Science, innovation and the role of government

Submission to the Productivity Commission Study into Science and Innovation

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Executive Summary

It is our contention that the direct contribution to innovation from science, including scientists, science research centres and academia, is small, indirect and dwarfed by other factors.

It is our further contention that the most important contribution of science to innovation comes through the education system—that is, in ensuring high quality output of engineers and scientists from institutions whose performance can be measured against the best in the world.

The policy focus on science as a driver of innovation and the funding of science to achieve innovation is misguided and may have had a negative effect on tertiary institutions in setting priorities on which they cannot deliver.

The tendency of governments, state and federal, to focus funding on a limited set of technological drivers such as biotechnology, ICT and advanced materials not only directs funding to a minor input in the innovation process but tends to limit choice in a `picking winners' manner.

We suspect that the removal of regulatory restrictions on developing technology or applying it might enable the development or application of innovative ideas.

Further, the present measures of innovative performance are deeply flawed and are of little value. It is clear to us that unless a direct measure of innovations such as counting the introduction of new products or processes is adopted, that there will be any useful advance in this area. We suspect that if government policy is ineffective in spurring innovation there is not much point in worrying about measuring its impact.

Introduction

Innovation is a complicated, uncertain and market driven process with many inputs. The Government has focussed on the contribution that science makes to innovation. This raises the immediate question of the contribution, both direct and indirect, of science per se and to its significance. The direct contribution is the invention or creation of ideas, products and processes in tertiary institutions and research institutes that are taken up commercially. The indirect contribution is through the education system at the level of a pool of understanding found in tertiary institutions and a stream of well-educated scientists, engineers and technologists.

Innovation is not the smooth progression of an idea from a university research laboratory through 'commercialization' to a successful business. The interaction of governments, academia, business and the commercial markets has a random pattern of success and failure. Further, a misreading of the innovation process may raise false and undeliverable expectations from universities and damage general education as priorities are shifted from what is well done towards what is not.

Perhaps the best critical writing on this subject was an article published in *The Economist* in 1982 (*The Economist* June 26, 1982, page 91, 'The pitfalls of trying to promote innovation').

The significance of science for directly driving Innovation

The commercial market is the final arbiter of innovative ideas. While a market of ideas exists in science and in research institutions, it is not the place where innovations are fashioned. Two recent publications, one a book by the eminent economist John Kay, *The Truth about Markets* (Penguin Books 2004) and the other an essay by an Industrial Visitor to Cambridge, Stephen Allott, 'From Science to Growth', (http://trinamo.co.uk/articles.htm) touch on how innovations come about in the market.

Table 1 shows studies of European and United States innovation in the 1980s, confirmed by United Kingdom data in 2001 and now preliminary results from Australia in 2003.

Australian data on Research and Development Expenditure and Licence Fees and Royalties paid by business tells a similar story in Table 2. This is a proxy for the importance business places on academia for innovation and problem solving.

Another measure of the importance is royalties received from patented innovations. This is shown in Table 3 and should be regarded as indicative only. One of the immediate problems with royalties is that a significant proportion of patents are licensed to overseas corporations and the benefits are largely gained offshore. This, on reflection, is not surprising. Researchers operate in a global competitive business. Their discoveries and ideas command worldwide attention. This exposes a fatal flaw in the linkage of Australian research to Australian business. Frequently we do not have businesses that could benefit.

Universities and government laboratories are minor direct contributors to innovation. Other surveys within companies show commercial staff were twice as successful as the technical staff in choosing winners, but still had a success rate of only 55 percent. The worst performers were CEOs. This is a mirror of the position of academia, as the equivalent of the technical staff, with the government as the CEO.

Being in the right place, in the market and in the business, are key attributes for successful innovation.

Table 1: Sources of Innovation

Sources of Innovation	1980's Survey in Europe and USA+	UK Innovation Survey 2001++	Australian Innovation Survey 2003+++
Business-general trade	80%	79%	88%
Competitors	6%	5%	
Customers	8%	12%	
Higher Education	4%	2%	
Government Laboratories	2%	2%	
Total	100%	100%	100%

\+ *The Economist* 1986
++ UK Innovation Survey 2001 Economic Trends 580 March 2002
+++ Innovation in Australian Business ABC 8158, 2005

Table 2: Measures of Business Expenditure for 2002-2003

Business expenditure through:	R&D Expenditure millions	R&D Expenditure percentage	Royalties and Licence fees paid by business (millions)
Internal Group	$5,354	89.5%	
Other	$373	6.2%	
Higher Education	$174	2.9%	$64
CSIRO	$78	1.3%	$14
Total	$5,979	100.0%	$78

Sources: ABS, DEST

Distortion of research directions

There are fears that government policy may distort university research directions. There are four National Research Priorities set by the Federal Government:

- An Environmentally Sustainable Australia;
- Promoting and Maintaining Good Health;
- Frontier Technologies for Building And Transforming Australian Industries and
- Safeguarding Australia.

