments, other Commonwealth agencies and a range of contracted service providers to provide high quality policy advice and services for the benefit of Australia.

As well as the Department, the Portfolio includes the following statutory bodies whose responsibilities relate to research and research training, some of which will be making separate submissions to the Inquiry:

- the Anglo Australian Telescope Board;
- the Australian Institute of Marine Science (AIMS);
- the Australian Nuclear Science and Technology Organisation (ANSTO);
- the Australian Research Council (ARC); and
- the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

The Portfolio has the primary responsibility for funding and policy-making in the higher education sector.

The Government has provided clear guidance on its priorities for science, research and innovation through its Innovation Action Plan - *Backing Australia's Ability* (BAA). The Department has the responsibility of monitoring BAA programs and policy issues on behalf of the Committee of Ministers overseeing implementation of BAA.

The Department supports the science and innovation framework through such bodies as the Prime Minister's Science, Engineering and Innovation Council (PMSEIC), the Chief Scientist, the Coordination Committee for Science and Technology and through targeted funding and international promotion of Australia's scientific and technological capabilities.

As the Department has an overview role with respect to Australia's science and innovation system, the Department's submission is provided from this perspective, but with particular emphasis on the Department's responsibilities in public sector science and higher education.

## Term of reference 1. What would be the economic benefit for Australia from a greater private sector investment in R&D?

As some background on Australia's R&D performance overall, the latest statistics from the Australian Bureau of Statistics (ABS) show that Australia's overall gross expenditure on R&D (GERD) in 2000-01 was at an all-time high of more than $10 billion, more than $1 billion higher than the previous survey (1988-99). All sectors performing research – business, government, universities, and private non-profit – recorded an increase in their investment in R&D.

Commonwealth Government financing of R&D reached an all-time high of $3.9 billion – an increase of 13% over 1998-99. Government financing of R&D in Australia is around 0.70% of GDP – above the OECD average of around 0.65% of GDP, and comparable with the USA (0.74%), Japan (0.58%) and Germany (0.78%).

The effect of *Backing Australia's Ability*, is not included in these figures but will become apparent in the next sequence of ABS data.

Although government funding of R&D, and the level of R&D performed in universities and government research agencies in Australia is higher than the OECD average as a percentage of GDP, Australia has a relatively low level of Business Expenditure on Research and Development (BERD) as a percentage of GDP compared with the majority of OECD countries.[i] (See below).

Firms benefit from investment in R&D by increasing their competitiveness. If Australia's firms become more competitive, Australia as a whole is likely to achieve greater economic growth, with the beneficial flow-ons of higher standard of living, lower unemployment and lower inflation.

What is meant by competitiveness? According to the Industry Commission[ii], a firm is competitive if it can maintain and expand its market share while making at least enough profit to induce it to stay in its existing line of business.

R&D improves competitiveness in two ways. First, it assists the firm to make its products more cheaply and efficiently by supplying the firm with the knowledge to increase its productivity – more goods can be produced for less cost. Second, it improves the goods themselves so that there is a greater demand for them. Or it creates a new good for which there is high demand, thus improving the firm's portfolio of products. The firm can either sell its products at a higher price, or a greater quantity at the same price, or a mixture of both.

The converse, failure to conduct R&D, means that firms are likely to lose market share to new products supplied by firms who can supply goods and services with higher quality and at lower cost. A basic economic benefit for Australia from a greater private sector investment in R&D is increasing the likelihood of Australia avoiding this adverse outcome.[iii]

What is beneficial for individual firms is certainly beneficial for Australia as a whole as the firms' growth adds to economic growth and employment – but that is only part of the story. The benefits of both successful R&D and not-quite-so-successful R&D by individual firms have "spillover" benefits for the Australian economy. "Spillover" effects are defined[iv] as any unpaid benefit or unrecompensed cost that flows to any agent other than the firm undertaking the R&D. Thus, by undertaking R&D, the firm generates "free" benefits for society as a whole. Such benefits include gains in knowledge and know-how of employees which they can take elsewhere, the increased demand for technically-advanced products supplied by other Australian firms, the raising of the general level of technical competence of that particular firm for which it does not necessarily charge full value. There are also a number of synergistic effects if a number of firms simultaneously engage in R&D in related areas, such as for example agriculture and pharmaceuticals.

Can the benefits to individual companies from conducting R&D, and the broader economic benefits, be quantified? The Industry Commission conducted a survey of investigations by economists into this question. While there was a wide divergence on the results, they found that

for investigations conducted in the USA and some other OECD countries in the past 20 years, the mean annual rate of return estimated for individual firms was 33 per cent of the R&D costs, although there was wide variation[v]. The mean estimated rate of return of further national "spillover" (social returns) for Japan and the USA was 85 per cent[vi].

More up-to-date estimates by Steve Dowrick[vii] quoted other studies giving private returns for the US at around 25% and social returns at around 50%.

Estimates for Australia are few, but the Bureau of Industry Economics estimated in 1992 that the mean rate of return to Australian society as a whole of R&D (social return) in the Industrial and Communication Technologies product field was 20 per cent, calculated ex-post, (apart from agriculture and mining related industries), while in 1988 it estimated the mean rate of return for Australian society from R&D in the minerals and process engineering technologies was 27 per cent[viii]. Estimates for social returns for R&D in agriculture in Australia vary between 2 and 138 per cent for various agricultural industries[ix]. So far as we are aware, there are no studies available on the private returns to R&D in Australia.

While returns to business R&D noted in the 1992 BIE research for mining and agricultural related industries were higher, the bulk of R&D for agricultural related industries is conducted by public research agencies, and private R&D in the mining and agricultural sectors combined is only 12 per cent of total business R&D on manufacturing and services.[x]

Thus on the current evidence, Australia as a whole would substantially benefit from *greater* private sector investment in R&D in Australia.

Detailed economic research on returns to R&D at the industry level has not been published in Australia since the publication of the Industry Commission Report No. 44, *Research and Development*, in 1995, which reported published data on social returns to R&D in Australia. There is a major need for more up-to-date research on the returns to R&D in Australia, especially for private returns to R&D in Australia, for which published results from any date are non-existent.

**Terms of Reference 2. What are the impediments to business investment in R&D?**

There are a several <u>potential</u> or <u>possible</u> impediments to business investment in R&D.

Based on the most recent research dating from 1992 previously discussed, the private returns to business R&D in Australia may not be sufficient to justify increased investment. The relatively low social rate of return (which includes the private rate of return – see below) of private industry R&D in Australia noted above (around 20 per cent outside the mining and agricultural industries), is a matter requiring further examination. This 1992 figure suggests that the private returns from a given investment in business R&D in Australia could be lower than those obtained by business R&D in the USA and other OECD countries. A relatively low return could be a major reason why the BERD to GDP ratio in Australia is low, even allowing for the effect of the relatively low proportion of manufacturing industry in Australia's economic activity[xi].

Private returns are defined as those returns appropriated by the firm undertaking the R&D. These include not only the profits resulting from the marketing of any products, but also receipts from selling R&D results (for example, royalties).

Social returns are those benefits which accrue to society as a whole from the conduct of R&D, including all private returns, and all those additional benefits from the conduct of R&D gained by society beyond the sum of these private returns. It is usually measured for a particular set of R&D by the flow of benefits accruing to society expressed a proportion of the cost of that R&D. By definition social returns must exceed private returns, as they include the private return of the R&D generating that social return.

Spillover benefits are the difference between the private and social returns. Spillover refers to any unpaid benefit or unrecompensed cost that flows to any agent other than the institution undertaking R&D.

While the terms spillover and social return are often used synonymously, it must be remembered that social return is a gross measure while spillover is a net measure of the benefits to society.

There is great deal of risk[xii] involved that a particular R&D project will not produce a return which covers its cost, much less generate a profit. The distribution of profitability among individual research areas is not uniform. It is even possible that the number of unprofitable areas outnumber the profitable areas. This distributional effect is masked by the average profitability figure.

Research on the distribution of the gains from R&D consistently indicate very skewed outcomes from R&D, with 80 per cent of returns coming from the success of 10 per cent of the projects[xiii]. The other 90 per cent of R&D projects return low profits or make a net loss.

Therefore the perceptions of risk may have a central role in expectations and decision-making.

As noted above, we are not aware of any studies on the private returns to R&D in Australia, nor of the influence of real or perceived risk of R&D on the level of business R&D conducted.

However, Australia’s relatively low level of BERD could be taken as prima facie evidence that private returns to business R&D and/or the real or perceived risk of R&D are a significant impediment to greater business R&D.

Arguments have been advanced that Australia’s relatively low level of BERD is a result of our industry structure, in particular:

- a relatively large services sector (where the propensity to conduct R&D is relatively low) and a relatively small manufacturing sector (where the propensity to conduct R&D is relatively high); and

- relatively high level of foreign ownership (with foreign-owned companies preferring to conduct their R&D in their base country)

- nearly two thirds of total R&D expenditure in the Australian private sector is conducted by firms of fewer than 1000 employees. (Such firms also employ more than 70% of people employed in private sector R&D.) By contrast, in the US, two thirds of the total R&D expenditure is conducted by firms of more than 5000 employees. If Australian business R&D expenditure is weighted to small firms, one inference is that our businesses may only be able to afford low-risk, low-scale incremental R&D. This would be expected to reduce the returns from R&D[xiv]

- if most of Australia's business R&D is conducted by small firms, it is likely to be self-funded, which may diminish the facility for risk-sharing as afforded by diversified venture capital sources.

The Industry Commission found[xv] that:

- the ranking of R&D to sales ratios by industry is much the same in Australia as in most industrialised countries; but
- almost without exception, industry-level BERD intensities in Australia are below those found internationally.

These findings relate to the early 1990s. We are not aware of any more recent quantitative studies of Australia's industry structure as a possible impediment to increased business investment in R&D.

The Industry Commission also found no conclusive evidence that the level of foreign ownership is an influence on BERD[xvi]. More recently the Australian Bureau of Statistics has published a review of the Foreign Ownership Characteristics of Businesses Undertaking Research and Experimental Development Activity in Australia[xvii]. The review finds that foreign-owned businesses are responsible for 42% of business R&D expenditure in Australia, but gives no information on the relative R&D propensities of foreign-owned and Australian-owned companies.

In summary, based on the latest research conducted in 1992, it seems that the most likely explanation for Australia's relatively low rate of BERD is that private returns to business R&D in Australia may not have been sufficient to justify increased investment. The factors which give rise to this situation are not well understood. As discussed under Term of Reference 3 below, the Government has in place a number of policies to foster greater business investment in R&D.

Another possible impediment to a greater business commitment to R&D is that private industry may not have sufficiently well developed linkages to gain from publicly-funded research. For example, studies[xviii] on citations of published research in US patents are regarded as evidence that publicly-sponsored basic research plays a role in the development of leading-edge technologies such as pharmaceuticals, chemicals, advanced electronics and, especially, biotechnology.

The forms of interaction between businesses and the publicly-funded research base, which includes both universities and other public research agencies, include:

- Licences, royalties or options on intellectual property: when a research organisation licences some item of intellectual property, it enters a contract with a commercial firm to allow it to use its discovery, usually in a patented form, in return for royalties;

- Outright sale of technology: there are occasions that the research organisation sells the technology outright and does not receive any further royalties;

- Spin off or start up companies to develop and sell the technology: sometimes the research organisation itself, or in partnership with other companies, sets up companies to exploit the new technology. This involves a varying amount of investment in the company for development, production and marketing, but provides the possibility that if the commercialisation is successful, the equity retained by the research organisation could appreciate significantly in value;

- Partnerships to conduct R&D between public research organisations and private firms: a recent study of the interaction between public R&D and private organisations by the OECD[xix] found that there was an increasing trend for private firms to enter into formal relationships with public organisations to conduct R&D in a specified area. There are varying degrees of involvement and co-investment in these so-called "Public/Private Partnerships", but their rapid growth reflects the success of this model;

- In the United States, the University of California and the Massachusetts Institute of Technology have found the total economic returns from companies founded by alumni far outweigh the returns from private sector activity carried out through other kinds of linkages with other of these institutions.

According to the most recently available data[xx], Australian universities sourced about 4.9% of their funds from the business sector in 2000. This suggests a somewhat lower level of university/industry collaboration than occurs in other major OECD countries: the USA (6.4%), the UK (7.1%), Japan (2.5%), Germany (11.3%) and Canada (8.9%).

A March 2002 study by the Australian Graduate School of Entrepreneurship at Swinburne University[xxi] found that North American data showed research expenditure nationally in the range A$130 to 177 million per spin-off company generated. For selected universities with a strong emphasis on spin-off company generation, this rate fell to one spin-off per A$40 million of research expenditure. The data suggested a target for Australia of one spin-off company per A$150 million of research expenditure or 25 to 30 new spin-offs per annum.

The rate of spin-off establishment in Australia was found to have increased in recent years with 86 Direct Research Spin-offs established by universities and public sector research agencies in period between and including the financial years 1997-1998 to 1999-2000. This suggested an annual rate of 29 new ventures - within the target range.

In view of these data on linkages and spin-offs, and the mechanisms in place to encourage linkages between Australian businesses and the publicly-funded research base and greater commercialisation of publicly-funded R&D (discussed further under Term of Reference 3 below), DEST does not consider that sub-optimal relationships with publicly-funded research organisations are a major impediment to business investment in R&D. This is not to say, however, that relationships have no room for improvement.

Lastly, a potential impediment to business investment in R&D is a lack of supply of trained and experienced researchers and technical staff. The education requirements of potential R&D researchers require large government investments in high quality tertiary education facilities and staff.

The issues in this area include the quantity and quality of graduate scientists, engineers and technologists, the quantity and quality of people with postgraduate research training, skilled immigration levels and arrangements, vocational training for specific support skills and the availability of vocational training for life long learning, and mechanisms for the interchange of personnel between the private sector and universities and government research agencies, important for countries such as Australia with a relatively large publicly-funded research base, and small business R&D base.

