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'Marking time?' – The evolution of the Australian national innovation system, 1996-2005

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Abstract
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2. 'Marking time?' – The evolution of the Australian national innovation system, 1996-2005

Sam Garrett-Jones

INTRODUCTION

This chapter reviews developments in Australia's national system of innovation over about the last decade. It focuses in particular on the objectives and effectiveness of the policies adopted by the current federal government since its election in 1996, and the prospects and challenges that Australia now faces in science and innovation.

Australia *is* different – in its economy, society and needs for technology – and yet its innovation policy apes the strongly market driven rhetoric of the large G8 economies. I argue that after 20 years of neo-liberal policies under successive labour and conservative governments the innovation system in Australia is at a crossroads. While market driven neo-liberal policies have improved the level of industrial innovation (though not without large government subsidies and with mixed success in the case of smaller firms) business investment in R&D and innovation is still low by OECD standards and, in contrast to many other countries, has barely grown in the last 10 years. Perhaps contentiously, I further argue that the critical weakness in Australia's innovation system is now the erosion of investment in public sector research. This is placing huge pressure on the universities, which are being required to take on the tasks of collaborating more closely with business and carrying out the industrially oriented, regionally important and public good strategic research. These demands may prove impossible to achieve at current levels of public funding to higher education and the government research organisations.

The socioeconomic landscape

Australia is a rich, medium sized 'industrialised' nation, but one that sits apart from the larger 'G8' countries in geography, historical development, economy and technology. Its population and economic activities are dispersed across the continent, presenting regional diversity and barriers to interaction. Australia's population of over 20 million is growing by 1.2 per cent annually, of which over half of the growth is accounted for by net immigration from overseas (Trewin, 2005). It enjoys a federal system of government with responsibilities shared by the Australian (or Commonwealth) government and eight State and Territory administrations. Its businesses are distant from the major markets of Europe and North America but close to rapidly expanding Asian markets. While the 'tyranny of distance' (Blainey, 1966) was largely overcome in the 20th century by telecommunications, mass air transport and, lately, by the advent of global electronic networks, Australia's society, economy and innovation system still carry its legacy.

The last decade has seen strong economic growth. Australia's GDP per capita stood at about US$29,000 in 2003 (at 2000 prices, PPP adjusted) (World Bank, 2005). GDP growth is around 3% (2.8% in 2002-03) and over the period 1994–2003 averaged 3.8% annually. This economic performance places Australia in the top half of the rank of OECD-member countries. However, as Table 1 shows, Australia's industry structure has changed little since 1996. The major structural changes in the economy occurred between 1985 and 1996 with a strong decline in agriculture and growth in manufacturing and services. The services sector remained the largest contributor to the economy in 2002 – at over 70% of GDP – substantially unchanged since 1996. However, the economic contribution of agriculture continued to decline to less than 3% of GDP in 2002 (Table 1). Manufacturing remained relatively stable at 12 – 13% of GDP.

Compared to other small-medium OECD economies, Australia has a relatively low trade intensity (Scott-Kemmis, 2004b). The indicators of trade and globalisation of Australian industry since 1996 (Table 1) show mixed outcomes. Foreign direct investment (FDI) (both net inflows and total) increased substantially. Overall, trade has become more important, but no growth is seen in exports of goods and services (as a proportion of GDP) between 1996 and 2002. This stands in contrast to the marked expansion of manufactures exports in the previous decade.

Table 1. Australia: Selected economic indicators, 1985 to 2002

	1985	*1996*	*2002*	*Change 1985-96*	*Change 1996-2002*
Agriculture, value added (% of GDP)	5.2	3.6	2.9	-30.9%	-18.4%
Industry, value added (% of GDP)	35.1	27.1	25.9	-22.7%	-4.3%
Manufacturing, value added (% of GDP)	..	13.5	11.8	..	-12.6%
Services, etc., value added (% of GDP)	59.7	69.3	71.1	16.0%	2.6%
Foreign direct investment, net inflows (% of GDP)	1.2	1.5	3.8	25.5%	155.2%
Gross foreign direct investment (% of GDP)	2.3	3.8	6.3	65.2%	68.3%
Trade (% of GDP)	34.7	39.4	41.9	13.7%	6.3%
Exports of goods and services (% of GDP)	15.7	19.8	19.7	26.7%	-0.7%
Food exports (% of merchandise exports)	24.8	24.8	21.8	0.0%	-12.4%
Manufactures exports (% of merchandise exports)	16.1	29.8	28.8	85.9%	-3.4%
Ores and metals exports (% of merchandise exports)	18.1	15.7	15.9	-13.4%	1.5%

Source: World Bank 2005.

OVERVIEW OF THE NATIONAL INNOVATION SYSTEM

The special socioeconomic character of Australia is mirrored in its innovation system. Bob Gregory, writing in Richard Nelson's seminal comparative book on national innovation systems, reviewed Australia's situation in the 1980s (Gregory, 1993). He identified several unique features of the system: (i) a low level of science and technology (S&T) expenditure; (ii) a high level of government involvement in both funding and undertaking research and of funding the universities; (iii) a low level of business R&D; and (iv) an exceptionally high dependence on foreign technology.

The low S&T expenditure is the product of limited business investment in innovation and research and development (R&D). By contrast, Australia's public sector R&D expenditure is on a par or higher than leading countries.

Australia's relatively high level of government-performed R&D (GOVERD) has been justified officially as reflecting 'factors like our industrial structure, biodiversity and the importance of the agricultural sector' (Australian Government, 2003),p 10). The Australian government takes the major role in supporting science and innovation. It is responsible for the largest public research agencies, for funding the greater share of research and teaching within Australia's 40 or so universities and for national promotion of industrial R&D and technological innovation. The State and Territory governments are active in traditional areas such as agricultural research and extension and in promoting regional industrial development. Their innovation and technology programs increasingly complement or leverage federal government initiatives and support research infrastructure such as the Australian Synchrotron.

When measured using a composite index of innovative capacity[1] (Porter and Stern, 2001) Australia has been described as 'a low second tier innovation economy' making a solid contribution to international knowledge but performing below others in the OECD middle ranking group such as Finland, Denmark, Norway, and Germany (Stern and Gans, 2003). In terms of national investments in R&D and innovation, patenting in the US, and export of 'high technology' goods Australia ranks in the lower half of the OECD countries (Dept. of Industry Tourism and Resources, n.d.). Australia's 'science base'[2] is generally perceived as stronger than its technology: it performs well against other OECD countries (corrected for population size) on outputs of scientific papers, but poorly on US utility patents for example (Dept. of Industry Tourism and Resources, n.d.);(Australian Government, 2003). Australia's world class science was again recognised in 2005 with the award of the Nobel Prize for physiology or medicine to Barry Marshall and Robin Warren for discovering the cause of gastritis and peptic ulcer disease. Marshall and Warren join nine other Australian Nobel laureates, six of whom are also in physiology or medicine.

Through the late 1980s and early 1990s the pattern of R&D investment changed considerably (Garrett-Jones, 2004). Business expenditure on R&D (BERD) grew markedly to peak at 0.86 per cent of GDP in 1995-96; business funding of R&D in the higher education and government sectors also increased substantially; and, in the public sector, expenditure by the government in its own research institutes declined and the universities eclipsed the government laboratories in their R&D effort. In this regard, Australia has become more like the leading OECD countries, where business innovation drives the national innovation system.

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[1] A high proportion of public expenditure on R&D counts as a negative factor in the index.

[2] I use this UK term in the Australian context to cover research and research training in higher education, publicly performed research, and publicly sponsored research in non-commercial organisations.

While business R&D expenditure in services (as a proportion of value added) is close to the OECD average, R&D expenditure in manufacturing by comparison is substantially lower than the average for the OECD countries. Around 40 per cent of Australia's businesses carried out some form of innovation in the three years to 2003, although more than 60 per cent of the larger firms (100+ employees) were innovators (Australian Bureau of Statistics, 2005). However, the 2003 innovation survey data show a sustained decline in the proportion of manufacturing firms undertaking product innovation by comparison with survey data from 1994 and 1997 (Australian Bureau of Statistics, 2005).