A whole of government approach aims to improve research and deliver significant long-term benefits. All government research and research funding agencies are to be judged against these priorities. However research with its own global marketplace will not be seriously affected by national priorities. Leading research universities will look at their particular areas of interest, hire leaders, present or future, and will contribute globally to their fields. We should expect that discoveries will have global appeal and be pursued by worldwide interests—and not contained within Australia.

There has been no study to our knowledge of possible distortions in research direction as a result of governments setting priorities. There is anecdotal evidence of distortions with researchers finding it easier to win funding with a commercial twist while regretting that it was not their preferred choice. There is also a temptation to claim a project is nearer to a commercial development state than is realistic.

In direct government funding of R&D through commercial grants such as Start and Commercial Ready, there are restrictions on how much of the grant may be spent overseas. The intent is to have work performed in Australia. This is a non-market intervention that can prevent work being carried out by those best qualified to do it. There can also be mismatched policies from government where departments have different aims, such as research funding and industry development, that have different time horizons.

There are overseas examples such as the UK industrial enzyme research funding of the 1970s, the Nixon 'War on Cancer', the Alvey programme for the computer industry that included research funding. None of these could be judged a success but whether they diverted research efforts is not known.

Universities and their contribution to Innovation

Universities make their contribution by the general education of graduates. Degrees in science, engineering and medicine may supply future technology based innovation. Degrees in the arts, law and commerce may do it for non-technology based innovation, a powerful area often overlooked. They enter businesses and the professions. They have to understand and solve problems in their own businesses. They have customers or clients who provide needs and opportunities.

Transfer of technology is most effective when people migrate out of universities and into business. The lessons are learned in business. Frequently staff depart to 'go out on their own'. The most famous example of this is the 'Traitorous Eight', the under-thirty engineers who walked out of Shockley Semiconductor in 1957. Robert Noyce and Gordon Moore went on to found Intel. Eugene Kleiner launched the premier venture capital firm Kleiner Perkins Caufield & Byers. These engineers along with the more mature founders of Hewlett-Packard seeded Silicon Valley. They used their wealth to fund the next generation of engineering entrepreneurs and so begat further wealth. (There is in fact a poster that shows the family tree of Silicon Valley starting from Fairchild Semiconductor.)

Research is part of a virtuous circle. Universities acquire prestige by being old and being good at research and their reputations attract good students. Second, innovations may still have their start in ideas, observations and

Table 3: Estimate of Innovation for 2002-2003

	millions	% Total Business Revenue (income)
Expenses paid by business		
Royalties and Licence Fees++	$78	0.01%
Business R&D at universities & CSIRO	$252	0.02%
Total Business R&D+	$7,167	0.44%
Total Business Innovation Expenses+	$20,297	1.24%
Revenue (income) received by business		
Total Sales generated from licences with an assumed 1.5% royalty++	$5,200	0.32%
Total Business Revenue (income)	$1,640,300	100.00%

+ from *Innovation in Australian Business* ABS 8158, 2005
++ a most uncertain value and upper limit derived from private communications from institutions with mostly overseas licensing.

interpretations. These are the classic outputs for university scholars. Their contributions are vital, as they 'know why' things happen, not 'know how' to make things happen.

Assessing the performance of the higher education institutions is best done within an education framework, taking into account international standards and education demand.

Measuring innovation

How to measure innovation and its precursors is an interesting and vexing question. The Innovation Report chooses measures that enable comparison with the OECD group of countries. Fifteen measures are grouped into knowledge creation, human resources, finance, knowledge diffusion, international collaboration and market outcomes.

Knowledge creation includes government and higher education and business Research and Development (R&D) as a percentage of GDP. R&D is defined as creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.

This measure is frequently used as the lead indicator for judging Australia's R&D performance against that of other countries. Its weakness is that OECD countries differ in their R&D mixes. Business R&D is particularly sensitive to R&D intensive industries.

Table 4 with selective country measures illustrates the difficulty of using the broad measures. There is no analysis of the industrial mix in Australia so that a more useful comparison could be made.