Australia is at the upper end of the proportion of science graduates in the labour force aged between 25 to 34 for OECD countries, and the figure of around 1300 science graduates per 100,000 in this 'youth labour force' is about the same as for France, New Zealand, Finland, United Kingdom, and Ireland, and is 25% more than for Japan and 50% more than for the United States and Germany[xxii]. The recent experience of the two small open economies on this list, Ireland and Finland, has been that the high proportion of science graduates in its youth labour force has been seen as a major positive influence in their path of more advanced industrialisation and their move into high technology industries. In 2001 there were 1595 Science and Engineering PhD graduates in Australia, 43% of the total PhD graduates in that year. Of these 26% were in the Physical sciences, 27% were in engineering, and 29% were in Life Sciences.[xxiii]

The issue of the so-called 'brain drain' has been a concern for policy-makers for a number of years. A recent study[xxiv] has found that over the three years of the study, Australia has registered a 'brain gain'. While there was a net loss of skilled residents, this was more than offset for almost every occupation by gains from settler movement and a net inflow of long term temporary residents. Overall, analysis over the period 1997-98 to 1999-2000 showed that overall there was a modest gain in skilled workers. There was little net resident loss for occupations even where international demand was strong, the highest losses being for a 2.1 per cent in the stock of workers for computer professionals, 2.9 per cent for accountants and 1.4 per cent for nurses. The predominance of the United Kingdom as a destination, the relatively high return rate and the youthful age of Australian residents departing for the United Kingdom, suggest that much of this movement is akin to the traditional 'boomerang' trip overseas. That is, the study found that most Australian residents return home after a period overseas.

Notwithstanding the above evidence that overall, Australia has a net 'brain gain' in almost all occupations, including those seen as important to facilitate business and R&D, it is possible that Australia may still be losing key personnel. The Federation Fellowships were introduced as a *Backing Australia's Ability* initiative to address this issue. A study into the more qualitative aspects of skilled migration is currently being conducted by Professor Graeme Hugo of Adelaide University. This study will shed further light on this issue.

To enhance Australia's innovation skills base, *Backing Australia's Ability* introduced measures under Australia's Migration Program, to encourage immigration of ICT professionals. One of these measures gave immediate processing priority to sponsorship, nomination and visa applications relating to the entry of an ICT professional. However, on 16 July 2002, the Minister for Immigration announced that this program had been suspended temporarily due to recent the downturn in demand for ICT professionals[xxv].

In view of these data, and the mechanisms in place to encourage the supply of skilled people for business R&D (discussed further under Term of Reference 3 below), DEST feels that supply of skills seems not to represent a major impediment to business investment in R&D. This is not to

say that an increased supply of qualified people would not help to stimulate greater investment in R&D. There is very likely to be a positive feedback between the quantity of investment in R&D in Australia and an increased supply of suitably qualified persons.

**Term of Reference 3. What steps need to be taken to better demonstrate to business the benefits of higher private sector investment in R & D?**

The Government has in place a number of policies and programs to encourage businesses to invest more in R&D, and therefore to demonstrate the benefits of higher investment in R&D.

Support through grants and other incentives

Relevant initiatives of *Backing Australia's Ability* (and administering agencies) are:

- $35 million for a National Innovation Awareness Program to raise understanding of the importance and commercial potential of science and technology ((Department of Industry Tourism and Resources (DITR), and DEST).
- $227 million in additional funding for the Cooperative Research Centres program (DEST) over three years from 2003/04 to 2005/06.
- 175% Tax Concession Premium for additional R&D, and R&D Tax Rebate for small companies. These supplement the ongoing 125% R&D Tax Concession (DITR).
- $535 million additional funding for the R&D Start program (DITR).
- More than doubling the funding for the Commercialising Emerging Technologies (COMET) Program, to help firms get their products to the market place (DITR).
- A PreSeed Fund for commercialising research from universities and public sector research agencies (DITR).
- Doubling the Biotechnology Innovation Fund (DITR).
- Additional funding for the New Industries Development Program for agribusiness (Department of Agriculture, Fisheries and Forestry).
- Through *Backing Australia's Ability* the Government is also providing $176 million to establish World Class Centres of Excellence in Biotechnology (DITR and the ARC) and Information and Communications Technology (Department of Communications, Information Technology and the Arts (DCITA) and the ARC), with strong industry participation.
- In addition the Government is providing support for venture capital through the Pooled Development Funds and Innovation Investment Funds.

Invest Australia (within the Industry, Tourism and Resources portfolio) encourages overseas companies to base R&D activities in Australia.

The $158 million BITS program (DCITA) is providing support to ICT start-up companies including through business incubation centres.

Some forms of R&D can only be conducted using large facilities and in some cases government-sponsored arrangements are required to provide infrastructure that can be shared between firms, and between basic research and commercial uses. The Major National Research Facilities program is an example of a mechanism to address this type of impediment. The MNRF program is funded through *Backing Australia's Ability* and is providing $155 million to support 15 leading-edge facilities. Other major facilities are supported through the CSIRO and the Australian Nuclear Science and Technology Organisation.

Links between private industry and publicly-funded research organisations

The Cooperative Research Centres (CRC) program is an example of a major public/private partnerships program of the type described under term of reference 1. Appendix 1 provides more information on the CRCs' interaction with industry.

The ARC Linkage program also encourages and develops long-term strategic research alliances between higher education institutions and industry, and fosters opportunities for postdoctoral researchers to pursue internationally competitive research in collaboration with industry. Major publicly-funded research organisations such as CSIRO, are also being further encouraged to engage and expand links with industry.

Further initiatives include a planned Commercialisation Forum and Trade Fair of Ideas sponsored by DEST, which will be held over three days in the first half of 2003. The Fair will provide an opportunity for researchers from universities, medical research institutes, Centres of Excellence, Co-operative Research Centres and other major research facilities to showcase their ideas to potential investors.

Appendix 2 summarises recent information on research commercialisation by Universities.

Programs and policies to ensure the supply of skilled R&D personnel

The Government is instituting major programs to improve the quantity and quality of graduate scientists. To address likely skill requirements in key innovation areas, *Backing Australia's Ability* provided $151 million to create an additional 2000 university places each year – with priority given to ICT, mathematics and science. This will rise to 5470 places by 2005. This initiative strengthens our national skills base while meeting employers' needs for high calibre graduates in these fields.

The government is also providing universities $25 million over three years from 2000-01 for the Science Lectureship initiative, a competitive grants scheme to assist universities or consortia of institutions, in partnership with industry to develop innovative approaches to science-related education, including the establishment of university lectureships and innovative course development.

The ARC Linkage program provides industry-oriented research training to prepare high-calibre postgraduate research students for work in industry and produces a national pool of world-class researchers to meet the needs of Australian industry.

Policies have been initiated aimed at improving life long learning at Postgraduate level. Over the five years to 2005-06 the government will lend an estimated $995 million to postgraduate students through the Postgraduate Education Loans scheme (PELS). PELS operates in a similar way to the existing Higher Education Contribution Scheme for undergraduate students.

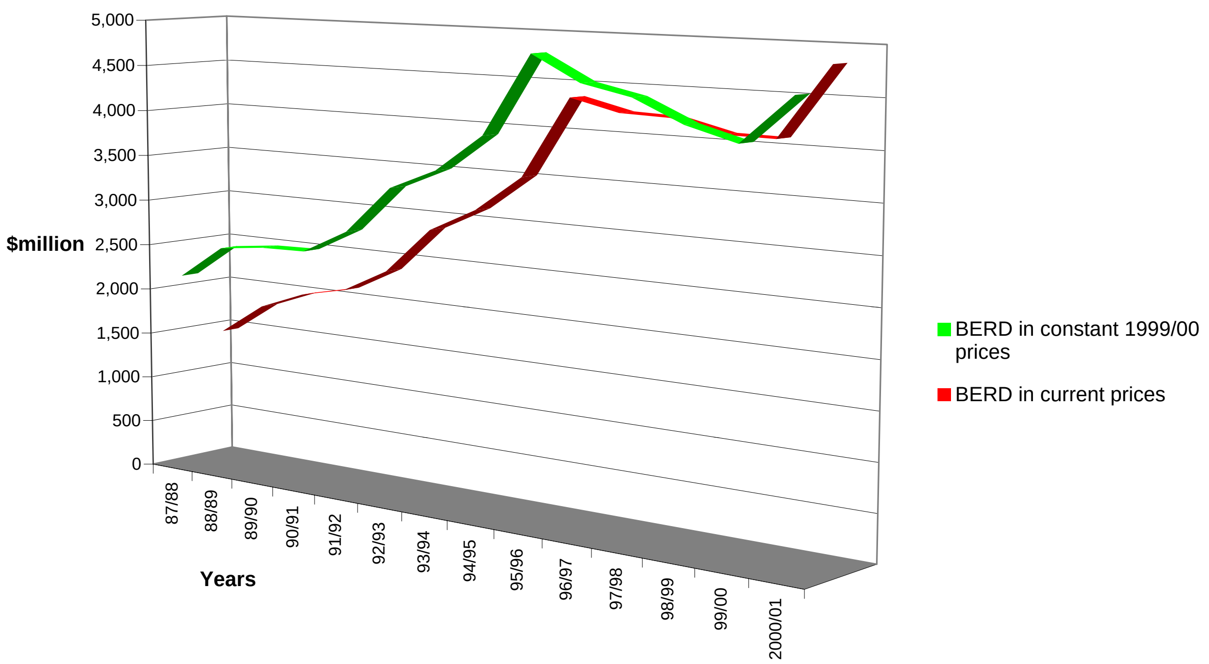
What more should be done?

Australia's BERD as a percentage of GDP was 0.72% in 2000-01 according to the most recently available figures[xxvi]. The United States, the UK, Finland, Sweden and Japan, have ratios exceeding 2%. Germany, France, Canada, Korea, Denmark and the Netherlands lie in the range

of 1% to 2%. Australia lies with a small group of OECD countries including the Czech Republic, Norway and Italy having ratios between 0.5% and 1.0% - in the lower end of the OECD range, but above the less industrialised European countries. The OECD average is around 1.5% and the European Union average around 1.2%.

BERD in 2000-01 was estimated to be $4.825 billion at current prices, an increase of 18% over 1999-2000. In volume terms, with the effect of changes in prices and wages and salaries removed, BERD increased by 12% over 1999-2000. This is 5% below the peak level recorded in 1995-96. Figure 1 shows trends in BERD over the last decade.

**Figure 1: Australian Business Expenditure on R&D (BERD) (1988 to 2001)**

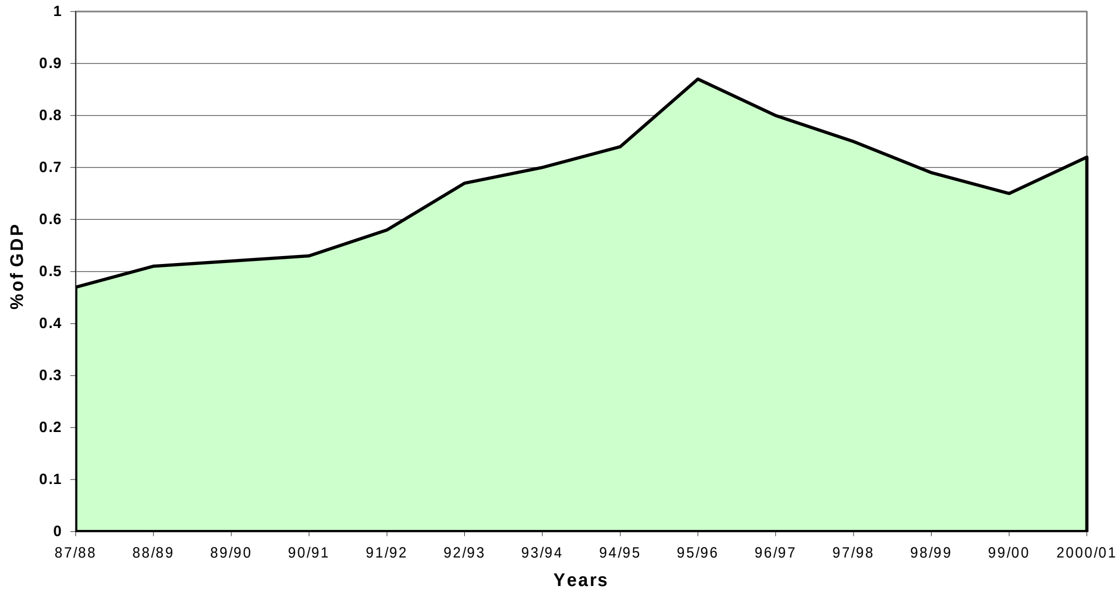



**Source**: *Research and Experimental Development - Business Australia* (ABS Cat. No. 8104.0). Note that BERD in constant prices was calculated on the basis of annual business enterprises deflators provided by the ABS in August 2002.

The same survey asked businesses to report what they expected their expenditure on R&D to be in 2001-02. Total BERD was expected to be about 1% higher in 2001-02 than in 2000-01. Experience from past surveys is that actual expenditure has exceeded projected expenditure by about 10%.

Australia's BERD as a percentage of GDP remains below the high of 0.87% in 1995-96. Figure 2 shows trends in the BERD to GDP ratio over the last decade.

**Figure 2: Australian Business Expenditure on R&D (BERD) as a % of GDP**




**Source**: *National Income, Expenditure and Product - Australian National Accounts* (ABS Cat. No. 5206.0).

The 2000-01 ABS data precedes the commencement of *Backing Australia's Ability* which includes a number of initiatives aimed at increasing BERD (as noted above). In view of this, the recent upturn, and the generally increasing trend over the last decade, DEST's view is that further initiatives to foster business investment in R&D should ideally await the evaluation of the impact and effectiveness of current initiatives, further studies to clarify the returns and risks associated with business R&D in Australia, and further studies on the possible structural factors underlying the relatively low level of BERD.