Recent analyses (Marceau and Manley, 2001) and (Scott-Kemmis, 2004b) explain how Australian business innovation *differs* from the small-medium OECD innovation systems like Finland, Ireland and Canada. There are few Australian based multinational companies and many of the large companies operating in Australia are headquartered overseas, leading to what has been called a 'branch office economy' (Garnaut, 2002). Like several of the case studies in this book, there is a high level of foreign ownership and investment, particularly in the R&D intensive industry sectors (Scott-Kemmis, 2004b). Australia's largest R&D performing firms include GM Holden, Ford and Bosch. Further, there are many small local firms, which make a proportionally larger contribution to business R&D (Scott-Kemmis, 2004b). Australia's manufacturing sector and especially 'high tech' manufacturing industry are relatively small. These sectors are strong R&D performers in other industrialised countries (Scott-Kemmis, 2004b). Lastly, many businesses remain directly or indirectly reliant on Australia's historical economic 'trump cards' of agriculture and natural resources production and processing. As a consequence of the country's relative specialisation in natural resource based commodities, Scott-Kemmis (2004b) stresses the importance of firms he characterises as 'resource-enabled but knowledge-based'. An example is Australia's well-known and successful wine industry. As Marceau and Manley point out, it is especially the case in Australia that innovation in the services industry has been closely connected with (and dependent upon) growth and innovation in the manufacturing, mining and resources industries, (Marceau and Manley, 2001). So, for example, the growth of software services for mining depends on a thriving mining industry. While Scott-Kemmis (Scott-Kemmis, 2004a; 2004b) observes that Australian firms are effective 'system integrators' in their use and adaptation of technology, he also concludes that firms and industries are strongly 'path dependent' and slow to evolve in terms of their technological specialisation. The innovation system as whole is therefore conservative and slow to capitalise on emerging areas.

Australia's innovative companies are typically exporters in the agricultural and minerals related sectors, or in niche markets often derived from public

sector research strengths. Successful firms include Cochlear and ResMed (medical devices), Aristocrat Leisure (gaming machines), CSL (biopharmaceuticals) and Metabolic Pharmaceuticals.

Challenges to the Australian innovation system

Australia's strong economic growth through the past decade does not appear to have been matched by the performance of the innovation system. Scott Kemmis (2004b) concludes that while Australia has experienced strong economic growth for a decade or more progress according to many standard innovation indicators falling. Similarly, Marceau and Manley (2001) conclude that Australia's innovation performance has been relatively poor over the past few years.

Scott-Kemmis views trends in Australia's innovation system in terms of two 'contrasting perspectives'. The first which is positive, reflects the dynamic growth of the system. It emphasises factors such as the strong public investment in R&D, strong performance in international science, high education levels in the labour force, the growth of manufacturing specialisation (wine, automotive components etc) and technological specialisation (biotechnology, pharmaceuticals, medical instruments); the strong diffusion and effective use of information and communications technologies (ICT), and the growth of knowledge-based services. Marceau and Manley (2001) also identify the growth in knowledge-based service industries, a strong increase in investment in machinery and equipment, and expansion (from a low base) of venture capital.

A second, less rosy, 'laggard' perspective focuses on Australia's low ranking within the OECD in indicators like level of GERD and BERD, poor export performance in medium and high tech manufacturing, limited availability of venture capital, international patenting (both in quantity and degree of specialisation), reliance on resource-based commodity exports and technology trade deficit (Scott-Kemmis, 2004b). Marceau and Manley (2001) identify further constraints in a declining proportion of firms claiming to undertake either product or process innovation; a fall in business R&D; poor management skills; the small contribution of the manufacturing sector to GDP; and a low and declining investment in staff training .

I draw two main conclusions from these analysts' important work. The first is that the Australia's innovation system *is* unique and does not neatly fit the pattern of, say, the middle ranking OECD countries. This distinctiveness of Australia's economy and its influence on patterns of innovation is widely acknowledge. The second conclusion, which is less generally accepted, is that policy prescriptions for science and innovation in Australia need to be tailored to local conditions and may differ markedly from the policies applied in other OECD countries. Gregory, for example, while comparing Australia with other OECD countries, saw it as 'strange' that the emphasis of

governments in the 1980s was on 'R&D expenditure to stimulate high-technology manufacturing' when, as he observed, 'most export growth still appears to be occurring around traditional export and new industries of tourism and services exports rather than high-technology manufactures' (Gregory, 1993: 348).

Australia's innovation policies are bound to consider the following aspects of the innovation system.

- The importance of innovation capabilities in small firms; the lack of support from local large innovative companies; and the technological and economic dominance of TNCs.
- The importance of the publicly funded 'science base' which has supported the agriculture and natural resource sectors and has underpinned successful commercialisation in e.g. biomedical enterprises.
- The inter-relatedness of the different industry sectors and the crucial importance for Australia of the diffusion of value-adding through innovation and learning to all sectors of the economy (see (Lundvall, 1992). An example is the importance to a growing knowledge-based services sector of an innovative and export oriented primary industries and manufacturing;
- Given the strength of the science base and the potential for linkage between industry sectors, the need for collaboration in research, innovation and commercialisation. Increasingly innovation must be seen as 'a process of interaction between a range of players' through 'networks, clusters and "complexes" of activity' (Marceau and Manley, 2001).
- Particular structural weakness in Australia's innovation system, such as entrepreneurial capability in business and paucity of venture capital.
- The federal dimension, i.e. the appropriate roles of national and local institutions, including governments, but also including national research councils and local universities and research institutes.

In my view, this implies that our support of the 'science base' while it must recognise the 'social shaping' effect of local industries (Pavitt, 1998) is likely to follow the model of the medium OECD countries. Policies aimed at nurturing of business innovation on the other hand need to be more creatively constructive, drawing upon the kinds of incentives used by both industrialised and developing countries.

How then has the Australian innovation system evolved in recent years in response to these challenges, what driving forces can be identified, and what effect have the changes had? I look first at the performance of R&D in the business and public sectors, and second at the effect of the suite of policies

adopted by the current federal government for supporting business innovation, the 'science base' and cross-sector collaboration.

SECTORAL CHANGES IN AUSTRALIAN R&D EXPENDITURE AND FUNDING

Expenditure on R&D by sector

Table 2 shows expenditure on R&D by business, government and higher education sectors for the period 1994-95 to 2002-03. In contrast to the 1980s and early 1990s, a period which saw rapid growth in business R&D and the ascendancy of the higher education sector (Garrett-Jones, 2004), only modest structural change is seen in the performance of R&D in the most recent decade. However, some of these earlier trends were sustained.

National expenditure on R&D (GERD) was almost static, at around 1.6 per cent of GDP. While GERD grew by nearly 30 per cent in real terms over the period to reach A$12.25 billion (Dept. of Education Science and Training, 2004b), this growth merely matched Australia's overall economic growth during the same time (averaging 3.5 per cent per annum from 1993 to 2003)(Dept. of Education Science and Training, 2004a). Thus R&D expenditure remained virtually unchanged as a proportion of GDP over the whole period (see Table 2). At 1.62 per cent of GDP in 2002-03, Australia was a middle ranking R&D performer, spending well below the European Union (15 country) and OECD averages of 1.9 and 2.3 per cent of GDP respectively (Dept. of Education Science and Training, 2004b).

R&D expenditure by business was cyclical, in response to general economic conditions, and in 2002-03 stood at nearly 0.8 per cent of GDP. It peaked at the start of the period in 1995-95 and in 2001-02, with a trough in expenditure centred on 1999-2000. This pattern is explained by a decline in R&D expenditures in the manufacturing industries and, to a lesser extent, the mining sector. Research expenditure in other industry sectors continued to grow strongly until 2001-02 (Dept. of Education Science and Training, 2004a). Almost two-thirds of manufacturing R&D expenditure was contributed by 'low technology' and 'medium low technology' industries and this figure changed little over the period 1995 to 2000. R&D expenditure by the 'high technology' industries grew from 17 per cent of manufacturing BERD to 21 per cent over the same period (Dept. of Education Science and Training, 2004a). By 2002-03, BERD had recovered to 0.79 per cent of GDP, but still stood well below the 1995-96 peak of 0.86 per cent.

The period also saw a continued strong decline in government expenditure on R&D in its own laboratories (GOVERD), both at the federal and state level. Just over 20 years ago, in 1981, the federal government was the largest R&D performer in Australia. In 2002-03, R&D expenditure by the

central and state governments combined ranked behind that by the business and higher education sectors at 0.33% of GDP.