Australian Treasury economists have recently published two papers (Davis and Tunny, Economic Roundup, Spring 2005, Tunny, Economic Roundup, Summer 2006) that cast doubt on the use of gross R&D data as an indicator of performance. They suggest that industry structure and geographical context are important in determining expenditure.

Australia is a small country with few "high tech" businesses. Total Australian business R&D spending was $6 billion in 2002 while Intel Corporation spent US$4 billion. Intel on the other hand has a market capitalization of US$140 billion and a skill base that covers every aspect of semi-conductor and integrated circuit development. They are arguably the original source of the IT revolution with their enabling electronics. We cannot possibly expect to match such a skill base.

Foreign and local ownership of business also needs to be taken into account. International business tends to keep R&D close to headquarters.

While Australia's R&D expenditure is seen as average, GDP growth over ten years places Australia second in the OECD behind Ireland. As a result absolute R&D expenditure has been carried up with the GDP growth. Further a comparison with our performance in the 1980s shows that along with other low-tech countries, we have lifted our industrial R&D expenditure significantly as a fraction of GDP. This represents no more than the general industrial shift to the use of more advanced technology. Clearly high national R&D spending is not a prerequisite of growth over the medium term. Fifteen years after the Dawkin's era there should have been some detectable impact on national performance. Is there any evidence that R&D has driven GDP growth?

In order to probe further into R&D expenditure, it is necessary to examine industry activity. A good starting point is to look at fully integrated businesses that are corporations, are profitable, and have sales, marketing and manufacturing. The simplest measure is the level of R&D as a percentage of sales. This should be compared to the performance of industry leaders. Other measures are patent and trademark activity but these are indirect output measures.

Table 4: Estimate of Innovation for 2002-2003

	GDP % Growth	Total R&D	Business R&D	Business R & D				Higher Education R&D
	1992 to 2002	% GDP 2001	% GDP 2001	% Business R & D 2001				% GDP 2001
				High-tech	Medium high-tech	Low-tech	Service	
Sweden	29	4.27	3.31	49.1	29.1	7.1	12.8	0.83
United States	37	2.82	2.1	39.4	19.4	6.1	34.4	0.4
Australia	47	1.53	0.72	21.4	15.4	13.7	39.9	0.41

Source: OECD in Figures 2003: Selected data from Tables on pages 14, 70 & 72

Table 5 shows selective worldwide and local corporations. The R&D intense pharmaceutical industry reflects its foreign origin with R&D expenditure four times more intense offshore. Home-grown CSL and Cochlear (although medical devices) reflect their local origin of R&D. Likewise the local software companies are R&D driven as much as the overseas giants.

Mergers play an important part in where R&D is performed. GlaxoSmithKline has become a major multinational with research centres in Europe and the United States. Varian Associates has its local subsidiary perform at twice the level of the corporation as a whole. This is a result of its origins with Techtron and a highly successful laboratory analyzer. GM also shows relatively high R&D levels. All of this is probably also a reflection of the quality of scientists and engineers trained here.

Finally BHP Billiton and RioTinto, our giants who are frequently criticized for not performing enough R&D, are really victims of the narrow definition of R&D since driving their R&D is exploration.

The examples show that R&D has different intensities within different industries. Further, it does not reflect the full range of innovative activities. In particular it ignores exploration for the mining and energy sectors. Further past history may determine where R&D is performed and mergers and acquisitions all have a secondary influence

Table 5: Research and Development Expenditure

Company		Revenue	R & D	R&D / Revenue (%)
GM	Worldwide	$268,774	$9,028	3.4
GM	Australia	$6,395	$313	4.9
Ford	Worldwide	$204,353	$10,278	5.0
Ford (estimate)	Australia	$4,500	$78	1.7
GlaxoSmithKline	Worldwide	$47,302	$6,586	13.9
GlaxoSmithKline	Australia	$1,169	$39	3.3
Eli Lilly	Worldwide	$19,247	$3,738	19.4
Eli Lilly	Australia	$358	$14	3.9
CSL Limited	Australia	$1,840	$101	5.5
Cochlear Limited	Australia	$285	$44	15.4
Varian Associates	Worldwide	$1,272	$68	5.3
Varian Associates	Australia	$121	$12	9.9
Microsoft	Worldwide	$51,160	$10,804	21.1
Oracle	Worldwide	$14,106	$1,775	12.6
Solution 6 Holdings	Australia	$180	$34	18.9
MYOB Limited	Australia	$90	$12	13.3
BHP Billiton	Worldwide	$25,393	$26	0.1
BHP incl. Exploration	Worldwide		$631	2.6
RioTinto	Worldwide	$19,632	$35	0.2
RioTinto incl. Exploration	Worldwide		$303	1.7

Sources: Annual Reports and IPRIA Report 2005

Government undermining innovation

One of the golden rules of public policy is 'first do no harm' and this rule is where government should focus. Governments—at state and federal level—are undermining the innovation process, limiting the funding and development of science in many areas even those that are government priorities.