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[i] OECD, Main Science and Technology Indicators, 2001-2, Tables 46 and 51.

[i] Industry Commission, Report Number 44, "Research and Development", 15 May 1995, pp 128-130. This section summarises the economic theory on the relationship between R&D and competitiveness, and relates conventional theory which incorporates technological advance as cost-free productivity- or product-improving change to the theories in the tradition of Schumpeter with the emphasis of product and process innovations as investment activities.

[iii] Ibid pp155-159. While the statement that that there is a key link between R&D and productivity, and through to growth, is not disputed by any responsible commentator, there are inherent difficulties in providing empirical evidence of this link for a small country such as Australia because of spillover effects from abroad. However recent work quoted by Dowrick "Investing in the Knowledge Economy" ANU Working Paper, April 2002, indicates that if Australia's total (public and private) R&D expenditure is increased by 10 per cent or $1 billion (0.15 per cent of GDP), the annual growth rate is increased by 0.1 per cent. Domestic R&D and spillovers from foreign R&D are of roughly equal importance for productivity growth, and social returns from R&D range from around 50 per cent. He goes on to say that given these returns, Australia and other OECD countries are suffering from gross under-investment in R&D.

[iv] Ibid p163. This is the same concept as the economic term "externality" specifically relating to the effects of R&D on the economy as a whole. "Spillover" is probably a more meaningful term, denoting any original, valuable knowledge generated in the research process which becomes publicly accessible. The distinction with an externality

is that a spillover need not necessarily be totally free, but the gain could be for instance be embodied into new equipment which is paid for.

[v] Industry Commission, Research and Development, Report No 44,15 May 1995, Table QA10

[vi] Ibid, Table QA3.

[vii] Dowrick, Steve "The contribution of Innovation and education to Economic Growth' Melbourne Institute Economic and Social Outlook conference, April 4-5, 2002.

[viii] Industry Commission, Research and Development, Report No 44,15 May 1995, Table QA15

[ix] Ibid, Table QA14

[x] ABS, Cat. No. 8112, "Research and Experimental Development", 2000-01, Table 5.
[xi] Steve Dowrick "the Contribution of Innovation and Education to Growth", Melbourne Institute Economic and Social Outlook Conference, April 4-5, 2002.

[xii] Ibid pp 169-172. The policy relevance of risk derives from the potential for underinvestment if individuals or firms are too risk adverse (a cultural problem), or lack the capacity to spread risk (a size or economic infrastructure problem). In these cases there is a theoretical argument, going back to Arrow's seminal work on the case of government intervention in R&D, for governments to intervene to pool or spread risk. It should be emphasised that this mechanism need not necessarily be in the nature of a direct subsidy. Subsidies as R&D incentives are a separate matter.

[xiii] Branscomb, Lewis M. "Understanding Private sector decision making on Early-stage, High-risk, Technology Based Projects', Report, Kennedy School of Government, Harvard University.

[xiv] OECD, STI Scoreboard, 2001

[xv] ibid, pp 146-147.

[xvi] ibid pp. 495-496.

[xvii] Australian Economic Indicators, August 2002, pp. 3-11.

[xviii] Inventing our future – the link between Australian patenting and basic science F. Narin, M. Albert, P. Kroll and D. Hicks, a report commissioned by the Australian Research Council and CSIRO and published in 2000.

[xix] OECD "Public/Private Partnership for Innovation', June 2002.

[xx] OECD, Main Science and Technology Indicators, 2002-1, Table 46 and ABS, catalogue 8111.0 Research and Experimental Development Higher Education Organisations Australia, 12 April 2002, Table 6.

[xxi] Yenken, John and Gillin, Murray, Australian University Spinoff Companies: Attitudes, Policies and Companies, Australian Graduate School of Entrepreneurship at Swinburne University of Technology Research Paper, Revised March 2002.

[xxii] OECD Indicators, 'Education at a Glance', 2001 Edition, Table C4.4, Chart C4.5.

[xxiii] Internal DEST Statistics.

[xxiv] Bob Birrell, Ian R.Dobson, Virginia Rapson and T. Fred Smith 'Skilled Labour: Gains and Losses' Centre for Population and Urban Research, Monash University, July 2001, pp5-6.

[xxv] Press Release by the Minister for Immigration and Multicultural and Indigenous Affairs dated July 16 2002, 'Minister suspends priority processing for ICT workers'.

[xxvi] Research and Experimental Development Businesses Australian Bureau of Statistics, 1 July 2002.

**APPENDIX 1**

## COOPERATIVE RESEARCH CENTRES (CRCs) – INTERACTION WITH INDUSTRY

A recent study[i] found that over the ten years of the CRC Programme, Centres have carried out nearly 4,300 contracts for industry and other users and have earned over $300 million for these services. The annual value of contracts to the CRCs has typically been of the order of $25-55 million. The Mining and Energy CRCs held the largest dollar share of contracts. CRCs in all industry sectors saw an increase in contract earnings in the second quinquennium of the Programme.

CRCs also reported nearly 150 technology commercialisation agreements in 2000/01 with private sector and other organisations, with a value to the Centres of around $3.8 million. By far the most common agreement was that for the licensing of intellectual property, which accounted for greater than two thirds of the agreements and nearly half the income. Spin-off companies and 'other' agreements were commonly used, with the 20 spin-off companies generating nearly twice as much income as 'other agreements'. Only a single instance of outright sale of technology was reported.

The study data record a wide range of income received[ii]. For example the average value of IP licensing ranged from $5000-$6000 in Agriculture and ICT sectors to around $100,000 in the Environment and Medical S&T fields. The average income from spin-off companies was generally greater, ranging between $140,000 and $200,000, at least in the Medical and IT fields. In terms of total income from technology agreements, by far the largest fields were the CRCs in ICT, receiving $1.6 million in 2000-01, and Medical S&T, with receipts of $1.4 million.

In regard to the CRCs' engagement with Small and Medium Enterprises, the survey found[iii] that in the period 1997-98 to 2000-01, more than 900 companies were involved each year with CRCs in one way or another. The majority of these were large entities: around 600 large companies have been involved annually with CRCs (averaging 62 per cent of companies involved) compared to about 350 SMEs (38 per cent of companies involved).

One of the clear features of the data assembled by the University of Wollongong is that it provides evidence of a strong shift towards 'core participation' by the private sector in CRCs, as opposed to the more distant forms of association. Although the overall number of companies involved with CRCs fell slightly over the period of the study, the number of companies engaged as 'core participants' increased and there was greater participation of SMEs as both core and supporting participants. Over 30 per cent more large firms, for example, were reported as 'core participants' in 2000-01 than in 1997-98. For SMEs the growth in core participants was even more dramatic with the number of companies recruited as core participants almost doubling over the same period. Also there was a 13 per cent increase in SMEs as 'supporting participant' involved in CRCs over the same period[iv].

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[i] Data collected in a Management Data Questionnaire quoted in Sam Garett-Jones and Tim Turpin, April 2002 "Measuring the Outcomes of the CRC Program: A Framework", Final Report, University of Wollongong, p 28.

[ii] Ibid p 89.

[iii] Sam Garret-Jones, Tim Turpin and David Steele "Measuring the Outcomes of the CRC Program: A Framework" University of Wollongong Report, April 2002, p37.

[iv] Sam Garret-Jones and Tim Turpin "Measuring the Outcomes of the CRC Program: a Framework", Final Report, University of Wollongong, April 2002, p99.

**Summary of patenting and related activities by universities and/or related entities (number of universities = 42)**

| | | | Universities |
|---|---|---|---|
| Stock of patents held by Australian universities and/or controlled entities at 31 December 2001 | Australian patents<br>Overseas patents<br>Total patents | 557<br>957<br>1,514 | (n=30)<br>(n=26)<br>(n=30) |
| Of the patents referred to above, patents granted for the first time in 2001 | Australian patents<br>Overseas patents<br>Total patents | 90<br>55<br>145 | (n=19)<br>(n=13)<br>(n=23) |
| Of the patents granted for the first time in 2001 | Granted to universities directly<br>Granted to commercial subsidiaries | 131<br>14 | (n=22)<br>(n= 4) |
| Patents held by institutions or controlled entities sold or transferred in 2001 | | 36 | (n= 8) |
| Licenses issued by institutions or controlled entities in 2001 | | 179 | (n=21) |
| Revenue generated by these 179 licenses referred to above | | $33,875,844 | (n=17) |
| Spin off companies generated by the institution or its controlled entities in 2001 | | 44 | (n=21) |
| Distribution of equity in university spin off companies generated in 2001 | University has 100% equity<br>University has 50% or above equity<br>University has less than 50% equity | 9<br>14<br>21 | |
| Equity share in the 35 instances where the university did not have 100% equity in these spin off companies | Equity shared between the university and originators<br>Equity shared with originator and third parties | 9<br>26 | |

Source: Department of Education, Science and Training (DEST), Research and Research Training Management Reports (RRTMRs) 2002.

**SUBMISSION OF THE DEPARTMENT OF EDUCATION, SCIENCE AND TRAINING**

**TO THE**

**HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON SCIENCE AND INNOVATION**

**INQUIRY INTO BUSINESS COMMITMENT TO R&D IN AUSTRALIA**

## Relevant responsibilities of the Education, Science and Training Portfolio

The Portfolio takes a national leadership role in education, science and training. It works with various stakeholders (including industry groups), State and Territory governments, other Commonwealth agencies and a range of contracted service providers to provide high quality policy advice and services for the benefit of Australia.

As well as the Department, the Portfolio includes the following statutory bodies whose responsibilities relate to research and research training, some of which will be making separate submissions to the Inquiry:

- the Anglo Australian Telescope Board;
- the Australian Institute of Marine Science (AIMS);
- the Australian Nuclear Science and Technology Organisation (ANSTO);
- the Australian Research Council (ARC); and
- the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

The Portfolio has the primary responsibility for funding and policy-making in the higher education sector.

The Government has provided clear guidance on its priorities for science, research and innovation through its Innovation Action Plan - *Backing Australia's Ability* (BAA). The Department has the responsibility of monitoring BAA programs and policy issues on behalf of the Committee of Ministers overseeing implementation of BAA.

The Department supports the science and innovation framework through such bodies as the Prime Minister's Science, Engineering and Innovation Council (PMSEIC), the Chief Scientist, the Coordination Committee for Science and Technology and through targeted funding and international promotion of Australia's scientific and technological capabilities.

As the Department has an overview role with respect to Australia's science and innovation system, the Department's submission is provided from this perspective, but with particular emphasis on the Department's responsibilities in public sector science and higher education.

## Term of reference 1. What would be the economic benefit for Australia from a greater private sector investment in R&D?

As some background on Australia's R&D performance overall, the latest statistics from the Australian Bureau of Statistics (ABS) show that Australia's overall gross expenditure on R&D (GERD) in 2000-01 was at an all-time high of more than $10 billion, more than $1 billion higher than the previous survey (1988-99). All sectors performing research – business, government, universities, and private non-profit – recorded an increase in their investment in R&D.

Commonwealth Government financing of R&D reached an all-time high of $3.9 billion – an increase of 13% over 1998-99. Government financing of R&D in Australia is around 0.70% of GDP – above the OECD average of around 0.65% of GDP, and comparable with the USA (0.74%), Japan (0.58%) and Germany (0.78%).

The effect of *Backing Australia's Ability*, is not included in these figures but will become apparent in the next sequence of ABS data.

Although government funding of R&D, and the level of R&D performed in universities and government research agencies in Australia is higher than the OECD average as a percentage of GDP, Australia has a relatively low level of Business Expenditure on Research and Development (BERD) as a percentage of GDP compared with the majority of OECD countries.[i] (See below).

Firms benefit from investment in R&D by increasing their competitiveness. If Australia's firms become more competitive, Australia as a whole is likely to achieve greater economic growth, with the beneficial flow-ons of higher standard of living, lower unemployment and lower inflation.

What is meant by competitiveness? According to the Industry Commission[ii], a firm is competitive if it can maintain and expand its market share while making at least enough profit to induce it to stay in its existing line of business.

R&D improves competitiveness in two ways. First, it assists the firm to make its products more cheaply and efficiently by supplying the firm with the knowledge to increase its productivity – more goods can be produced for less cost. Second, it improves the goods themselves so that there is a greater demand for them. Or it creates a new good for which there is high demand, thus improving the firm's portfolio of products. The firm can either sell its products at a higher price, or a greater quantity at the same price, or a mixture of both.

The converse, failure to conduct R&D, means that firms are likely to lose market share to new products supplied by firms who can supply goods and services with higher quality and at lower cost. A basic economic benefit for Australia from a greater private sector investment in R&D is increasing the likelihood of Australia avoiding this adverse outcome.[iii]

What is beneficial for individual firms is certainly beneficial for Australia as a whole as the firms' growth adds to economic growth and employment – but that is only part of the story. The benefits of both successful R&D and not-quite-so-successful R&D by individual firms have "spillover" benefits for the Australian economy. "Spillover" effects are defined[iv] as any unpaid benefit or unrecompensed cost that flows to any agent other than the firm undertaking the R&D. Thus, by undertaking R&D, the firm generates "free" benefits for society as a whole. Such benefits include gains in knowledge and know-how of employees which they can take elsewhere, the increased demand for technically-advanced products supplied by other Australian firms, the raising of the general level of technical competence of that particular firm for which it does not necessarily charge full value. There are also a number of synergistic effects if a number of firms simultaneously engage in R&D in related areas, such as for example agriculture and pharmaceuticals.

Can the benefits to individual companies from conducting R&D, and the broader economic benefits, be quantified? The Industry Commission conducted a survey of investigations by economists into this question. While there was a wide divergence on the results, they found that

for investigations conducted in the USA and some other OECD countries in the past 20 years, the mean annual rate of return estimated for individual firms was 33 per cent of the R&D costs, although there was wide variation[v]. The mean estimated rate of return of further national "spillover" (social returns) for Japan and the USA was 85 per cent[vi].