Table 2. R&D expenditure by sector of performance, 1994-95 to 2002-03

Sector	% of GDP										
	1994–95	*1995-96*	*1996-97*	*1997-98*	*1998-99*	*1999-2000*	*2000-01*	*2001-02*	*2002-03*	*2003-04*	*Change 1995-2003*
Business	0.74	0.86	0.80	0.75	0.69	0.65	0.74	0.81	0.79	0.89	6.5%
Commonwealth Govt.	0.25		0.24		0.20		0.21		0.20		-19.8%
State/Terr. Govt.	0.17		0.15		0.15		0.14		0.13		-24.1%
Higher education	0.39		0.44		0.43		0.42		0.45		17.1%
Private non-profit	0.03		0.04		0.04		0.04		0.05		47.1%
Subtotal: Comm + State Govt	0.42		0.39		0.35		0.35		0.33		-21.5%
Subtotal: Govt + Higher education	0.81		0.83		0.78		0.77		0.78		-2.9%
Total GERD	1.58		1.66		1.51		1.55		1.62		2.5%

Table 2 (continued)

Sector	% of GERD					
	1994–95	*1996-97*	*1998-99*	*2000-01*	*2002-03*	*Change 1995-2003*
Business	47.0%	48.2%	45.9%	47.8%	48.8%	3.9%
Commonwealth Govt.	16.0%	14.4%	13.2%	13.5%	12.5%	-21.8%
State/Terr. Govt.	10.5%	9.1%	9.7%	9.1%	7.8%	-26.0%
Higher education	24.5%	26.2%	28.7%	26.8%	28.0%	14.3%
Private non-profit	2.0%	2.1%	2.5%	2.8%	2.9%	43.5%
Subtotal: Comm + State Govt	26.5%	23.5%	22.9%	22.6%	20.3%	-23.4%
Subtotal: Govt + Higher education	51.0%	49.7%	51.6%	49.4%	48.3%	-5.3%
Total GERD	100.0%	100.0%	100.0%	100.0%	100.0%	-

Source: (Australian Bureau of Statistics, various years-a; Australian Bureau of Statistics, various years-b; Dept. of Education Science and Training, 2004a; Dept. of Education Science and Training, 2004b)

The recent period has seen continuing growth in the contribution of higher education to national R&D (HERD). By 1996-97 higher education R&D had overtaken GOVERD to become and the second largest R&D performer after business. In 2002-03 HERD reached a peak of 0.45 per cent of GDP. Yet, looking at the public sector as a whole, the decline in government R&D has not been countered by the expansion of R&D investments in the universities. Overall then, one sees an erosion of publicly performed R&D between 1994-95 and 2002-03. Despite the growth in higher education R&D, overall expenditure on publicly performed R&D (government + higher education) fell by about three per cent from 0.81 per cent of GDP to 0.78 per cent over the period.

Cross-sector funding of R&D

The federal government provides by far the majority of public funding for R&D. It contributed about 86 per cent of higher education R&D funding in 2002-03, a slight reduction on the 89 per cent of HERD funded in 1994-95 (Australian Bureau of Statistics, various years).

Table 3. Intramural and extramural Business R&D funding, 1994-95 to 2002-03

Sector	**% of Business funded R&D**				
	1994–95	*1996-97*	*1998-99*	*2000-01*	*2002-03*
Business	94.3%	93.6%	92.8%	94.0%	94.1%
Commonwealth Govt.	2.5%	1.8%	1.8%	1.6%	1.4%
State/Terr. Govt.	0.9%	1.0%	1.4%	1.1%	0.9%
Higher education	1.9%	2.9%	3.3%	2.8%	3.1%
Private non-profit	0.4%	0.7%	0.7%	0.4%	0.6%
Sub total Govt	3.4%	2.8%	3.2%	2.7%	2.3%
Sub total ex Business	5.7%	6.4%	7.2%	6.0%	5.9%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: (Australian Bureau of Statistics, various years-a)

Business funding of R&D in the public sector has increased and has been directed preferentially to the universities. As Table 3 shows, about 94 per cent of business expenditure on R&D is spent intramurally or with other businesses. Of the remainder, the universities have received about 3 per cent

of business funding in the most recent survey years, an increase from around 2 per cent in 1994-95. By contrast, the proportion of business funds flowing to the government sector has declined consistently through the period. Business funds to the federal government agencies fell from 2.5 per cent in 1994-95 to 1.4 per cent of all business-funded R&D in 2002-03.

In summary, over the decade to 2003, Australia experienced no sustained growth in expenditure on R&D as a proportion of national wealth. Business R&D expenditure was no greater than it was in the mid 1990s. The importance of the government research agencies continued to decline, while that of the higher education sector grew. Overall, there was a fall in public sector R&D which was not offset by increased business expenditures. The patterns of cross-sector funding by businesses suggests that R&D within the universities became more important to Australian businesses, while that in government laboratories was viewed as less relevant.

CASE STUDY – INNOVATION POLICY UNDER THE CURRENT FEDERAL GOVERNMENT

The general election of November 2004 returned the Howard conservative Liberal-National coalition (first elected in March 1996) for a fourth term as Australia's federal government Moreover, the electorate delivered the government control of the federal upper house, the Senate, ensuring passage of Howard's controversial reforms in the areas of higher education, telecommunications policy and industrial relations. Yet all State and Territory governments remained controlled by the opposition Australian Labor Party (ALP).

In practice, for the last 15-20 years, both conservative and labour governments in Australia have followed a strongly neo-liberal approach to science and innovation policy, albeit one tempered by political pragmatism. Under the current federal government, the pendulum has swung to the market end of the spectrum of market driven and interventionist policies – what Fred Argy has called 'hard liberalism', although perhaps less so than rhetoric might suggest. In opposition, the ALP proposed an alternative agenda in 2001 to develop a 'knowledge nation', based on, inter alia, enhanced education opportunities, strengthening of 'great national institutions' like CSIRO, and 'a transformed national culture emphasising knowledge, excellence and innovation' (Jones, 2001). The ALP's task force also recommended a doubling of national expenditure on R&D by 2010.

The Howard government's main claim is less visionary but perhaps a more practical one in 'providing an economic climate in which innovation can thrive' (Howard, 2001). The government points to tax reforms, lower company tax and a more flexible labour market as contributing to a competitive economic environment with high growth, high productivity and

low inflation (Howard, 2001). But Howard's term has also seen comprehensive reviews of federal policies and initiatives for research and innovation in business, the universities, the government research agencies and research councils (see Table 5). By 2004, the Prime Minister was in a position to announce that 'I have identified science and innovation as one of the Government's strategic policy priorities' and that the government's goal was 'for Australia to build a world-class innovation system' (Dept. of Education Science and Training, 2004c). However, those who read this as increased federal funding for research and innovation were to be disappointed.

Government outlays for science and innovation

The trends in federal government outlays for science and innovation (Table 4) tell part of the story. Over the decade 1996 to 2005 Commonwealth government outlays grew by a mere 12.5 per cent in real terms to reach around A$5 billion (at 2002-03 prices). The business enterprise sector was the biggest loser of government support. Outlays for business research and innovation fell by 26 per cent in real terms over the decade, reflecting cuts to the tax concession for industry R&D (see below). The federal research agencies gained a very modest growth in budget allocations of around 11 per cent over the period (Table 4a). Funding for the Defence S&T Organisation (DSTO) however fell by 13 per cent in real terms. Funds for research in the higher education sector increased by 22 per cent, while what the government terms 'multi-sector' funding showed the greatest growth at 65 per cent over the decade. This 'multi-sector' category comprises both support cross-sector R&D arrangements such as the Cooperative Research Centres (CRC) Program (approaching A$200 million annually in 2002-03 prices), as well as funding sources which are open to competitive bids from both universities and other public sector research agencies (and in some cases businesses), notably the National Health and Medical Research Council (NHMRC) grants (about A$400 million annually) and the rural R&D corporation funds (also around A$200 million annually) (Dept. of Education Science and Training, 2004a).