Biotechnology

For example, biotechnology is a major focus of government funding and assistance. It is seen as a driver of innovation, new business and products. Governments, at all levels are spending hundreds of millions of dollars of taxpayer funds every year to train biotechnologists, undertake research, develop biotech products and businesses and promote the commercialization of products.

While much is made of biotech applications in the medical fields, the truth is that the scope for full-scale commercialisation of biomedical product in Australia is greatly limited by the size of its market, the absence of large, local firms and barriers to overseas markets. Most local biomedical discoveries will be developed overseas particularly in the US where the market is huge, prices not regulated or capped by government and where the regulatory approval is essential to worldwide success.

Australia's greatest potential lies in the application of biotechnology to agriculture and food. Here the local markets are large and there are many large firms that export to the world. In addition there is a large local research base, a body of expertise and an industry with a long track record of innovation and a need to continue innovative developments.

Governments recognize the potential of agricultural biotechnology yet five states have placed moratoriums on the use of new biotech crops. They have applied these bans to the use of GM Canola despite the crop gaining clearance from the gene technology regulator. The moratorium is based on the need to protect the overseas markets of domestic Canola producers. Yet all the evidence commissioned by the said governments clearly indicate that the crop poses no threat to markets, on the contrary, the failure to adopt the technology poses a real threat to the viability of the growers.

The Northern Territory has put in place a ban on local development and use of GM Cotton. Western Australia is currently considering a similar ban. This ban comes despite the unequivocal and documented success of GM cotton elsewhere in Australia.

As a result of these bans, research into agricultural biotechnology is being restricted, commercialisation trials are going off-shore, research facilities are closing, business opportunities are being lost and the viability of growers is under threat.

Nuclear energy

The development of nuclear energy and the production and disposal of nuclear fuel are now back on the world's agenda, with hundreds of new nuclear plants on the drawing board.

Despite Australia having the largest know reserves of uranium and being the second largest exporting country for yellow cake, Australian Governments have effectively banned the commercial use of nuclear technology, other than the small reactor at Lucas Height that is used largely for nuclear medicine.

As a result, the expertise and research in nuclear energy in Australia is all but lost. In fact there is more local knowledge invested in windmills than nuclear energy despite the later generating 20 times more of the world's energy both at present and into the future.

In the 1960s and 1970s Australia had developed world class expertise in various area of nuclear energy including the crucial area of waste disposal. As a result of government bans, this research has not advanced. Given that Australia provides the most geological and politically suitable sights for large scale disposal of nuclear waste, this loss of knowledge, skill and innovation has been costly.

Again as with restriction on biotechnology, the most potent contribution of government to the advancement of science and innovation in nuclear energy is to remove the unwarranted restrictions on it.

Stem cell research

A similar scenario exists for stem cell research. Governments, federal and state, simultaneously promote research and development into stem cells while placing restriction on the collection of embryonic stem cells for research purposes.

It is recognized that unlike the ban on biotech crops, the restriction on the collection of embryonic stems cells for research purpose does have wide spread public support.

Communications technology

It is entirely possible that the regulation of media and telecommunications has limited innovation. The choice of frequency bands and the setting of broadcasting standards for 'high definition television' and the invention of 'datacasting' may isolate Australia technically. However, the spread of the internet, like a new nervous system, with its accumulating functions may well save us from isolation.

Conclusion

Australia possesses few fully integrated 'high-tech' companies. We have a beginning but it takes ten to twenty years to build a substantial business.

How can government assist? It is remote from the action. Its bureaucracy does not get direct market signals. So governments should not be too prescriptive in setting research directions. They should support infrastructure and ensure a continuing high standard of general undergraduate education. It should be possible to establish an encouraging regulatory framework, both technical and financial, so that development is not constrained. Progress will be made more by example than policy.

Governments should not think that research will directly lead to wealth creation or that royalties will be an important source of revenue for higher education.

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