More up-to-date estimates by Steve Dowrick[vii] quoted other studies giving private returns for the US at around 25% and social returns at around 50%.

Estimates for Australia are few, but the Bureau of Industry Economics estimated in 1992 that the mean rate of return to Australian society as a whole of R&D (social return) in the Industrial and Communication Technologies product field was 20 per cent, calculated ex-post, (apart from agriculture and mining related industries), while in 1988 it estimated the mean rate of return for Australian society from R&D in the minerals and process engineering technologies was 27 per cent[viii]. Estimates for social returns for R&D in agriculture in Australia vary between 2 and 138 per cent for various agricultural industries[ix]. So far as we are aware, there are no studies available on the private returns to R&D in Australia.

While returns to business R&D noted in the 1992 BIE research for mining and agricultural related industries were higher, the bulk of R&D for agricultural related industries is conducted by public research agencies, and private R&D in the mining and agricultural sectors combined is only 12 per cent of total business R&D on manufacturing and services.[x]

Thus on the current evidence, Australia as a whole would substantially benefit from *greater* private sector investment in R&D in Australia.

Detailed economic research on returns to R&D at the industry level has not been published in Australia since the publication of the Industry Commission Report No. 44, *Research and Development*, in 1995, which reported published data on social returns to R&D in Australia. There is a major need for more up-to-date research on the returns to R&D in Australia, especially for private returns to R&D in Australia, for which published results from any date are non-existent.

**Terms of Reference 2. What are the impediments to business investment in R&D?**

There are a several <u>potential</u> or <u>possible</u> impediments to business investment in R&D.

Based on the most recent research dating from 1992 previously discussed, the private returns to business R&D in Australia may not be sufficient to justify increased investment. The relatively low social rate of return (which includes the private rate of return – see below) of private industry R&D in Australia noted above (around 20 per cent outside the mining and agricultural industries), is a matter requiring further examination. This 1992 figure suggests that the private returns from a given investment in business R&D in Australia could be lower than those obtained by business R&D in the USA and other OECD countries. A relatively low return could be a major reason why the BERD to GDP ratio in Australia is low, even allowing for the effect of the relatively low proportion of manufacturing industry in Australia's economic activity[xi].

Private returns are defined as those returns appropriated by the firm undertaking the R&D. These include not only the profits resulting from the marketing of any products, but also receipts from selling R&D results (for example, royalties).

Social returns are those benefits which accrue to society as a whole from the conduct of R&D, including all private returns, and all those additional benefits from the conduct of R&D gained by society beyond the sum of these private returns. It is usually measured for a particular set of R&D by the flow of benefits accruing to society expressed a proportion of the cost of that R&D. By definition social returns must exceed private returns, as they include the private return of the R&D generating that social return.

Spillover benefits are the difference between the private and social returns. Spillover refers to any unpaid benefit or unrecompensed cost that flows to any agent other than the institution undertaking R&D.

While the terms spillover and social return are often used synonymously, it must be remembered that social return is a gross measure while spillover is a net measure of the benefits to society.

There is great deal of risk[xii] involved that a particular R&D project will not produce a return which covers its cost, much less generate a profit.  The distribution of profitability among individual research areas is not uniform.  It is even possible that the number of unprofitable areas outnumber the profitable areas. This distributional effect is masked by the average profitability figure.

Research on the distribution of the gains from R&D consistently indicate very skewed outcomes from R&D, with 80 per cent of returns coming from the success of 10 per cent of the projects[xiii]. The other 90 per cent of R&D projects return low profits or make a net loss.

Therefore the perceptions of risk may have a central role in expectations and decision-making.

As noted above, we are not aware of any studies on the private returns to R&D in Australia, nor of the influence of real or perceived risk of R&D on the level of business R&D conducted.

However, Australia's relatively low level of BERD could be taken as prima facie evidence that private returns to business R&D and/or the real or perceived risk of R&D are a significant impediment to greater business R&D.

Arguments have been advanced that Australia's relatively low level of BERD is a result of our industry structure, in particular:

- a relatively large services sector (where the propensity to conduct R&D is relatively low) and a relatively small manufacturing sector (where the propensity to conduct R&D is relatively high); and

- relatively high level of foreign ownership (with foreign-owned companies preferring to conduct their R&D in their base country)

- nearly two thirds of total R&D expenditure in the Australian private sector is conducted by firms of fewer than 1000 employees. (Such firms also employ more than 70% of people employed in private sector R&D.) By contrast, in the US, two thirds of the total R&D expenditure is conducted by firms of more than 5000 employees. If Australian business R&D expenditure is weighted to small firms, one inference is that our businesses may only be able to afford low-risk, low-scale incremental R&D. This would be expected to reduce the returns from R&D[xiv]

- if most of Australia's business R&D is conducted by small firms, it is likely to be self-funded, which may diminish the facility for risk-sharing as afforded by diversified venture capital sources.

The Industry Commission found[xv] that:

- the ranking of R&D to sales ratios by industry is much the same in Australia as in most industrialised countries; but
- almost without exception, industry-level BERD intensities in Australia are below those found internationally.

These findings relate to the early 1990s. We are not aware of any more recent quantitative studies of Australia's industry structure as a possible impediment to increased business investment in R&D.

The Industry Commission also found no conclusive evidence that the level of foreign ownership is an influence on BERD[xvi]. More recently the Australian Bureau of Statistics has published a review of the Foreign Ownership Characteristics of Businesses Undertaking Research and Experimental Development Activity in Australia[xvii]. The review finds that foreign-owned businesses are responsible for 42% of business R&D expenditure in Australia, but gives no information on the relative R&D propensities of foreign-owned and Australian-owned companies.

In summary, based on the latest research conducted in 1992, it seems that the most likely explanation for Australia's relatively low rate of BERD is that private returns to business R&D in Australia may not have been sufficient to justify increased investment. The factors which give rise to this situation are not well understood. As discussed under Term of Reference 3 below, the Government has in place a number of policies to foster greater business investment in R&D.

Another possible impediment to a greater business commitment to R&D is that private industry may not have sufficiently well developed linkages to gain from publicly-funded research. For example, studies[xviii] on citations of published research in US patents are regarded as evidence that publicly-sponsored basic research plays a role in the development of leading-edge technologies such as pharmaceuticals, chemicals, advanced electronics and, especially, biotechnology.

The forms of interaction between businesses and the publicly-funded research base, which includes both universities and other public research agencies, include:

- Licences, royalties or options on intellectual property: when a research organisation licences some item of intellectual property, it enters a contract with a commercial firm to allow it to use its discovery, usually in a patented form, in return for royalties;

- Outright sale of technology: there are occasions that the research organisation sells the technology outright and does not receive any further royalties;

- Spin off or start up companies to develop and sell the technology: sometimes the research organisation itself, or in partnership with other companies, sets up companies to exploit the new technology. This involves a varying amount of investment in the company for development, production and marketing, but provides the possibility that if the commercialisation is successful, the equity retained by the research organisation could appreciate significantly in value;

- Partnerships to conduct R&D between public research organisations and private firms: a recent study of the interaction between public R&D and private organisations by the OECD[xix] found that there was an increasing trend for private firms to enter into formal relationships with public organisations to conduct R&D in a specified area. There are varying degrees of involvement and co-investment in these so-called "Public/Private Partnerships", but their rapid growth reflects the success of this model;

- In the United States, the University of California and the Massachusetts Institute of Technology have found the total economic returns from companies founded by alumni far outweigh the returns from private sector activity carried out through other kinds of linkages with other of these institutions.

According to the most recently available data[xx], Australian universities sourced about 4.9% of their funds from the business sector in 2000. This suggests a somewhat lower level of university/industry collaboration than occurs in other major OECD countries: the USA (6.4%), the UK (7.1%), Japan (2.5%), Germany (11.3%) and Canada (8.9%).

A March 2002 study by the Australian Graduate School of Entrepreneurship at Swinburne University[xxi] found that North American data showed research expenditure nationally in the range A$130 to 177 million per spin-off company generated. For selected universities with a strong emphasis on spin-off company generation, this rate fell to one spin-off per A$40 million of research expenditure. The data suggested a target for Australia of one spin-off company per A$150 million of research expenditure or 25 to 30 new spin-offs per annum.

The rate of spin-off establishment in Australia was found to have increased in recent years with 86 Direct Research Spin-offs established by universities and public sector research agencies in period between and including the financial years 1997-1998 to 1999-2000. This suggested an annual rate of 29 new ventures - within the target range.

In view of these data on linkages and spin-offs, and the mechanisms in place to encourage linkages between Australian businesses and the publicly-funded research base and greater commercialisation of publicly-funded R&D (discussed further under Term of Reference 3 below), DEST does not consider that sub-optimal relationships with publicly-funded research organisations are a major impediment to business investment in R&D. This is not to say, however, that relationships have no room for improvement.

Lastly, a potential impediment to business investment in R&D is a lack of supply of trained and experienced researchers and technical staff. The education requirements of potential R&D researchers require large government investments in high quality tertiary education facilities and staff.

The issues in this area include the quantity and quality of graduate scientists, engineers and technologists, the quantity and quality of people with postgraduate research training, skilled immigration levels and arrangements, vocational training for specific support skills and the availability of vocational training for life long learning, and mechanisms for the interchange of personnel between the private sector and universities and government research agencies, important for countries such as Australia with a relatively large publicly-funded research base, and small business R&D base.

Australia is at the upper end of the proportion of science graduates in the labour force aged between 25 to 34 for OECD countries, and the figure of around 1300 science graduates per 100,000 in this 'youth labour force' is about the same as for France, New Zealand, Finland, United Kingdom, and Ireland, and is 25% more than for Japan and 50% more than for the United States and Germany[xxii]. The recent experience of the two small open economies on this list, Ireland and Finland, has been that the high proportion of science graduates in its youth labour force has been seen as a major positive influence in their path of more advanced industrialisation and their move into high technology industries. In 2001 there were 1595 Science and Engineering PhD graduates in Australia, 43% of the total PhD graduates in that year. Of these 26% were in the Physical sciences, 27% were in engineering, and 29% were in Life Sciences.[xxiii]

The issue of the so-called 'brain drain' has been a concern for policy-makers for a number of years. A recent study[xxiv] has found that over the three years of the study, Australia has registered a 'brain gain'. While there was a net loss of skilled residents, this was more than offset for almost every occupation by gains from settler movement and a net inflow of long term temporary residents. Overall, analysis over the period 1997-98 to 1999-2000 showed that overall there was a modest gain in skilled workers. There was little net resident loss for occupations even where international demand was strong, the highest losses being for a 2.1 per cent in the stock of workers for computer professionals, 2.9 per cent for accountants and 1.4 per cent for nurses. The predominance of the United Kingdom as a destination, the relatively high return rate and the youthful age of Australian residents departing for the United Kingdom, suggest that much of this movement is akin to the traditional 'boomerang' trip overseas. That is, the study found that most Australian residents return home after a period overseas.

Notwithstanding the above evidence that overall, Australia has a net 'brain gain' in almost all occupations, including those seen as important to facilitate business and R&D, it is possible that Australia may still be losing key personnel. The Federation Fellowships were introduced as a *Backing Australia's Ability* initiative to address this issue. A study into the more qualitative aspects of skilled migration is currently being conducted by Professor Graeme Hugo of Adelaide University. This study will shed further light on this issue.

To enhance Australia's innovation skills base, *Backing Australia's Ability* introduced measures under Australia's Migration Program, to encourage immigration of ICT professionals. One of these measures gave immediate processing priority to sponsorship, nomination and visa applications relating to the entry of an ICT professional. However, on 16 July 2002, the Minister for Immigration announced that this program had been suspended temporarily due to recent the downturn in demand for ICT professionals[xxv].

In view of these data, and the mechanisms in place to encourage the supply of skilled people for business R&D (discussed further under Term of Reference 3 below), DEST feels that supply of skills seems not to represent a major impediment to business investment in R&D. This is not to

say that an increased supply of qualified people would not help to stimulate greater investment in R&D. There is very likely to be a positive feedback between the quantity of investment in R&D in Australia and an increased supply of suitably qualified persons.

**Term of Reference 3. What steps need to be taken to better demonstrate to business the benefits of higher private sector investment in R & D?**

The Government has in place a number of policies and programs to encourage businesses to invest more in R&D, and therefore to demonstrate the benefits of higher investment in R&D.

<u>Support through grants and other incentives</u>

Relevant initiatives of *Backing Australia's Ability* (and administering agencies) are:

- $35 million for a National Innovation Awareness Program to raise understanding of the importance and commercial potential of science and technology ((Department of Industry Tourism and Resources (DITR), and DEST).
- $227 million in additional funding for the Cooperative Research Centres program (DEST) over three years from 2003/04 to 2005/06.
- 175% Tax Concession Premium for additional R&D, and R&D Tax Rebate for small companies. These supplement the ongoing 125% R&D Tax Concession (DITR).
- $535 million additional funding for the R&D Start program (DITR).
- More than doubling the funding for the Commercialising Emerging Technologies (COMET) Program, to help firms get their products to the market place (DITR).
- A PreSeed Fund for commercialising research from universities and public sector research agencies (DITR).
- Doubling the Biotechnology Innovation Fund (DITR).
- Additional funding for the New Industries Development Program for agribusiness (Department of Agriculture, Fisheries and Forestry).
- Through *Backing Australia's Ability* the Government is also providing $176 million to establish World Class Centres of Excellence in Biotechnology (DITR and the ARC) and Information and Communications Technology (Department of Communications, Information Technology and the Arts (DCITA) and the ARC), with strong industry participation.
- In addition the Government is providing support for venture capital through the Pooled Development Funds and Innovation Investment Funds.