Table 4. Commonwealth Government outlays for science and innovation, 1995-96 to 2004-05

	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	est. 2003-04	est. 2004-05	Change 1995-96 to 2004-05
(a) A$ million (chain volume measures, 2002-03)											
Major Federal Research Agencies (1)	1,069.0	1,113.5	1,048.5	1,050.1	1,104.5	1,146.9	1,200.9	1,218.1	1,253.9	1,183.7	10.7%
Business Enterprise Sector	1,107.3	742.3	628.3	666.6	816.8	839.8	902.4	777.4	807.8	818.6	-26.1%
Higher Education Sector	1,746.5	1,834.4	1,881.1	1,941.6	1,959.1	1,888.1	1,925.9	1,972.9	2,096.0	2,134.1	22.2%
Multi-Sector (2)	530.2	537.0	578.3	567.1	526.0	647.2	655.0	694.4	855.9	874.9	65.0%
Total Comm. Govt. outlays for S&I	**4,453.0**	**4,227.2**	**4,136.2**	**4,225.4**	**4,406.4**	**4,522.0**	**4,684.2**	**4,662.8**	**5,013.6**	**5,011.3**	**12.5%**
(b)% of Comm. Govt. outlays for S&I											
Major Federal Research Agencies	24.0%	26.3%	25.3%	24.9%	25.1%	25.4%	25.6%	26.1%	25.0%	23.6%	-1.6%
Business Enterprise Sector	24.9%	17.6%	15.2%	15.8%	18.5%	18.6%	19.3%	16.7%	16.1%	16.3%	-34.3%
Higher Education Sector	39.2%	43.4%	45.5%	46.0%	44.5%	41.8%	41.1%	42.3%	41.8%	42.6%	8.6%
Multi-Sector	11.9%	12.7%	14.0%	13.4%	11.9%	14.3%	14.0%	14.9%	17.1%	17.5%	46.6%
	100.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**-**

Table 4 (continued)

(c)% of GDP											
Major Federal Research Agencies	0.18	0.18	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.15	-19.7%
Business Enterprise Sector	0.19	0.12	0.10	0.10	0.12	0.12	0.12	0.10	0.10	0.10	-46.4%
Higher Education Sector	0.30	0.30	0.30	0.29	0.28	0.27	0.26	0.26	0.27	0.26	-11.4%
Multi-Sector	0.09	0.09	0.09	0.09	0.08	0.09	0.09	0.09	0.11	0.11	19.6%
Comm. Govt. outlays as% of GDP	**0.76**	**0.70**	**0.66**	**0.64**	**0.64**	**0.64**	**0.64**	**0.62**	**0.64**	**0.62**	**-18.4%**

Source: (Dept. of Education Science and Training, 2004a), Table 3.1.2.
Notes: (1) DSTO, CSIRO and other R&D agencies; (2) Including NHMRC and other health support, rural funds and CRCs.

As a proportion of federal spending, the government research agencies as a whole retained their budget share at about 24 per cent of outlays through the period (Table 4b), while the 'multi-sector' competitive grants and the higher education sector received an increased proportion of outlays. Overall, the increase in government outlays was substantially below the rate of economic growth over the decade. As a result outlays on science and innovation programs declined by more than 18 per cent over the period when expressed as a proportion of GDP. All sectors, apart from the 'multi-sector' category showed a decline in funding as a proportion of GDP over the decade.

In summary, federal government outlays on science and innovation more than kept pace with inflation over the period 1995-2004. However, they *fell* by more than 18 per cent as a share of national wealth. The government reallocated funds in two ways. First was to divert funds away from the business sector and towards the public sector – notably to the universities and the 'multi-sector' funding agencies. Second was a diversion from direct funding channels – particularly to the government research agencies – to indirect competitive funding schemes.

Government policies and incentives for science and innovation

Given the broad budgetary approach to science and innovation outlined above, how has this been achieved in practice? Table 5 summarises chronologically the main science and innovation initiatives over the period of the current federal government. Policy statements and funding initiatives of the government are covered, as are independent, government commissioned reviews and House of Representatives inquiries. Inquiries by the Senate are excluded because the government did not command a majority there during most of the period under review. I have excluded some initiatives, especially those specific to a particular industry sector.

Table 5 ventures a subjective assessment of the importance and impact of each measure to the innovation sectors: business, government research, higher education, and 'cross-sectoral' (i.e. promoting cross-sector linkages or substantially affecting one or more of the previous sectors). This subjective assessment (from one to three 'stars') is based on (a) the level of additional funding actually committed; (b) the effective degree of implementation or influence of the policy or recommendations; and (c) the extent of change in the innovation system were the proposal to be fully implemented. A 'three star' initiative has had a significant effect while a 'one star' is judged less effective or with narrower impact. Let us consider the main trends in government policy for each sector.

Table 5. Major Federal Government science and innovation policy statements and initiatives, 1996-2004

Year/ Month	***Initiative***	***Main measures***	***GR***	***BE***	***HE***	***XS***
1996	Tax concession for industry R&D reduced from 150% to 125%; tax syndicates curtailed.	Reduction in revenue foregone thorough the tax concession; tightening of eligibility		***		**
1996 Nov	R&D Start Program established	R&D Start grants; Graduate Program for small firms		***		
~1996	Strategic Partnership Industry Development Agreements Program (replaced 2002)	Agreements with major ICT suppliers on R&D and supply chain development		*		
~1996	Pooled Development Funds (PDF) retained (est. 1992)	Support for local venture capital industry		**		
1997 June	'Going for Growth' (Mortimer Report) released	Rationalisation of R&D and innovation assistance to business; major changes to innovation program administration	*	*		
1997 June	'Priority Matters' report by the Chief Scientist (Stocker, 1997)	Recommendations on organisational arrangements for public S&T; and for setting national priorities: 'The Government should articulate a preferred vision for Australia's development toward national goals in the spheres of economic and industry development, quality of the environment, and social well-being' … 'This national-level identification of priorities should concentrate on the structural level'	**		*	*
1997 July	'The Global Information Economy: The Way Ahead' (Goldsworthy Report) released (Information Industries Taskforce, 1997)	Recommended creation of Information Industries Minister and Council		*		

Year/ Month	*Initiative*	*Main measures*	*GR*	*BE*	*HE*	*XS*
1997	Innovation Investment Fund (IIF)	Access to equity capital		**		
1997 Dec	Government Statement: 'Investing for Growth' (Australian Government, 1997)	A range of industry incentives including funding for R&D grants, venture capital and technology diffusion: Extension of R&D Start Program; Expansion of IIF program Industry sectoral 'Action Agendas'		**		
1997	Cooperative Research Centres Program retained (est. 1990)	Nine funding rounds 1990-2004	**	*	**	***
1998 Apr	Australian Greenhouse Office (AGO) established	Funds for greenhouse research	*			
1998 Apr	Report of the review of higher education financing and policy released (West Report)	Strategic planning, priority setting and coordination for university research; 'student centred' funding			**	
1998	Review of greater commercialisation and self funding in the Cooperative Research Centres Programme released (Mercer and Stocker, 1998)	Support for CRC program; increase user input to governance; develop core performance indicators for all CRCs				**
1999	'Inquiry into the effects on research and development of public policy reform in the past decade' (House of Representatives Standing Committee on Industry Science and Resources, 1999)	Maintain funding for CRC Program – govt. response agreed; Address HE research infrastructure needs; Counter the decline in BERD – govt. noted.		*		

Year/ Month	*Initiative*	*Main measures*	*GR*	*BE*	*HE*	*XS*
1999	Increase in length of patent protection for pharmaceuticals to 25 years			*		
1999 early	'The Virtuous Cycle' report (Wills Report) released (Health and Medical Research Strategic Review, 1999) and Govt. response.	Doubling of competitive funding for health and medical R&D under NHMRC			**	**
1999 May	Biotechnology Australia established			*		*
1999 July	Pharmaceutical Industry Investment Program (PIIP) (ceased July 2004)	Compensation for reduced pharmaceutical prices under Pharmaceutical Benefits Scheme Replacement for 'Factor f' program		**		
1999 July	Shipbuilding Innovation Scheme	Benefit for eligible R&D		*		
1999 July	Building Information Technology Strengths (BITS) (ceased June 2004)	Seed capital for ICT start-up companies		**		
1999 Nov	Commercialising Emerging Technologies (COMET) scheme established	Support to enable individuals, early growth firms and spin-off companies from public sector research institutions to manage innovation and commercialisation.		**		
1999 Jun, Dec	'New Knowledge, New Opportunities' Discussion paper; and 'Knowledge and Innovation: a policy statement on research and research training' Higher Education White Paper (Kemp, 1999).	University reforms, performance based funding for research student places (i.e. greater competition for PhD and Masters research students), requirement for annual Research and Research Training Management reports, establishment of independent Australian Research Council; encouragement of commercialisation and 'an entrepreneurial culture among researchers'			***	