Invest Australia (within the Industry, Tourism and Resources portfolio) encourages overseas companies to base R&D activities in Australia.

The $158 million BITS program (DCITA) is providing support to ICT start-up companies including through business incubation centres.

Some forms of R&D can only be conducted using large facilities and in some cases government-sponsored arrangements are required to provide infrastructure that can be shared between firms, and between basic research and commercial uses. The Major National Research Facilities program is an example of a mechanism to address this type of impediment. The MNRF program is funded through *Backing Australia's Ability* and is providing $155 million to support 15 leading-edge facilities. Other major facilities are supported through the CSIRO and the Australian Nuclear Science and Technology Organisation.

Links between private industry and publicly-funded research organisations

The Cooperative Research Centres (CRC) program is an example of a major public/private partnerships program of the type described under term of reference 1. Appendix 1 provides more information on the CRCs' interaction with industry.

The ARC Linkage program also encourages and develops long-term strategic research alliances between higher education institutions and industry, and fosters opportunities for postdoctoral researchers to pursue internationally competitive research in collaboration with industry. Major publicly-funded research organisations such as CSIRO, are also being further encouraged to engage and expand links with industry.

Further initiatives include a planned Commercialisation Forum and Trade Fair of Ideas sponsored by DEST, which will be held over three days in the first half of 2003. The Fair will provide an opportunity for researchers from universities, medical research institutes, Centres of Excellence, Co-operative Research Centres and other major research facilities to showcase their ideas to potential investors.

Appendix 2 summarises recent information on research commercialisation by Universities.

Programs and policies to ensure the supply of skilled R&D personnel

The Government is instituting major programs to improve the quantity and quality of graduate scientists. To address likely skill requirements in key innovation areas, *Backing Australia's Ability* provided $151 million to create an additional 2000 university places each year – with priority given to ICT, mathematics and science. This will rise to 5470 places by 2005. This initiative strengthens our national skills base while meeting employers' needs for high calibre graduates in these fields.

The government is also providing universities $25 million over three years from 2000-01 for the Science Lectureship initiative, a competitive grants scheme to assist universities or consortia of institutions, in partnership with industry to develop innovative approaches to science-related education, including the establishment of university lectureships and innovative course development.

The ARC Linkage program provides industry-oriented research training to prepare high-calibre postgraduate research students for work in industry and produces a national pool of world-class researchers to meet the needs of Australian industry.

Policies have been initiated aimed at improving life long learning at Postgraduate level. Over the five years to 2005-06 the government will lend an estimated $995 million to postgraduate students through the Postgraduate Education Loans scheme (PELS). PELS operates in a similar way to the existing Higher Education Contribution Scheme for undergraduate students.

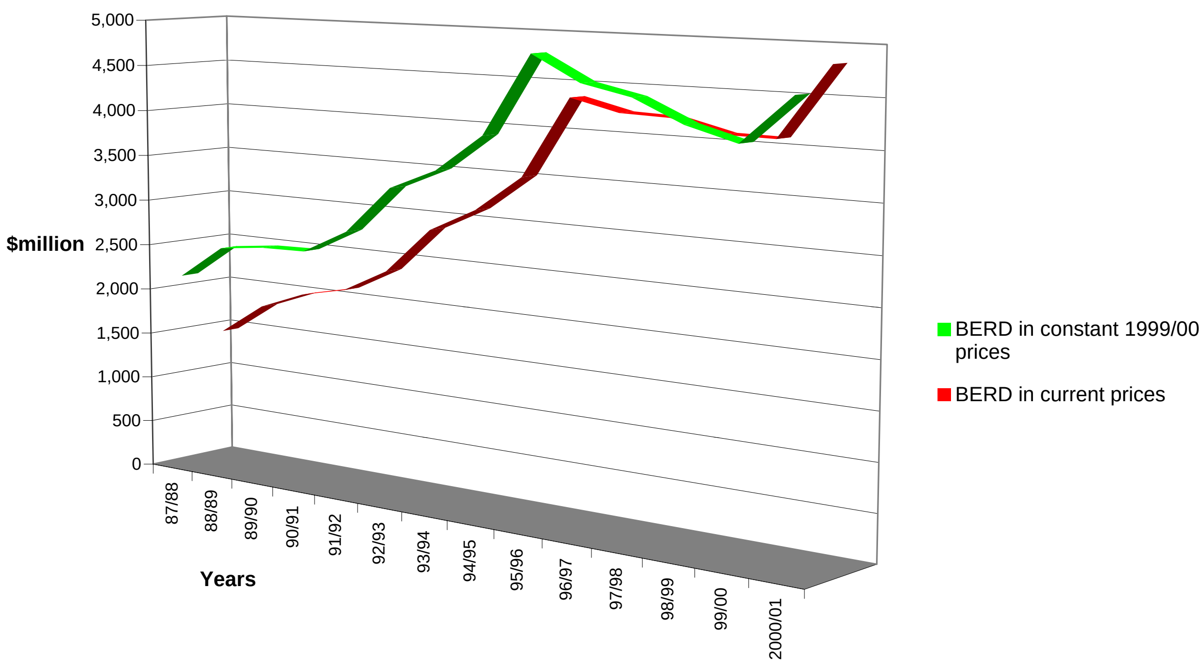
What more should be done?

Australia's BERD as a percentage of GDP was 0.72% in 2000-01 according to the most recently available figures[xxvi]. The United States, the UK, Finland, Sweden and Japan, have ratios exceeding 2%. Germany, France, Canada, Korea, Denmark and the Netherlands lie in the range

of 1% to 2%. Australia lies with a small group of OECD countries including the Czech Republic, Norway and Italy having ratios between 0.5% and 1.0% - in the lower end of the OECD range, but above the less industrialised European countries. The OECD average is around 1.5% and the European Union average around 1.2%.

BERD in 2000-01 was estimated to be $4.825 billion at current prices, an increase of 18% over 1999-2000. In volume terms, with the effect of changes in prices and wages and salaries removed, BERD increased by 12% over 1999-2000. This is 5% below the peak level recorded in 1995-96. Figure 1 shows trends in BERD over the last decade.

**Figure 1: Australian Business Expenditure on R&D (BERD) (1988 to 2001)**

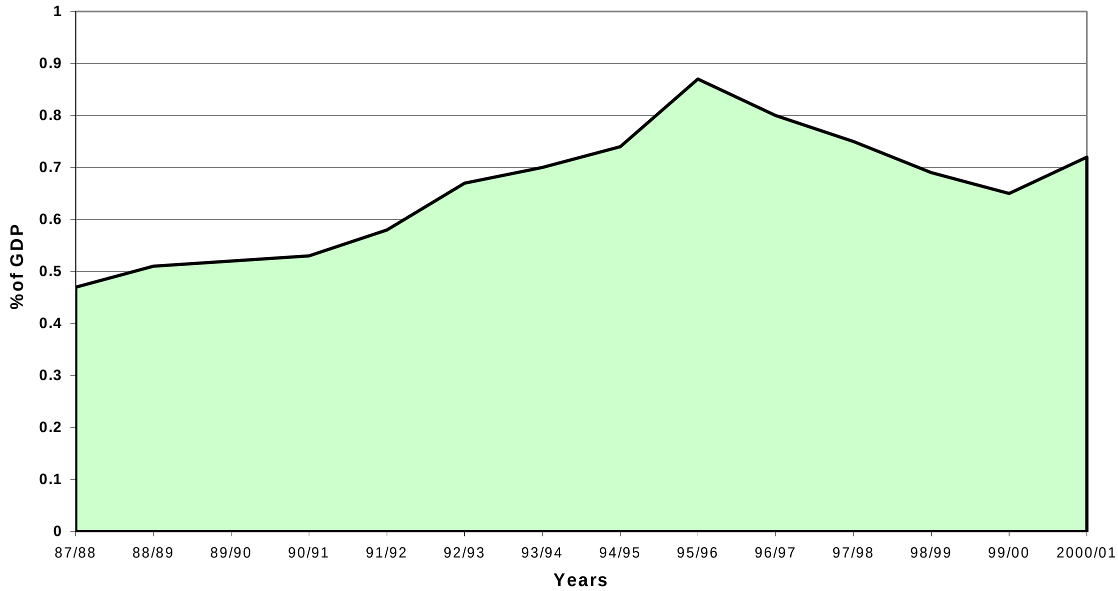



**Source**: *Research and Experimental Development - Business Australia* (ABS Cat. No. 8104.0). Note that BERD in constant prices was calculated on the basis of annual business enterprises deflators provided by the ABS in August 2002.

The same survey asked businesses to report what they expected their expenditure on R&D to be in 2001-02. Total BERD was expected to be about 1% higher in 2001-02 than in 2000-01. Experience from past surveys is that actual expenditure has exceeded projected expenditure by about 10%.

Australia's BERD as a percentage of GDP remains below the high of 0.87% in 1995-96. Figure 2 shows trends in the BERD to GDP ratio over the last decade.

**Figure 2: Australian Business Expenditure on R&D (BERD) as a % of GDP**




**Source:** *National Income, Expenditure and Product - Australian National Accounts* (ABS Cat. No. 5206.0).

The 2000-01 ABS data precedes the commencement of *Backing Australia's Ability* which includes a number of initiatives aimed at increasing BERD (as noted above). In view of this, the recent upturn, and the generally increasing trend over the last decade, DEST's view is that further initiatives to foster business investment in R&D should ideally await the evaluation of the impact and effectiveness of current initiatives, further studies to clarify the returns and risks associated with business R&D in Australia, and further studies on the possible structural factors underlying the relatively low level of BERD.

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[i] OECD, Main Science and Technology Indicators, 2001-2, Tables 46 and 51.

[i] Industry Commission, Report Number 44, "Research and Development", 15 May 1995, pp 128-130. This section summarises the economic theory on the relationship between R&D and competitiveness, and relates conventional theory which incorporates technological advance as cost-free productivity- or product-improving change to the theories in the tradition of Schumpeter with the emphasis of product and process innovations as investment activities.

[iii] Ibid pp155-159. While the statement that that there is a key link between R&D and productivity, and through to growth, is not disputed by any responsible commentator, there are inherent difficulties in providing empirical evidence of this link for a small country such as Australia because of spillover effects from abroad. However recent work quoted by Dowrick "Investing in the Knowledge Economy" ANU Working Paper, April 2002, indicates that if Australia's total (public and private) R&D expenditure is increased by 10 per cent or $1 billion (0.15 per cent of GDP), the annual growth rate is increased by 0.1 per cent. Domestic R&D and spillovers from foreign R&D are of roughly equal importance for productivity growth, and social returns from R&D range from around 50 per cent. He goes on to say that given these returns, Australia and other OECD countries are suffering from gross under-investment in R&D.

[iv] Ibid p163. This is the same concept as the economic term "externality" specifically relating to the effects of R&D on the economy as a whole. "Spillover" is probably a more meaningful term, denoting any original, valuable knowledge generated in the research process which becomes publicly accessible. The distinction with an externality

is that a spillover need not necessarily be totally free, but the gain could be for instance be embodied into new equipment which is paid for.

[v] Industry Commission, Research and Development, Report No 44,15 May 1995, Table QA10

[vi] Ibid, Table QA3.

[vii] Dowrick, Steve "The contribution of Innovation and education to Economic Growth' Melbourne Institute Economic and Social Outlook conference, April 4-5, 2002.

[viii] Industry Commission, Research and Development, Report No 44,15 May 1995, Table QA15

[ix] Ibid, Table QA14

[x] ABS, Cat. No. 8112, "Research and Experimental Development", 2000-01, Table 5.
[xi] Steve Dowrick "the Contribution of Innovation and Education to Growth", Melbourne Institute Economic and Social Outlook Conference, April 4-5, 2002.

[xii] Ibid pp 169-172. The policy relevance of risk derives from the potential for underinvestment if individuals or firms are too risk adverse (a cultural problem), or lack the capacity to spread risk (a size or economic infrastructure problem). In these cases there is a theoretical argument, going back to Arrow's seminal work on the case of government intervention in R&D, for governments to intervene to pool or spread risk. It should be emphasised that this mechanism need not necessarily be in the nature of a direct subsidy. Subsidies as R&D incentives are a separate matter.

[xiii] Branscomb, Lewis M. "Understanding Private sector decision making on Early-stage, High-risk, Technology Based Projects', Report, Kennedy School of Government, Harvard University.

[xiv] OECD, STI Scoreboard, 2001

[xv] ibid, pp 146-147.

[xvi] ibid pp. 495-496.

[xvii] Australian Economic Indicators, August 2002, pp. 3-11.

[xviii] Inventing our future – the link between Australian patenting and basic science F. Narin, M. Albert, P. Kroll and D. Hicks, a report commissioned by the Australian Research Council and CSIRO and published in 2000.

[xix] OECD "Public/Private Partnership for Innovation', June 2002.

[xx] OECD, Main Science and Technology Indicators, 2002-1, Table 46 and ABS, catalogue 8111.0 Research and Experimental Development Higher Education Organisations Australia, 12 April 2002, Table 6.

[xxi] Yenken, John and Gillin, Murray, Australian University Spinoff Companies: Attitudes, Policies and Companies, Australian Graduate School of Entrepreneurship at Swinburne University of Technology Research Paper, Revised March 2002.

[xxii] OECD Indicators, 'Education at a Glance', 2001 Edition, Table C4.4, Chart C4.5.

[xxiii] Internal DEST Statistics.

[xxiv] Bob Birrell, Ian R.Dobson, Virginia Rapson and T. Fred Smith 'Skilled Labour: Gains and Losses' Centre for Population and Urban Research, Monash University, July 2001, pp5-6.

[xxv] Press Release by the Minister for Immigration and Multicultural and Indigenous Affairs dated July 16 2002, 'Minister suspends priority processing for ICT workers'.

[xxvi] Research and Experimental Development Businesses Australian Bureau of Statistics, 1 July 2002.

**APPENDIX 1**

## COOPERATIVE RESEARCH CENTRES (CRCs) – INTERACTION WITH INDUSTRY

A recent study[i] found that over the ten years of the CRC Programme, Centres have carried out nearly 4,300 contracts for industry and other users and have earned over $300 million for these services. The annual value of contracts to the CRCs has typically been of the order of $25-55 million. The Mining and Energy CRCs held the largest dollar share of contracts. CRCs in all industry sectors saw an increase in contract earnings in the second quinquennium of the Programme.

CRCs also reported nearly 150 technology commercialisation agreements in 2000/01 with private sector and other organisations, with a value to the Centres of around $3.8 million. By far the most common agreement was that for the licensing of intellectual property, which accounted for greater than two thirds of the agreements and nearly half the income. Spin-off companies and 'other' agreements were commonly used, with the 20 spin-off companies generating nearly twice as much income as 'other agreements'. Only a single instance of outright sale of technology was reported.

The study data record a wide range of income received[ii]. For example the average value of IP licensing ranged from $5000-$6000 in Agriculture and ICT sectors to around $100,000 in the Environment and Medical S&T fields. The average income from spin-off companies was generally greater, ranging between $140,000 and $200,000, at least in the Medical and IT fields. In terms of total income from technology agreements, by far the largest fields were the CRCs in ICT, receiving $1.6 million in 2000-01, and Medical S&T, with receipts of $1.4 million.

In regard to the CRCs' engagement with Small and Medium Enterprises, the survey found[iii] that in the period 1997-98 to 2000-01, more than 900 companies were involved each year with CRCs in one way or another. The majority of these were large entities: around 600 large companies have been involved annually with CRCs (averaging 62 per cent of companies involved) compared to about 350 SMEs (38 per cent of companies involved).

One of the clear features of the data assembled by the University of Wollongong is that it provides evidence of a strong shift towards 'core participation' by the private sector in CRCs, as opposed to the more distant forms of association. Although the overall number of companies involved with CRCs fell slightly over the period of the study, the number of companies engaged as 'core participants' increased and there was greater participation of SMEs as both core and supporting participants. Over 30 per cent more large firms, for example, were reported as 'core participants' in 2000-01 than in 1997-98. For SMEs the growth in core participants was even more dramatic with the number of companies recruited as core participants almost doubling over the same period. Also there was a 13 per cent increase in SMEs as 'supporting participant' involved in CRCs over the same period[iv].

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[i] Data collected in a Management Data Questionnaire quoted in Sam Garett-Jones and Tim Turpin, April 2002 "Measuring the Outcomes of the CRC Program: A Framework", Final Report, University of Wollongong, p 28.

[ii] Ibid p 89.

[iii] Sam Garret-Jones, Tim Turpin and David Steele "Measuring the Outcomes of the CRC Program: A Framework" University of Wollongong Report, April 2002, p37.

[iv] Sam Garret-Jones and Tim Turpin "Measuring the Outcomes of the CRC Program: a Framework", Final Report, University of Wollongong, April 2002, p99.

## Summary of patenting and related activities by universities and/or related entities (number of universities = 42)

| | | | Universities |
|---|---|---|---|
| Stock of patents held by Australian universities and/or controlled entities at 31 December 2001 | Australian patents | 557 | (n=30) |
| | Overseas patents | 957 | (n=26) |
| | Total patents | 1,514 | (n=30) |
| Of the patents referred to above, patents granted for the first time in 2001 | Australian patents | 90 | (n=19) |
| | Overseas patents | 55 | (n=13) |
| | Total patents | 145 | (n=23) |
| Of the patents granted for the first time in 2001 | Granted to universities directly | 131 | (n=22) |
| | Granted to commercial subsidiaries | 14 | (n= 4) |
| Patents held by institutions or controlled entities sold or transferred in 2001 | | 36 | (n= 8) |
| Licenses issued by institutions or controlled entities in 2001 | | 179 | (n=21) |
| Revenue generated by these 179 licenses referred to above | | $33,875,844 | (n=17) |
| Spin off companies generated by the institution or its controlled entities in 2001 | | 44 | (n=21) |
| Distribution of equity in university spin off companies generated in 2001 | University has 100% equity | 9 | |
| | University has 50% or above equity | 14 | |
| | University has less than 50% equity | 21 | |
| Equity share in the 35 instances where the university did not have 100% equity in these spin off companies | Equity shared between the university and originators | 9 | |
| | Equity shared with originator and third parties | 26 | |

Source: Department of Education, Science and Training (DEST), Research and Research Training Management Reports (RRTMRs) 2002.

**SUBMISSION OF THE DEPARTMENT OF EDUCATION, SCIENCE AND TRAINING**

**TO THE**

**HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON SCIENCE AND INNOVATION**

**INQUIRY INTO BUSINESS COMMITMENT TO R&D IN AUSTRALIA**

## Relevant responsibilities of the Education, Science and Training Portfolio

The Portfolio takes a national leadership role in education, science and training. It works with various stakeholders (including industry groups), State and Territory governments, other Commonwealth agencies and a range of contracted service providers to provide high quality policy advice and services for the benefit of Australia.

As well as the Department, the Portfolio includes the following statutory bodies whose responsibilities relate to research and research training, some of which will be making separate submissions to the Inquiry:

- the Anglo Australian Telescope Board;
- the Australian Institute of Marine Science (AIMS);
- the Australian Nuclear Science and Technology Organisation (ANSTO);
- the Australian Research Council (ARC); and
- the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

The Portfolio has the primary responsibility for funding and policy-making in the higher education sector.

The Government has provided clear guidance on its priorities for science, research and innovation through its Innovation Action Plan - *Backing Australia's Ability* (BAA). The Department has the responsibility of monitoring BAA programs and policy issues on behalf of the Committee of Ministers overseeing implementation of BAA.

The Department supports the science and innovation framework through such bodies as the Prime Minister's Science, Engineering and Innovation Council (PMSEIC), the Chief Scientist, the Coordination Committee for Science and Technology and through targeted funding and international promotion of Australia's scientific and technological capabilities.

As the Department has an overview role with respect to Australia's science and innovation system, the Department's submission is provided from this perspective, but with particular emphasis on the Department's responsibilities in public sector science and higher education.

## Term of reference 1. What would be the economic benefit for Australia from a greater private sector investment in R&D?

As some background on Australia's R&D performance overall, the latest statistics from the Australian Bureau of Statistics (ABS) show that Australia's overall gross expenditure on R&D (GERD) in 2000-01 was at an all-time high of more than $10 billion, more than $1 billion higher than the previous survey (1988-99). All sectors performing research – business, government, universities, and private non-profit – recorded an increase in their investment in R&D.

Commonwealth Government financing of R&D reached an all-time high of $3.9 billion – an increase of 13% over 1998-99. Government financing of R&D in Australia is around 0.70% of GDP – above the OECD average of around 0.65% of GDP, and comparable with the USA (0.74%), Japan (0.58%) and Germany (0.78%).

The effect of *Backing Australia's Ability*, is not included in these figures but will become apparent in the next sequence of ABS data.

Although government funding of R&D, and the level of R&D performed in universities and government research agencies in Australia is higher than the OECD average as a percentage of GDP, Australia has a relatively low level of Business Expenditure on Research and Development (BERD) as a percentage of GDP compared with the majority of OECD countries.[i] (See below).

Firms benefit from investment in R&D by increasing their competitiveness. If Australia's firms become more competitive, Australia as a whole is likely to achieve greater economic growth, with the beneficial flow-ons of higher standard of living, lower unemployment and lower inflation.

What is meant by competitiveness? According to the Industry Commission[ii], a firm is competitive if it can maintain and expand its market share while making at least enough profit to induce it to stay in its existing line of business.

R&D improves competitiveness in two ways. First, it assists the firm to make its products more cheaply and efficiently by supplying the firm with the knowledge to increase its productivity – more goods can be produced for less cost. Second, it improves the goods themselves so that there is a greater demand for them. Or it creates a new good for which there is high demand, thus improving the firm's portfolio of products. The firm can either sell its products at a higher price, or a greater quantity at the same price, or a mixture of both.

The converse, failure to conduct R&D, means that firms are likely to lose market share to new products supplied by firms who can supply goods and services with higher quality and at lower cost. A basic economic benefit for Australia from a greater private sector investment in R&D is increasing the likelihood of Australia avoiding this adverse outcome.[iii]

What is beneficial for individual firms is certainly beneficial for Australia as a whole as the firms' growth adds to economic growth and employment – but that is only part of the story. The benefits of both successful R&D and not-quite-so-successful R&D by individual firms have "spillover" benefits for the Australian economy. "Spillover" effects are defined[iv] as any unpaid benefit or unrecompensed cost that flows to any agent other than the firm undertaking the R&D. Thus, by undertaking R&D, the firm generates "free" benefits for society as a whole. Such benefits include gains in knowledge and know-how of employees which they can take elsewhere, the increased demand for technically-advanced products supplied by other Australian firms, the raising of the general level of technical competence of that particular firm for which it does not necessarily charge full value. There are also a number of synergistic effects if a number of firms simultaneously engage in R&D in related areas, such as for example agriculture and pharmaceuticals.

Can the benefits to individual companies from conducting R&D, and the broader economic benefits, be quantified? The Industry Commission conducted a survey of investigations by economists into this question. While there was a wide divergence on the results, they found that

for investigations conducted in the USA and some other OECD countries in the past 20 years, the mean annual rate of return estimated for individual firms was 33 per cent of the R&D costs, although there was wide variation[v]. The mean estimated rate of return of further national "spillover" (social returns) for Japan and the USA was 85 per cent[vi].

More up-to-date estimates by Steve Dowrick[vii] quoted other studies giving private returns for the US at around 25% and social returns at around 50%.

Estimates for Australia are few, but the Bureau of Industry Economics estimated in 1992 that the mean rate of return to Australian society as a whole of R&D (social return) in the Industrial and Communication Technologies product field was 20 per cent, calculated ex-post, (apart from agriculture and mining related industries), while in 1988 it estimated the mean rate of return for Australian society from R&D in the minerals and process engineering technologies was 27 per cent[viii]. Estimates for social returns for R&D in agriculture in Australia vary between 2 and 138 per cent for various agricultural industries[ix]. So far as we are aware, there are no studies available on the private returns to R&D in Australia.

While returns to business R&D noted in the 1992 BIE research for mining and agricultural related industries were higher, the bulk of R&D for agricultural related industries is conducted by public research agencies, and private R&D in the mining and agricultural sectors combined is only 12 per cent of total business R&D on manufacturing and services.[x]

Thus on the current evidence, Australia as a whole would substantially benefit from *greater* private sector investment in R&D in Australia.

Detailed economic research on returns to R&D at the industry level has not been published in Australia since the publication of the Industry Commission Report No. 44, *Research and Development*, in 1995, which reported published data on social returns to R&D in Australia. There is a major need for more up-to-date research on the returns to R&D in Australia, especially for private returns to R&D in Australia, for which published results from any date are non-existent.

**Terms of Reference 2. What are the impediments to business investment in R&D?**

There are a several <u>potential</u> or <u>possible</u> impediments to business investment in R&D.

Based on the most recent research dating from 1992 previously discussed, the private returns to business R&D in Australia may not be sufficient to justify increased investment. The relatively low social rate of return (which includes the private rate of return – see below) of private industry R&D in Australia noted above (around 20 per cent outside the mining and agricultural industries), is a matter requiring further examination. This 1992 figure suggests that the private returns from a given investment in business R&D in Australia could be lower than those obtained by business R&D in the USA and other OECD countries. A relatively low return could be a major reason why the BERD to GDP ratio in Australia is low, even allowing for the effect of the relatively low proportion of manufacturing industry in Australia's economic activity[xi].

Private returns are defined as those returns appropriated by the firm undertaking the R&D. These include not only the profits resulting from the marketing of any products, but also receipts from selling R&D results (for example, royalties).

Social returns are those benefits which accrue to society as a whole from the conduct of R&D, including all private returns, and all those additional benefits from the conduct of R&D gained by society beyond the sum of these private returns. It is usually measured for a particular set of R&D by the flow of benefits accruing to society expressed a proportion of the cost of that R&D. By definition social returns must exceed private returns, as they include the private return of the R&D generating that social return.

Spillover benefits are the difference between the private and social returns. Spillover refers to any unpaid benefit or unrecompensed cost that flows to any agent other than the institution undertaking R&D.

While the terms spillover and social return are often used synonymously, it must be remembered that social return is a gross measure while spillover is a net measure of the benefits to society.

There is great deal of risk[xii] involved that a particular R&D project will not produce a return which covers its cost, much less generate a profit. The distribution of profitability among individual research areas is not uniform. It is even possible that the number of unprofitable areas outnumber the profitable areas. This distributional effect is masked by the average profitability figure.

Research on the distribution of the gains from R&D consistently indicate very skewed outcomes from R&D, with 80 per cent of returns coming from the success of 10 per cent of the projects[xiii]. The other 90 per cent of R&D projects return low profits or make a net loss.

Therefore the perceptions of risk may have a central role in expectations and decision-making.

As noted above, we are not aware of any studies on the private returns to R&D in Australia, nor of the influence of real or perceived risk of R&D on the level of business R&D conducted.

However, Australia’s relatively low level of BERD could be taken as prima facie evidence that private returns to business R&D and/or the real or perceived risk of R&D are a significant impediment to greater business R&D.

Arguments have been advanced that Australia’s relatively low level of BERD is a result of our industry structure, in particular:

- a relatively large services sector (where the propensity to conduct R&D is relatively low) and a relatively small manufacturing sector (where the propensity to conduct R&D is relatively high); and

- relatively high level of foreign ownership (with foreign-owned companies preferring to conduct their R&D in their base country)

- nearly two thirds of total R&D expenditure in the Australian private sector is conducted by firms of fewer than 1000 employees. (Such firms also employ more than 70% of people employed in private sector R&D.) By contrast, in the US, two thirds of the total R&D expenditure is conducted by firms of more than 5000 employees. If Australian business R&D expenditure is weighted to small firms, one inference is that our businesses may only be able to afford low-risk, low-scale incremental R&D. This would be expected to reduce the returns from R&D[xiv]

- if most of Australia's business R&D is conducted by small firms, it is likely to be self-funded, which may diminish the facility for risk-sharing as afforded by diversified venture capital sources.