Year/ Month	*Initiative*	*Main measures*	*GR*	*BE*	*HE*	*XS*
2000	Copyright Amendment	Comprehensive reform of Copyright Act to account for digital technologies		*		
2000 Feb -	National Innovation Summit convened with Business Council of Australia; Report of the Innovation Summit Implementation Group (Miles Report) (Innovation Summit Implementation Group, 2000)	The Summit produced at least 140 recommendations about many aspects of the innovation that were distilled to 24 by the ISIG. Many were picked up subsequently by the Science Capability Review and the BAA statement.		**		
2000 July	National Biotechnology Strategy announced	Biotechnology Innovation Fund (BIF) established		*		
2000 July	Textile, Clothing and Footwear Strategic Investment Program	R&D grants		*		
2000 July	Contract awarded for construction of 'OPAL' nuclear research reactor	'OPAL' replacement research reactor for ANSTO. Construction commenced in 2002 for full commissioning in 2006	***	**	**	**
2000 Nov	Chief Scientist's report 'The Chance to Change' released (Batterham, 2000)	Outcome of the Australian Science Capability Review. Recommendations include: incr. in science students and postdoctoral fellows; incr. funds for ARC and research infrastructure; expansion of CRC Program; better IP management by universities and government agencies. Themes of investment in culture, ideas and commercialisation.	*			

Year/ Month	*Initiative*	*Main measures*	*GR*	*BE*	*HE*	*XS*
2001 Jan	The government's major policy statement 'Backing Australia's Ability: An Innovation Action Plan for the Future' ('BAA 1'), promising 'A$2.9 bill. of additional funding over 5 years' (Australian Government, 2001)	Access to pre-seed funding for development of commercial proposals; review of access to government funded research; Ministerial Committee to implement BAA; explicit National Research Priorities (NRP) to be developed National Innovation Awareness Strategy; 175% 'premium' tax concession for 'additional' R&D; Innovation Access Program; expansion of (COMET) program; New Industries Development Program (rural and regional businesses); continuation of R&D Start Program 2000 Additional university places annually in ICT, mathematics and science; loans scheme for postgraduate students; support for research infrastructure; Access to pre-seed funding Doubling of ARC grant funding over 5 years; Centres of Excellence in ICT and Biotechnology; increased funding for Cooperative Research Centres; A$155 mill. for 15 new 'collaborative' Major National Research Facilities (Aug 2001); Systemic Infrastructure Initiative	**	**	*	**
2001 May	Low cost 'innovation patent' introduced			**		
2002 Feb	ARC Priority Areas announced	Priority areas for ARC and for new Centres of Excellence (initial 5-year funding) are: Nanomaterials and Biomaterials; Genome/Phenome Research; Complex/Intelligent System; and Photon Science and Technology	*		**	

Year/ Month	*Initiative*	*Main measures*	*GR*	*BE*	*HE*	*XS*
2002 April	'Higher Education at the Crossroads' – Ministerial discussion paper. Review of Higher Education system announced. (Nelson, 2002a)	Not specifically on research, but set the government agenda for higher education. Proposes more 'user pays'; deregulation of student fees;			***	
2002 June-Dec	First CSIRO Flagships announced; internal restructure	At the time of writing, the Flagships are: Preventative Health Light Metals Food Futures Energy Transformed Water for a Healthy Country Wealth from Oceans	*			
2002 Sept	External Earnings Targets for government research agencies abolished (Batterham, 2002)	Targets of around 30% of funding from non-appropriation sources commenced in 1988		**		
2002 Dec	Automobile Competitiveness and Investment Scheme (ACIS) renewed	Competitive R&D grants and allowances		*		
2002 Dec	National Research Priorities (NRP) announced	Priorities are: An Environmentally Sustainable Australia, Promoting and Maintaining Good Health, Frontier Technologies for Building and Transforming Australian Industries, and Safeguarding Australia	**		*	
2003	National Innovation Council est. (Chair: David Miles)	Advisory Council to the Minister for Industry; Responsible for funding under the National Innovation Awareness Strategy		*	*	

Year/ Month	*Initiative*	*Main measures*	*GR*	*BE*	*HE*	*XS*
2003 May	'Our Universities – Backing Australia's Future' Ministerial Statement released	Increased student fees; introduced student loan; Announced reviews of collaboration between universities and publicly funded research agencies; higher education research funding schemes; and development of a national research infrastructure strategy	*		***	*
2003 June	House of Representatives Standing Committee on Science and Innovation report: 'Riding the Innovation Wave: The Case for Increasing Business Investment in R&D' (Australia. House of Representatives Standing Committee on Science and Innovation, 2003) (Australian Government, 2004)	Rec. that federal govt. encourages state and local government to promote R&D; more commercial focus for R&D Corporations Recommendations include: expansion of innovation mentoring services for SMEs; tax offsets for R&D by TNCs in Australia; voluntary sector levies on SMEs to fund R&D; simplify federal R&D support to firms and provide 5 year continuity for programs; expand incremental/premium tax concession and link to NRPs; Incr. funding for START and COMET programs Make university superannuation more flexible to allow staff to move to businesses; Expand Graduate START; monitor access of regional universities to CRC program. Incr. no. of 'research brokers'; Develop guidelines for public/private collaborative R&D	*		*	
2003 Aug	Howard Partners evaluation of CRC Program released	Recommends continuation of the CRC Program, but with more focus on research as an 'investment vehicle'				**
2003 Sept	Pharmaceuticals Partnership Program (P3) launched; first grants commence July 2004	Replaces PIIP Competitive program: companies receive 30 cents per additional dollar of eligible R&D;	*			
2003 Nov	'Mapping Australian Science and Innovation' (MASI) report released (Australian Government, 2003)	A major review of Australia's science and innovation strengths and weaknesses; frank in its findings; supported by a range of case studies.	*			

Year/ Month	*Initiative*	*Main measures*	*GR*	*BE*	*HE*	*XS*
2004 Mar	Reports of three reviews of higher education research released. (Dept. of Education Science and Training, 2004d; Dept. of Education Science and Training, 2004e); (National Research Infrastructure Taskforce, 2004)	Closer collaboration between universities and major publicly funded research agencies (McGauchie) – recommends performance assessment framework for universities and public research agencies Evaluation of Knowledge and Innovation reforms (Fell); and National Research Infrastructure Taskforce (Sargent) - recommends establishment of NRI Council	**		**	
2004 May	Backing Australia's Ability: Building our future through science and innovation ('BAA 2') policy statement released	Funds for CSIRO National Flagships Initiative; improvement in monitoring quality of achievements Commercial Ready program replaces R&D Start, BIF and elements of the Innovation Access programs; improvement in monitoring quality of achievements; Incr. Funds for NHMRC and ARC; CRC program to be more commercially focused; National Collaborative Research Infrastructure Strategy	**	**	**	*
2004 Oct	Industry Cooperative Innovation Program	Support cooperative projects by firms to develop and use new technologies, with priority being given to projects meeting strategic industry needs identified through an industry 'Action Agenda'.		*		
2004 Oct	Commercial Ready Program commences	Replaces R&D Start, BIF and parts of Innovation Access Program		**		
2004 Dec	Grant Committee report on NHMRC released	Overhaul of NHMRC recommended to align with changes recommended by Wills Review	*			
2005 Aug	CSIRO's Flagship Collaboration Fund launched	'Enhanced collaborative research between universities, the CSIRO and other publicly funded research agencies'.	*			**
2005 Aug	11 new ARC Centres of Excellence announced	Articulated with NRP areas			**	

Year/ Month	*Initiative*	*Main measures*	*GR*	*BE*	*HE*	*XS*
2005 Feb, Sept	Expert Advisory Group set up under Roberts (former UK HE Funding Council) Research Quality Framework' Preferred Model' released	Development of 'Quality and Accessibility Frameworks' for Publicly Funded Research	**		***	
2005 Sept	National Collaborative Research Infrastructure Strategy (NCRIS) standing committee established		*		**	*

BUSINESS INNOVATION

In the lead up to the 1996 election the then shadow science minister observed that the single most important obstacle to Australia's progress as a competitive technologically competent nation is our low level of industrial R&D (Hill, 1996). Business was therefore surprised that the first act of the Howard government on gaining office was to cut back drastically the existing incentives for industrial research and development. In June 1996 the tax concession for industry R&D was reduced from 150 per cent to 125 per cent, largely on the grounds that the budgetary cost of the concession – and particularly the access allowed to syndicates of firms – was impossible to control. With changes to concession rate and eligibility (as well as general company tax reductions) this had an immediate effect on the cost to the government of the tax concession, reducing it from around A$950 million in 1995-96 (in 2002-03 prices) to less than A$600 million the following year (Australian Government, 2003). A 'premium' tax concession rate of 175 per cent was introduced for incremental (additional) R&D in 2001. However, since 2001-02 the value of the R&D tax concessions to industry has stood at less than A$400 million annually (at 2002-03 prices)(Dept. of Education Science and Training, 2004a).

Industry was partially recompensed by a growth in targeted grant programs such as the R&D Start scheme (now part of the 'Commercial Ready' program). The value of these programs grew by over 150 per cent over the period to stand at about A$150 million in 2004-05 (Dept. of Education Science and Training, 2004a). However, grants and loans did not make up the shortfall caused by changes to the tax concession and, as noted, since 1996, government support for research and innovation in firms has fallen by 26 per cent (Table 4). New policies have concentrated on the 'downstream' end of innovation, such as through the Innovation Investment Fund (investment equity), 'pre-seed' project funding, the 'COMET' program and continued support for the local venture capital industry.

To its credit, the government has promoted an active debate on innovation policy, through in the 'Innovation Summit' sponsored with the Business Council of Australia in 2001 and through the two 'Backing Australia's Ability' (BAA) white papers (Australian Government, 2001; Dept. of Education Science and Training, 2004c). Three themes can be identified in this discourse.

The first is the debate between strategic intervention and a 'hands off' laissez faire approach. Jonathon West (2004) characterises the prevalent policymakers' view as 'innovation should be driven by the market… if the market does not support innovation, so be it'. In retort, West points to the low level of support for education and basic research and limited attractors for capturing the profits from innovation and concludes that 'it should be apparent that the market alone will not come to the nation's rescue' (West,

2004). Phillip Bullock, the head of IBM Australia/New Zealand, recently agreed: 'We can conclude that relying on market-driven funding for innovation is not working' (Bullock, 2004) (page no.). The government's own commendable 'Mapping Australian Science and Innovation' exercise commented that government support for business R&D in Australia was low by international standards, being less than half that of the leading OECD countries (Australian Government, 2003:23).

How this debate has played out can be illustrated by two early reports that the government commissioned. Arguing for a National Information Industries Strategy, the Goldsworthy report warned of a 'new century of technological colonisation' if Australia did not act (Information Industries Taskforce, 1997). The report's suggested 'actions' were predominantly interventionist. Mortimer's review of business programs for investment, innovation and export, on the other hand, took a far more wary approach to government intervention in the form of financial assistance to business. While he recommended that government incentives be combined to form a single Innovation Program, he favoured uniform incentives for all firms, rather than programs targeted at particular industries or classes of firms (like SMEs). He was especially critical of schemes which produced 'private benefit' for firms and recommended the termination of CRCs which fell into this category and retention of the CRC Program only for 'public good' research (Review of Business Programs, 1997). The government largely rejected Mortimer's prescriptions and treated Goldsworthy's more favourably. Targets in Mortimer's sights like AusIndustry, the Industry R&D Board and the CRC Program were retained rather than abolished, while new initiatives like the Building IT Strengths (BITS) incubator program, National ICT Australia (NICTA) and, for a while, a National Office of the Information Economy promoted innovation in the information industries.

The second theme within government support for innovation has been the balance of programs between the largest firms (including TNCs) and SMEs. The Start program and the Innovation Investment Fund were aimed mainly at small firms unable to take advantage of the tax concession. Multinational firms in the pharmaceuticals, information technology and automobile industries have also been recruited to strategic partnership or industry restructuring schemes with targets for R&D and innovation. These have not met with unqualified success. In 2002, Ericsson pulled out of R&D in Australia, closing its Asia-Pacific Lab, and firms such as Kodak and Nissan have ceased local manufacturing.

The third debate might be termed that between the 'old economy' and the 'new economy'. Government innovation programs in recent years have various promoted the development of new technology-based industries as well as supporting currently competitive industries through for example the rural industry Research Corporations. At the national level, Australia faces a version of the 'innovators dilemma' (Christensen, 1997): that is, how to pursue successful innovation in established, essential industry sectors like

agriculture and mineral resources while at the same time backing developments in the 'next big thing' in technologies or markets. Here Australia is not alone. As Keith Smith comments, 'Within most OECD economies, policymakers remain heavily focused on ICT, biotech and nanotechnology issues (both in innovation and diffusion policy) to the exclusion of most of the areas of knowledge that are, in fact, producing change across major industries. Policy remains focused on a science-based model of innovation to the exclusion of a genuinely learning-based approach' (Smith, 2004). (Page no.)

The frequent changes to industry innovation incentives shown in Table 5 to some extent reflect an experimental approach to the challenge of imbuing a learning and innovation culture throughout the economy. However, firms have found the changes in schemes and eligibility confusing, prompting a Parliamentary Committee to recommend their simplification and longer continuity (Australia. House of Representatives Standing Committee on Science and Innovation, 2003).

While particular initiatives like Start appear to have been effective, it is hard to discern an overall 'vision' for industrial innovation policy, notwithstanding the Innovation Summit's 'blueprint for change' (Innovation Summit Implementation Group, 2000). Overall, the Howard government's assistance for innovation in industry can be criticised for its lack of stability, its inconsistency and meagreness.

PUBLIC SECTOR R&D

CSIRO, Australia's iconic civil research agency, has a budget of around A$900 million, including over A$300 million from business and other users. Yet policy has tended to view government-performed research as a negative factor in innovation performance (see (Stern and Gans, 2003). Much of the policy rhetoric, for example in the 'Backing Australia's Ability' statements is about 'commercialising' public sector R&D rather than about its public good:

> *Backing Australia's Ability* will assist the greater commercial application of research from universities and public sector research agencies, like the CSIRO, by encouraging the commercial linkages with industry and removing impediments for promising research to go forward to the stage of commercial viability. (Howard, 2001) (Page no.)

The federal government has not treated its own research agencies kindly, expecting them to supplement static or declining government funding through industry partnerships or competitive grant funds. In Senate Estimates Committee hearings in 2003, Geoff Garrett, chief executive of CSIRO, said that one of the organisation's key strategic messages had been 'partner or

perish' (CSIRO, 2004). How far this had become ingrained was reflected in the abolition of formal 'external earnings targets' in 2002 (Batterham, 2002), presumably on the basis that such targets were no longer necessary.

In 2002 CSIRO started to restructure its research programs around a series of 'National Research Flagships', which are heralded as 'a major refocussing' of CSIRO's research and commercialisation activities:

> 'Flagships are multidisciplinary research partnerships that align Divisions across CSIRO and external agencies to tackle big, audacious goals in areas of major national significance. Their larger scale, longer timeframes and clear focus on adoption of research outputs are designed to maximise their impact on their goals.' (www.csiro.au)

CSIRO plans ultimately to allocate about 40 per cent of its resources to the Flagships (CSIRO, 2004). Despite the promise of new government funds for the Flagships (Dept. of Education Science and Training, 2004c), in mid 2003 the CSIRO Staff Association reportedly accused the government of 'doing a demolition job' on CSIRO: 'The Government's program of neglect and long-term cutbacks have caused the biggest crisis in CSIRO's history. Staff… fear for the future viability of the organisation and its vital research work', the president of association is quoted as saying (Anon., 2003). It can be argued that the Flagship structure makes the future break-up of CSIRO, along the lines of the New Zealand model of research institutes, more feasible.