The Industry Commission found[xv] that:

- the ranking of R&D to sales ratios by industry is much the same in Australia as in most industrialised countries; but
- almost without exception, industry-level BERD intensities in Australia are below those found internationally.

These findings relate to the early 1990s. We are not aware of any more recent quantitative studies of Australia's industry structure as a possible impediment to increased business investment in R&D.

The Industry Commission also found no conclusive evidence that the level of foreign ownership is an influence on BERD[xvi]. More recently the Australian Bureau of Statistics has published a review of the Foreign Ownership Characteristics of Businesses Undertaking Research and Experimental Development Activity in Australia[xvii]. The review finds that foreign-owned businesses are responsible for 42% of business R&D expenditure in Australia, but gives no information on the relative R&D propensities of foreign-owned and Australian-owned companies.

In summary, based on the latest research conducted in 1992, it seems that the most likely explanation for Australia's relatively low rate of BERD is that private returns to business R&D in Australia may not have been sufficient to justify increased investment. The factors which give rise to this situation are not well understood. As discussed under Term of Reference 3 below, the Government has in place a number of policies to foster greater business investment in R&D.

Another possible impediment to a greater business commitment to R&D is that private industry may not have sufficiently well developed linkages to gain from publicly-funded research. For example, studies[xviii] on citations of published research in US patents are regarded as evidence that publicly-sponsored basic research plays a role in the development of leading-edge technologies such as pharmaceuticals, chemicals, advanced electronics and, especially, biotechnology.

The forms of interaction between businesses and the publicly-funded research base, which includes both universities and other public research agencies, include:

- Licences, royalties or options on intellectual property: when a research organisation licences some item of intellectual property, it enters a contract with a commercial firm to allow it to use its discovery, usually in a patented form, in return for royalties;

- Outright sale of technology: there are occasions that the research organisation sells the technology outright and does not receive any further royalties;

- Spin off or start up companies to develop and sell the technology: sometimes the research organisation itself, or in partnership with other companies, sets up companies to exploit the new technology. This involves a varying amount of investment in the company for development, production and marketing, but provides the possibility that if the commercialisation is successful, the equity retained by the research organisation could appreciate significantly in value;

- Partnerships to conduct R&D between public research organisations and private firms: a recent study of the interaction between public R&D and private organisations by the OECD[xix] found that there was an increasing trend for private firms to enter into formal relationships with public organisations to conduct R&D in a specified area. There are varying degrees of involvement and co-investment in these so-called "Public/Private Partnerships", but their rapid growth reflects the success of this model;

- In the United States, the University of California and the Massachusetts Institute of Technology have found the total economic returns from companies founded by alumni far outweigh the returns from private sector activity carried out through other kinds of linkages with other of these institutions.

According to the most recently available data[xx], Australian universities sourced about 4.9% of their funds from the business sector in 2000. This suggests a somewhat lower level of university/industry collaboration than occurs in other major OECD countries: the USA (6.4%), the UK (7.1%), Japan (2.5%), Germany (11.3%) and Canada (8.9%).

A March 2002 study by the Australian Graduate School of Entrepreneurship at Swinburne University[xxi] found that North American data showed research expenditure nationally in the range A$130 to 177 million per spin-off company generated. For selected universities with a strong emphasis on spin-off company generation, this rate fell to one spin-off per A$40 million of research expenditure. The data suggested a target for Australia of one spin-off company per A$150 million of research expenditure or 25 to 30 new spin-offs per annum.

The rate of spin-off establishment in Australia was found to have increased in recent years with 86 Direct Research Spin-offs established by universities and public sector research agencies in period between and including the financial years 1997-1998 to 1999-2000. This suggested an annual rate of 29 new ventures - within the target range.

In view of these data on linkages and spin-offs, and the mechanisms in place to encourage linkages between Australian businesses and the publicly-funded research base and greater commercialisation of publicly-funded R&D (discussed further under Term of Reference 3 below), DEST does not consider that sub-optimal relationships with publicly-funded research organisations are a major impediment to business investment in R&D. This is not to say, however, that relationships have no room for improvement.

Lastly, a potential impediment to business investment in R&D is a lack of supply of trained and experienced researchers and technical staff. The education requirements of potential R&D researchers require large government investments in high quality tertiary education facilities and staff.

The issues in this area include the quantity and quality of graduate scientists, engineers and technologists, the quantity and quality of people with postgraduate research training, skilled immigration levels and arrangements, vocational training for specific support skills and the availability of vocational training for life long learning, and mechanisms for the interchange of personnel between the private sector and universities and government research agencies, important for countries such as Australia with a relatively large publicly-funded research base, and small business R&D base.

Australia is at the upper end of the proportion of science graduates in the labour force aged between 25 to 34 for OECD countries, and the figure of around 1300 science graduates per 100,000 in this 'youth labour force' is about the same as for France, New Zealand, Finland, United Kingdom, and Ireland, and is 25% more than for Japan and 50% more than for the United States and Germany[xxii]. The recent experience of the two small open economies on this list, Ireland and Finland, has been that the high proportion of science graduates in its youth labour force has been seen as a major positive influence in their path of more advanced industrialisation and their move into high technology industries. In 2001 there were 1595 Science and Engineering PhD graduates in Australia, 43% of the total PhD graduates in that year. Of these 26% were in the Physical sciences, 27% were in engineering, and 29% were in Life Sciences.[xxiii]

The issue of the so-called 'brain drain' has been a concern for policy-makers for a number of years. A recent study[xxiv] has found that over the three years of the study, Australia has registered a 'brain gain'. While there was a net loss of skilled residents, this was more than offset for almost every occupation by gains from settler movement and a net inflow of long term temporary residents. Overall, analysis over the period 1997-98 to 1999-2000 showed that overall there was a modest gain in skilled workers. There was little net resident loss for occupations even where international demand was strong, the highest losses being for a 2.1 per cent in the stock of workers for computer professionals, 2.9 per cent for accountants and 1.4 per cent for nurses. The predominance of the United Kingdom as a destination, the relatively high return rate and the youthful age of Australian residents departing for the United Kingdom, suggest that much of this movement is akin to the traditional 'boomerang' trip overseas. That is, the study found that most Australian residents return home after a period overseas.

Notwithstanding the above evidence that overall, Australia has a net 'brain gain' in almost all occupations, including those seen as important to facilitate business and R&D, it is possible that Australia may still be losing key personnel. The Federation Fellowships were introduced as a *Backing Australia's Ability* initiative to address this issue. A study into the more qualitative aspects of skilled migration is currently being conducted by Professor Graeme Hugo of Adelaide University. This study will shed further light on this issue.

To enhance Australia's innovation skills base, *Backing Australia's Ability* introduced measures under Australia's Migration Program, to encourage immigration of ICT professionals. One of these measures gave immediate processing priority to sponsorship, nomination and visa applications relating to the entry of an ICT professional. However, on 16 July 2002, the Minister for Immigration announced that this program had been suspended temporarily due to recent the downturn in demand for ICT professionals[xxv].

In view of these data, and the mechanisms in place to encourage the supply of skilled people for business R&D (discussed further under Term of Reference 3 below), DEST feels that supply of skills seems not to represent a major impediment to business investment in R&D. This is not to

say that an increased supply of qualified people would not help to stimulate greater investment in R&D. There is very likely to be a positive feedback between the quantity of investment in R&D in Australia and an increased supply of suitably qualified persons.

**Term of Reference 3. What steps need to be taken to better demonstrate to business the benefits of higher private sector investment in R & D?**

The Government has in place a number of policies and programs to encourage businesses to invest more in R&D, and therefore to demonstrate the benefits of higher investment in R&D.

Support through grants and other incentives

Relevant initiatives of *Backing Australia's Ability* (and administering agencies) are:

- $35 million for a National Innovation Awareness Program to raise understanding of the importance and commercial potential of science and technology ((Department of Industry Tourism and Resources (DITR), and DEST).
- $227 million in additional funding for the Cooperative Research Centres program (DEST) over three years from 2003/04 to 2005/06.
- 175% Tax Concession Premium for additional R&D, and R&D Tax Rebate for small companies. These supplement the ongoing 125% R&D Tax Concession (DITR).
- $535 million additional funding for the R&D Start program (DITR).
- More than doubling the funding for the Commercialising Emerging Technologies (COMET) Program, to help firms get their products to the market place (DITR).
- A PreSeed Fund for commercialising research from universities and public sector research agencies (DITR).
- Doubling the Biotechnology Innovation Fund (DITR).
- Additional funding for the New Industries Development Program for agribusiness (Department of Agriculture, Fisheries and Forestry).
- Through *Backing Australia's Ability* the Government is also providing $176 million to establish World Class Centres of Excellence in Biotechnology (DITR and the ARC) and Information and Communications Technology (Department of Communications, Information Technology and the Arts (DCITA) and the ARC), with strong industry participation.
- In addition the Government is providing support for venture capital through the Pooled Development Funds and Innovation Investment Funds.

Invest Australia (within the Industry, Tourism and Resources portfolio) encourages overseas companies to base R&D activities in Australia.

The $158 million BITS program (DCITA) is providing support to ICT start-up companies including through business incubation centres.

Some forms of R&D can only be conducted using large facilities and in some cases government-sponsored arrangements are required to provide infrastructure that can be shared between firms, and between basic research and commercial uses. The Major National Research Facilities program is an example of a mechanism to address this type of impediment. The MNRF program is funded through *Backing Australia's Ability* and is providing $155 million to support 15 leading-edge facilities. Other major facilities are supported through the CSIRO and the Australian Nuclear Science and Technology Organisation.

Links between private industry and publicly-funded research organisations

The Cooperative Research Centres (CRC) program is an example of a major public/private partnerships program of the type described under term of reference 1. Appendix 1 provides more information on the CRCs' interaction with industry.

The ARC Linkage program also encourages and develops long-term strategic research alliances between higher education institutions and industry, and fosters opportunities for postdoctoral researchers to pursue internationally competitive research in collaboration with industry. Major publicly-funded research organisations such as CSIRO, are also being further encouraged to engage and expand links with industry.

Further initiatives include a planned Commercialisation Forum and Trade Fair of Ideas sponsored by DEST, which will be held over three days in the first half of 2003. The Fair will provide an opportunity for researchers from universities, medical research institutes, Centres of Excellence, Co-operative Research Centres and other major research facilities to showcase their ideas to potential investors.

Appendix 2 summarises recent information on research commercialisation by Universities.

Programs and policies to ensure the supply of skilled R&D personnel

The Government is instituting major programs to improve the quantity and quality of graduate scientists. To address likely skill requirements in key innovation areas, *Backing Australia's Ability* provided $151 million to create an additional 2000 university places each year – with priority given to ICT, mathematics and science. This will rise to 5470 places by 2005. This initiative strengthens our national skills base while meeting employers' needs for high calibre graduates in these fields.

The government is also providing universities $25 million over three years from 2000-01 for the Science Lectureship initiative, a competitive grants scheme to assist universities or consortia of institutions, in partnership with industry to develop innovative approaches to science-related education, including the establishment of university lectureships and innovative course development.

The ARC Linkage program provides industry-oriented research training to prepare high-calibre postgraduate research students for work in industry and produces a national pool of world-class researchers to meet the needs of Australian industry.

Policies have been initiated aimed at improving life long learning at Postgraduate level. Over the five years to 2005-06 the government will lend an estimated $995 million to postgraduate students through the Postgraduate Education Loans scheme (PELS). PELS operates in a similar way to the existing Higher Education Contribution Scheme for undergraduate students.

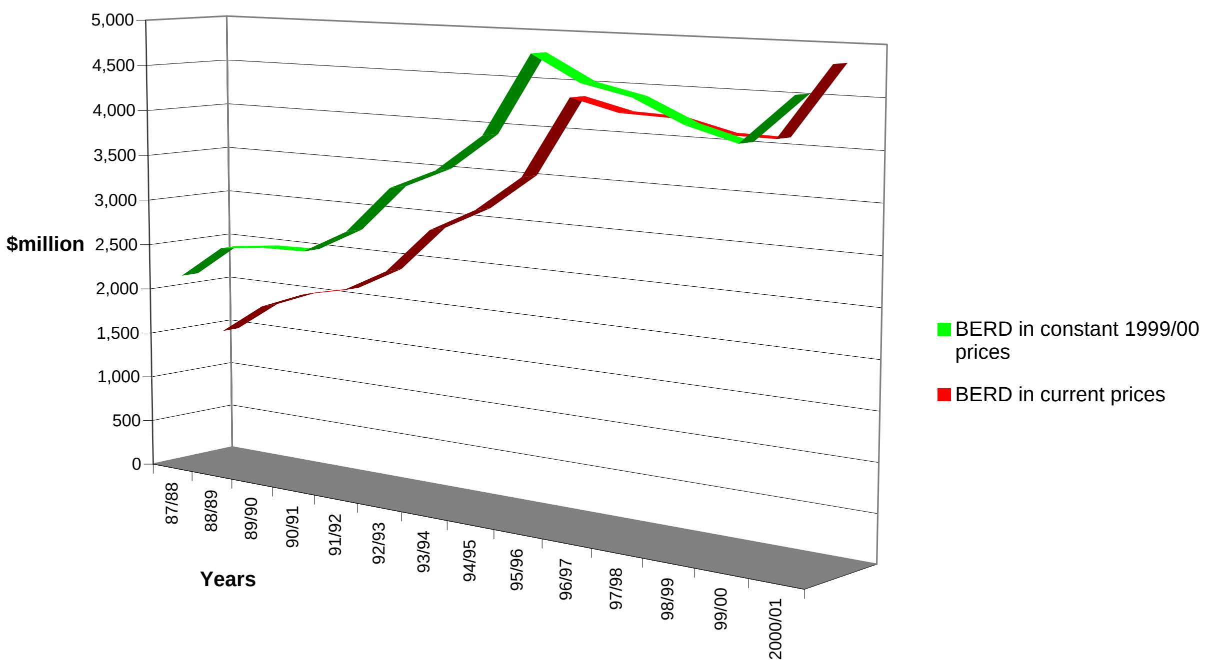
What more should be done?