Spurred by Chief Scientist John Stocker's report 'Priority Matters' (Stocker, 1997), the setting of research priorities forms a second theme in government policy toward public sector R&D. The government has made a significant push to integrate the research effort of the government laboratories and to some extent the universities through priority setting, through evaluation of their outcomes and more recently through the proposed application of common quality assessment frameworks for research (RQF). Four broad national research priorities (NRPs) were announced by the federal government in 2002 (see Table). These had been foreshadowed in the government's major policy document 'Backing Australia's Ability' in 2001. The original NRPs were developed following a consultation process under Jim Peacock, respected bioscientist and head of the Australian Academy of Science,[3] and the subsidiary goals were expanded following representations by social sciences and humanities research leaders in early 2003. Each federal agency (including the research councils) is required to report annually on how their investments align with the national research priorities. The CSIRO Flagships have come to be 'closely aligned with the Government's National Research Priorities and build on CSIRO's core science capability' (CSIRO, 2004). Similarly, proposals for the ARC's

[3] Peacock was appointed federal Chief Scientist in February 2006.

Centres of Excellence are now tied to the NRPs. Clearly agencies like CSIRO will be assessing the viability of programs that do not demonstrably fall within the NRP areas.

Since 1999, all federal government research agencies have been subject to Output Pricing Reviews by the Department of Finance and Administration (DOFA). These reviews examine the quantity, quality and price of outputs produced in an attempt to assess whether the government is getting good value for the taxpayers' funds. The process emphasises indicators of agency outputs and outcomes. The framework sensibly recognises that research agencies are valued as much for their standing *capacity* to deliver research expertise as for their specific R&D activities and the Reviews have been largely qualitative in nature. Following the recommendations of the McGauchie review of 2004 (Dept. of Education Science and Training, 2004e) there have been moves to standardise the reporting of research outcomes through the development of a 'quality and accessibility framework' for all publicly funded research (see below).

In Australia's relatively small science system, finding capital for the provision of major national research facilities has always been problematic. The provision of major facilities and research infrastructure is a recurring theme in federal government science policy. The current government has perhaps achieved more that its predecessors in this regard. The major capital project has been the construction and commissioning of a replacement research reactor (Open Pool Australian Light-water, or OPAL) for the Australian Nuclear S&T Organisation (ANSTO). Federal-State-university collaboration has led to the construction of the Australian Synchrotron in Melbourne, to open in 2007. The Sargent taskforce recommended the establishment of a standing committee to address research infrastructure needs (National Research Infrastructure Taskforce, 2004), and the government has created a body to oversee a National Collaborative Research Infrastructure Strategy (NCRIS).

In summary, the watchword for government research agencies over the last decade has been to commercialise, to 'partner or perish' and to align more closely with explicit national research priorities. This approach is now being extended to the provision of major national research facilities and research infrastructure for government laboratories and universities.

THE HIGHER EDUCATION AND HEALTH RESEARCH SECTORS

The Howard government inherited the 'unified national system' of higher education. It is important to note that 'unified does not mean uniform' to paraphrase (Wood and Meek, 2002). Eight large, highly 'research intensive' universities dominate the system, and 8-10 more enjoy significant but

restricted research strengths (Garrett-Jones et al., 2000). The former Minister for Education and Science signalled a further concentration of research funding, commenting 'when you fund and administer [all universities] in the exactly same way it is prescription for mediocrity' (Nelson, 2002b). The government has made some moves to support regional universities separately such as through 'regional protection funding' for research, introduced in 2004. Overall, the policy has been to increase competition for research funds (both grants and institutional funds) against a background of increased 'user pays' for students.

The higher education sector saw substantial growth in research expenditure over the decade from 1996 (see Table 2). During this period the university system (and its research activity) was subject to almost continual review. Roderick West's broad review (Higher Education Financing and Policy Review Committee, 1998) prompted the government's 'Knowledge and Innovation' white paper the following year (Kemp, 1999). This required the universities to produce regular management plans for research and research training and encouraged commercialisation by the universities. It also increased performance based funding for research students. The 2002 'Crossroads' review of the higher education system led to a Ministerial statement 'Our Universities: Backing Australia's Future' (Nelson, 2003) that announced three further reviews. These inquiries, which reported in 2004, were in relation to enhanced collaboration between universities and government research agencies (Dept. of Education Science and Training, 2004e); an assessment of the impact of the 'Knowledge and Innovation' reforms under Chris Fell (Dept. of Education Science and Training, 2004d), and on research infrastructure (National Research Infrastructure Taskforce, 2004). Fell's report found 'that the sector has responded well to *Knowledge and Innovation* and that the reforms are working as intended' (p. vii). However the report made several recommendations about increased funding, more discretionary funds and greater emphasis on quality of outcomes.

Reviewing the status of higher education R&D in Australia, Wood and Meek (2002) are highly critical of the Howard government's policies. Rather than a 'stable and predictable' policy environment, universities have been subject to what they term the 'weariness' of constant review and accountability. Initial cuts in funding made in 1996 – including reducing operating grants and failure to provide supplementation for academic salary increases – has had a 'profound and largely negative effect' (Wood and Meek, 2002). Government funding for higher education declined from over 0.70 per cent of GDP in 1996-97 to less than 0.55 per cent in 2003-04 (Wood and Meek, 2002). This has been somewhat offset by increased student fee income and, to a smaller degree, commercial funding of research. However, Wood and Meek see this as an abrogation of responsibility for public funding of higher education but, more significantly, as handing the direction of the universities over to the 'vagaries' of market forces. A report by the (opposition controlled) Senate in late 2001 entitled 'Universities in Crisis'

recommended a significant expansion in public investment in higher education. The government rejected the premise of a higher education funding crisis. But concerns about under-funding of the universities and the innovation system as a whole are echoed by senior academic managers. The Australian Vice-Chancellors' Committee criticised the second 'Backing Australia's Ability' (BAA2) white paper (Dept. of Education Science and Training, 2004c) for not giving a clear plan for the national innovation system and for failing to increase overall investment in research and innovation (Anon., 2003). The AVCC itself has set a national 'research and innovation investment target' of 2 per cent of GDP by 2010. The Vice-Chancellor of the Australian National University, Ian Chubb, is on record as saying that BAA2 would see Australia 'treading water' in its capacity for research and innovation over the next five years (Anon., 2004).

As providers of competitive funding to the universities and health research institutions the main research councils have fared well under the current government. Funds for the National Health and Medical Research Council (NHMRC) doubled with the government's response to the 1999 Wills Report (Health and Medical Research Strategic Review, 1999), while the first 'Backing Australia's Ability' statement (Australian Government, 2001) announced a doubling of funding to the ARC. Both councils have been re-established as independent statutory bodies. Recommendations in the West review encouraged the ARC in setting priorities within its own funding programs. However, there was some criticism of the hasty announcement of ARC priorities by the Education Minister in 2001, which set priorities for about one-third of ARC's grant budget and for the ARC Centres of Excellence.

As noted, the government has announced the introduction of common quality assessment frameworks for research (RQF) for the universities and government agencies, for implementation from 2007. The RQF will replace Australia's unique form of ex post quantitative evaluation for higher education research funding which gives weight to numbers of publications. Linda Butler's analysis 'raises important questions on the wisdom of a policy that rewards quantity, with scant regard to quality' (Butler, 2003) (p 154). Butler shows that Australian representation in the Science Citation Index (SCI) increased by 25 per cent in the decade to 2001 (Butler, 2003). The universities contributed an increasing proportion of these publications – three-quarters in 2000, compared to two-thirds 'historically'. By contrast, Butler comments that 'the government sector's growth … evaporated in the latter half of the 1990s' (p 150) with CSIRO and hospitals showing a similar trend. Of concern, despite the growth in output, the international research community is paying less regard to these publications. Australia's share of the world's 'citation pool' fell with respect to other OECD countries. As Butler comments 'Australia's increase in output appears to be at the expense of impact' (p 147). Increasingly, it seems, academics are publishing in lower impact journals.

The RQF – along the lines of the UK Research Assessment Exercise – is therefore cautiously welcomed. The unit of assessment is to be research 'groupings' nominated by the universities. The proposal was seen by the former Minister as a mechanism for redistributing institutional research funding from the Education ministry and influencing grant funding from the research councils (Expert Advisory Group for the RQF, 2005), but the all important 'funding formula' (how the quality assessments will be linked to research funding) remains to be decided. It is also unclear how research 'impacts' will be assessed and used. Depending on how the proposals are ultimately implemented they may well prompt further concentration of research funding in the larger universities, effectively leading to a the restoration of a two-tier higher education system in research.

On the positive side, then, competitive funding through the well-regarded research councils has increased, and a more integrated approach to research infrastructure embarked upon. The RQF may be a positive (but expensive) step, but its ramifications are as yet unclear. Overall, though, the universities are currently under immense pressure, facing new demands to become more entrepreneurial, to expand their contribution to commercial outcomes and cross-sector collaboration, resolving tensions between teaching and research, and from the user pays philosophy. Essentially the universities are being expected to continue to expand, to encompass a wider range of research and innovation activities, and to adopt a more 'market' approach to education within public funding that is actually falling as a proportion of GDP.

CROSS-SECTOR R&D

We have observed an evolution of cross-sector R&D collaboration in Australia towards 'formalised and structured arrangements' (Garrett-Jones and Turpin, 1997). This trend has continued under the current government. Government policy constantly stresses the need to build linkages within the national innovation system, particularly between the public sector and industry. The second 'Backing Australia's Ability' white paper for example states that:

> A fundamental objective of this package is to boost collaboration between the key players in the innovation system: business, universities and publicly funded research agencies. Collaboration increases the 'interconnectedness' of the system, providing more and varied pathways for research to be used and commercialised. (Dept. of Education Science and Training, 2004c) Page no.

The Cooperative Research Centres Program (CRC Program), which started in 1990, is the Australian largest federal investment in cross-sector R&D. There are currently more than 70 CRCs in operation. The Program links different R&D sectors and institutions: universities, federal and State government research authorities, individual firms, and industry-led public sector intermediaries such as the rural R&D corporations. The program has survived proposals to curtail it (Review of Business Programs, 1997) and pressures for greater 'self funding' (Mercer and Stocker, 1998). While Program objectives have from the outset promoted 'the links between research and its commercial and other applications' (Slatyer, 1994), the current objectives have 'drifted significantly' from the original ones (Howard Partners, 2003). The government has, from 2004, required 'a stronger commercial focus' through strong industry partners and plans for commercialisation or utilisation.

The CRC Program is widely supported. It is credited with 'changing research cultures' and promoting increased and more effective cross-sectoral, multidisciplinary and multi-organisational research, technology development and commercialisation (Howard and Partners, 2003). As a result the CRC has become a dominant (if not *the* dominant) model for cross-sector R&D in Australia, but a dominance which is now being challenged.

In 2003, the government announced new 'national centres of excellence' in biotechnology and information and communications technology outside the CRC Program. Unlike the CRCs, where the research areas are proposed by the participants, the scope of the new national centres was nominated by government following consultation with scientists and industry. Cross-sector R&D linkages are increasingly being supported by Australia's research councils and other funding bodies. The first National Centres – National ICT Australia (NICTA) and the National Stem Cell Centre - were both funded by direct grants and funding through ARC. NICTA involves collaboration between the federal, NSW and ACT governments and two universities. Significantly, the administration of the CRC Program remains separate from the main research councils.

The research councils themselves to sponsor a range of collaborative arrangements from grants and industry-linked scholarships and fellowships through to large collaborative centres. Examples include the ARC's 'Linkage Program'. Other government schemes, such as the R&D Start program and the R&D Corporations also support cross-sector collaboration. Observers have pointed to the range of cross-sector research, training and commercialisation arrangements in Australia and stress the need for policy to maintain and support this plurality and complexity (Garrett-Jones and Turpin, 1997); (Howard Partners, 2001). Managing the growth of cross-sector collaboration is a significant challenge for universities and research institutions. As Tim Turpin has noted, 'the CRCs have acted as powerful vanguards in the transformation of the university research system' (Turpin, 1997). This transformation carries notable risks to the university as an

organisation and to academic research (Garrett-Jones et al., 2005) and it is possible that the system's 'carrying capacity' for this form of collaborative centre has been reached.

Howard's record on science and innovation

The federal government's approach to science and innovation may be characterised in several ways. First, they have seen science and innovation policy as a 'zero sum' game. Despite well-publicised policy announcements such as the two 'Backing Australia's Ability' policy statements there has been very little increase in spending in real terms and, as a proportion of GDP, government outlays have fallen by almost one-fifth since they took office. As a result policy changes have had to be effected through reallocation of resources or thorough non-budget sources of funding. The main 'losers' in this reallocation have been the business sector and to some extent the government research agencies, while the 'winners' have been the main research councils and the universities. This places huge pressure on the universities which are being required to take on the tasks of collaborating more closely with business and carrying out much of the industrially oriented, regionally important and public good strategic research.

Second, policy initiatives have become surprisingly pragmatic and interventionist in relation to industrial innovation, Business innovation policy has become less neo-liberal in some aspects – reflecting a compromise between political interests. But the government's approach to the public sector – where a strongly market-led philosophy has prevailed – has been far more dogmatic. The imperative for commercial funding and commercial returns has eroded the capability for public interest research and undermined strategic industrial research in the government sector.

Third, not surprisingly in this policy environment, has been the emphasis on leveraging the resources of all parts of the innovation system in order to achieve efficiencies and synergies in research outcomes. However, again, one can argue that these initiatives have emphasised near-term commercial outcomes at the expense of longer term benefits to society as whole.

CONCLUSION AND ASSESSMENT

Where does Australia's national system of innovation stand in the first decade of the 21st Century? By comparison with many of the case study countries in this volume, Australia has enviably strong, robust and dynamic capabilities in science and innovation. But, despite much rhetoric and re-organisation, in my view the system in general and federal policy in particular has simply 'marked time' over the last decade.

With regard to funding, both the national expenditure on R&D and business expenditure on R&D have barely increased as proportion of GDP over the last 10 years. The low level of industrial R&D thus remains as much of an obstacle to Australia's progress as it did in 1996. The problems of industry structure (particularly the lack of innovation in small firms) remain. It has proven difficult to develop innovation-based enterprises even in areas where Australia has a strong science base:

> 'there is little evidence of significant, emerging areas of technological specialisation'…'we are not generating 'sustainable new paths of technological accumulation' (Scott-Kemmis, 2004a). (Page no.)

Krishna has commented 'the science policy discourse over the last decade led to the emergence of a new system of innovation in Australia' around collaboration in research and commercialisation (Krishna, 2005). (page no.) But this 'collaborative research' space has not only grown but has become increasingly contested and even confused. As Krishna correctly observes, the research roles of CSIRO and the universities are converging (Krishna, 2005). Where one could formerly identify clearly distinct roles for the government research agencies, universities and ad hoc mission-oriented research programs, there is now a plurality of policy, funding and research performing agencies competing variously for human resources (the scientists), for partners (firms and research groups) and of course for funding. These changes may well be beneficial but will have far reaching and as yet unknown consequences for the future management of higher education, research and research funding in Australia.

The government has compounded the weakness of the business sector by pressure on the strong 'science base' – one of Australia's acknowledged strengths. Government outlays on science and innovation and on higher education research have fallen as a proportion of GDP. Trying to 'answer' the challenges of Australia's innovation system within a zero sum game is unlikely to be successful while other countries are substantially increasing their commitment to science, innovation and learning.

The past federal Chief Scientist, Dr Robin Batterham, observed that science and technology in Australia was not at the top of the Treasury's priority list, unlike in the United Kingdom (Anon., 2005). Despite some worthwhile structural reforms, science and innovation policy in Australia does not occupy centre stage: not in strategic planning, not in resource allocation and not in the minds of business, public and politicians. As Tim Turpin has acutely observed, this means we are stuck with an old paradigm, where 'science as an institution, a career or a national objective is not deeply embedded in Australian cultural values'. The challenge to Australia remains to 'bring science and technology in from the cold… integrated with and embedded in the culture, ideas and markets that comprise our national innovation system' (Turpin, 2000). The invocation of former AVCC head Ian Chubb is apt: 'I suggest that we can't afford to wait. Nobody else is waiting for us' (Wood and Meek, 2002: 23).

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