Australia's BERD as a percentage of GDP was 0.72% in 2000-01 according to the most recently available figures[xxvi]. The United States, the UK, Finland, Sweden and Japan, have ratios exceeding 2%. Germany, France, Canada, Korea, Denmark and the Netherlands lie in the range

of 1% to 2%. Australia lies with a small group of OECD countries including the Czech Republic, Norway and Italy having ratios between 0.5% and 1.0% - in the lower end of the OECD range, but above the less industrialised European countries. The OECD average is around 1.5% and the European Union average around 1.2%.

BERD in 2000-01 was estimated to be $4.825 billion at current prices, an increase of 18% over 1999-2000. In volume terms, with the effect of changes in prices and wages and salaries removed, BERD increased by 12% over 1999-2000. This is 5% below the peak level recorded in 1995-96. Figure 1 shows trends in BERD over the last decade.

**Figure 1: Australian Business Expenditure on R&D (BERD) (1988 to 2001)**

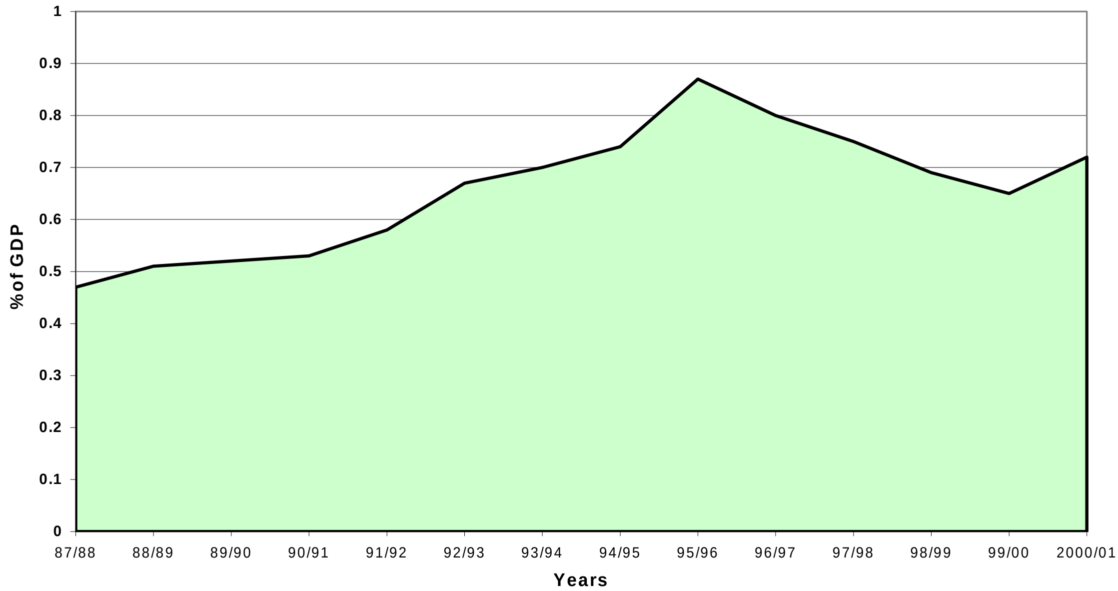



**Source**: *Research and Experimental Development - Business Australia* (ABS Cat. No. 8104.0). Note that BERD in constant prices was calculated on the basis of annual business enterprises deflators provided by the ABS in August 2002.

The same survey asked businesses to report what they expected their expenditure on R&D to be in 2001-02. Total BERD was expected to be about 1% higher in 2001-02 than in 2000-01. Experience from past surveys is that actual expenditure has exceeded projected expenditure by about 10%.

Australia's BERD as a percentage of GDP remains below the high of 0.87% in 1995-96. Figure 2 shows trends in the BERD to GDP ratio over the last decade.

**Figure 2: Australian Business Expenditure on R&D (BERD) as a % of GDP**




**Source**: *National Income, Expenditure and Product - Australian National Accounts* (ABS Cat. No. 5206.0).

The 2000-01 ABS data precedes the commencement of *Backing Australia's Ability* which includes a number of initiatives aimed at increasing BERD (as noted above). In view of this, the recent upturn, and the generally increasing trend over the last decade, DEST's view is that further initiatives to foster business investment in R&D should ideally await the evaluation of the impact and effectiveness of current initiatives, further studies to clarify the returns and risks associated with business R&D in Australia, and further studies on the possible structural factors underlying the relatively low level of BERD.

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[i] OECD, Main Science and Technology Indicators, 2001-2, Tables 46 and 51.

[i] Industry Commission, Report Number 44, "Research and Development", 15 May 1995, pp 128-130. This section summarises the economic theory on the relationship between R&D and competitiveness, and relates conventional theory which incorporates technological advance as cost-free productivity- or product-improving change to the theories in the tradition of Schumpeter with the emphasis of product and process innovations as investment activities.

[iii] Ibid pp155-159. While the statement that that there is a key link between R&D and productivity, and through to growth, is not disputed by any responsible commentator, there are inherent difficulties in providing empirical evidence of this link for a small country such as Australia because of spillover effects from abroad. However recent work quoted by Dowrick "Investing in the Knowledge Economy" ANU Working Paper, April 2002, indicates that if Australia's total (public and private) R&D expenditure is increased by 10 per cent or $1 billion (0.15 per cent of GDP), the annual growth rate is increased by 0.1 per cent. Domestic R&D and spillovers from foreign R&D are of roughly equal importance for productivity growth, and social returns from R&D range from around 50 per cent. He goes on to say that given these returns, Australia and other OECD countries are suffering from gross under-investment in R&D.

[iv] Ibid p163. This is the same concept as the economic term "externality" specifically relating to the effects of R&D on the economy as a whole. "Spillover" is probably a more meaningful term, denoting any original, valuable knowledge generated in the research process which becomes publicly accessible. The distinction with an externality

is that a spillover need not necessarily be totally free, but the gain could be for instance be embodied into new equipment which is paid for.

[v] Industry Commission, Research and Development, Report No 44,15 May 1995, Table QA10

[vi] Ibid, Table QA3.

[vii] Dowrick, Steve "The contribution of Innovation and education to Economic Growth' Melbourne Institute Economic and Social Outlook conference, April 4-5, 2002.

[viii] Industry Commission, Research and Development, Report No 44,15 May 1995, Table QA15

[ix] Ibid, Table QA14

[x] ABS, Cat. No. 8112, "Research and Experimental Development", 2000-01, Table 5.
[xi] Steve Dowrick "the Contribution of Innovation and Education to Growth", Melbourne Institute Economic and Social Outlook Conference, April 4-5, 2002.

[xii] Ibid pp 169-172. The policy relevance of risk derives from the potential for underinvestment if individuals or firms are too risk adverse (a cultural problem), or lack the capacity to spread risk (a size or economic infrastructure problem). In these cases there is a theoretical argument, going back to Arrow's seminal work on the case of government intervention in R&D, for governments to intervene to pool or spread risk. It should be emphasised that this mechanism need not necessarily be in the nature of a direct subsidy. Subsidies as R&D incentives are a separate matter.

[xiii] Branscomb, Lewis M. "Understanding Private sector decision making on Early-stage, High-risk, Technology Based Projects', Report, Kennedy School of Government, Harvard University.

[xiv] OECD, STI Scoreboard, 2001

[xv] ibid, pp 146-147.

[xvi] ibid pp. 495-496.

[xvii] Australian Economic Indicators, August 2002, pp. 3-11.

[xviii] Inventing our future – the link between Australian patenting and basic science F. Narin, M. Albert, P. Kroll and D. Hicks, a report commissioned by the Australian Research Council and CSIRO and published in 2000.

[xix] OECD "Public/Private Partnership for Innovation', June 2002.

[xx] OECD, Main Science and Technology Indicators, 2002-1, Table 46 and ABS, catalogue 8111.0 Research and Experimental Development Higher Education Organisations Australia, 12 April 2002, Table 6.

[xxi] Yenken, John and Gillin, Murray, Australian University Spinoff Companies: Attitudes, Policies and Companies, Australian Graduate School of Entrepreneurship at Swinburne University of Technology Research Paper, Revised March 2002.

[xxii] OECD Indicators, 'Education at a Glance', 2001 Edition, Table C4.4, Chart C4.5.

[xxiii] Internal DEST Statistics.

[xxiv] Bob Birrell, Ian R.Dobson, Virginia Rapson and T. Fred Smith 'Skilled Labour: Gains and Losses' Centre for Population and Urban Research, Monash University, July 2001, pp5-6.

[xxv] Press Release by the Minister for Immigration and Multicultural and Indigenous Affairs dated July 16 2002, 'Minister suspends priority processing for ICT workers'.

[xxvi] Research and Experimental Development Businesses Australian Bureau of Statistics, 1 July 2002.

**APPENDIX 1**

## COOPERATIVE RESEARCH CENTRES (CRCs) – INTERACTION WITH INDUSTRY

A recent study[i] found that over the ten years of the CRC Programme, Centres have carried out nearly 4,300 contracts for industry and other users and have earned over $300 million for these services. The annual value of contracts to the CRCs has typically been of the order of $25-55 million. The Mining and Energy CRCs held the largest dollar share of contracts. CRCs in all industry sectors saw an increase in contract earnings in the second quinquennium of the Programme.

CRCs also reported nearly 150 technology commercialisation agreements in 2000/01 with private sector and other organisations, with a value to the Centres of around $3.8 million. By far the most common agreement was that for the licensing of intellectual property, which accounted for greater than two thirds of the agreements and nearly half the income. Spin-off companies and ‘other’ agreements were commonly used, with the 20 spin-off companies generating nearly twice as much income as ‘other agreements’. Only a single instance of outright sale of technology was reported.

The study data record a wide range of income received[ii]. For example the average value of IP licensing ranged from $5000-$6000 in Agriculture and ICT sectors to around $100,000 in the Environment and Medical S&T fields. The average income from spin-off companies was generally greater, ranging between $140,000 and $200,000, at least in the Medical and IT fields. In terms of total income from technology agreements, by far the largest fields were the CRCs in ICT, receiving $1.6 million in 2000-01, and Medical S&T, with receipts of $1.4 million.

In regard to the CRCs’ engagement with Small and Medium Enterprises, the survey found[iii] that in the period 1997-98 to 2000-01, more than 900 companies were involved each year with CRCs in one way or another. The majority of these were large entities: around 600 large companies have been involved annually with CRCs (averaging 62 per cent of companies involved) compared to about 350 SMEs (38 per cent of companies involved).

One of the clear features of the data assembled by the University of Wollongong is that it provides evidence of a strong shift towards ‘core participation’ by the private sector in CRCs, as opposed to the more distant forms of association. Although the overall number of companies involved with CRCs fell slightly over the period of the study, the number of companies engaged as ‘core participants’ increased and there was greater participation of SMEs as both core and supporting participants. Over 30 per cent more large firms, for example, were reported as ‘core participants’ in 2000-01 than in 1997-98. For SMEs the growth in core participants was even more dramatic with the number of companies recruited as core participants almost doubling over the same period. Also there was a 13 per cent increase in SMEs as ‘supporting participant’ involved in CRCs over the same period[iv].

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[i] Data collected in a Management Data Questionnaire quoted in Sam Garett-Jones and Tim Turpin, April 2002 “Measuring the Outcomes of the CRC Program: A Framework”, Final Report, University of Wollongong, p 28.

[ii] Ibid p 89.

[iii] Sam Garret-Jones, Tim Turpin and David Steele “Measuring the Outcomes of the CRC Program: A Framework” University of Wollongong Report, April 2002, p37.

[iv] Sam Garret-Jones and Tim Turpin “Measuring the Outcomes of the CRC Program: a Framework”, Final Report, University of Wollongong, April 2002, p99.

**Summary of patenting and related activities by universities and/or related entities (number of universities = 42)**

| | | | Universities |
|---|---|---|---|
| Stock of patents held by Australian universities and/or controlled entities at 31 December 2001 | Australian patents<br>Overseas patents<br>Total patents | 557<br>957<br>1,514 | (n=30)<br>(n=26)<br>(n=30) |
| Of the patents referred to above, patents granted for the first time in 2001 | Australian patents<br>Overseas patents<br>Total patents | 90<br>55<br>145 | (n=19)<br>(n=13)<br>(n=23) |
| Of the patents granted for the first time in 2001 | Granted to universities directly<br>Granted to commercial subsidiaries | 131<br>14 | (n=22)<br>(n= 4) |
| Patents held by institutions or controlled entities sold or transferred in 2001 | | 36 | (n= 8) |
| Licenses issued by institutions or controlled entities in 2001 | | 179 | (n=21) |
| Revenue generated by these 179 licenses referred to above | | $33,875,844 | (n=17) |
| Spin off companies generated by the institution or its controlled entities in 2001 | | 44 | (n=21) |
| Distribution of equity in university spin off companies generated in 2001 | University has 100% equity<br>University has 50% or above equity<br>University has less than 50% equity | 9<br>14<br>21 | |
| Equity share in the 35 instances where the university did not have 100% equity in these spin off companies | Equity shared between the university and originators<br>Equity shared with originator and third parties | 9<br>26 | |

Source: Department of Education, Science and Training (DEST), Research and Research Training Management Reports (RRTMRs) 2002.