Submission to Productivity Commission Study of Public Support for Science and Innovation in Australia

(i) Analytical methodology to characterise innovation: Econometric vs Complex System view

The chaotic non- linear ecosystem nature of successful innovation lends itself more to complex system analysis than to more traditional econometric models. The latter tend to be based on a value chain approach, where there is a sequence to the flow, and value is generated as risk decreases. IP is a currency in this model and the public policy emphasis is focussed on interventions which mediate or respond to risks associated with market failure.

In complex system analysis, on the other hand, the structure is not rigid but rather emerges from autonomous players making (local) choices that result in collective value. IP is less important as a currency, and there are benefits from unintended consequences of actions, as much as from identified externalities and spillovers. The public policy emphasis needs therefore to be on the creation of the environment in which the players can act. A complex system may not be rigid but this does not compromise its robustness.

An important difference in approach flows from the above distinction: in econometric analysis specific variables may be selected for management, whereas in a complex system such micro management will be counterproductive, if not destructive.

(ii) Market failure vs market success: in search of the global niche and the role of public policy

There is an interesting reversal occurring in the role of public policy – to the extent that such policy is directed at preserving the economic and social well being of a nation's citizens: whereas, in a closed national market system, there may be an argument for the role of policy being to compensate for market failure, the situation has changed dramatically, with national systems now fully exposed to the global market system. The focus of public policy in this context is to compensate for market success, ie for the success of the global market and its consequences for the local national market.

In Australia's case, the potential for economic gravity to drain our intellectual capital and intellectual property to larger, higher investing, markets is already observable. So too, however, is the success is those instances where a niche capability has been developed – very often with government policy support, at least in the early stages – and achieved enough scale to compete on a global scale eg Cochlear (cochlear implants/Melbourne Uni basic research/public interest grant/R&D tax concession); Bishop Technologies (supplier of technology to the global automotive supply chain); Mining services exports(significant mining technology research via CSIRO); Premium wine exporters (research funded industry by with, state and federal/CSIRO support). In each of these cases the initiative was taken by industry, based on the opportunity of the global market niche, but the contribution of public policy support was pivotal in businesses acquiring the necessary level of scale and capability to secure a position in the niche.

There is a cautionary note to add to the encouraging evidence provided by such examples of global niche success, and that is the increasing divergence between business interest and national interest. Once businesses become global players, even in a niche capacity, increasingly their strategic decisions will be framed by their global performance parameters and not necessarily by what is in Australia's best interest. Public policy is now faced with the challenge of facilitating and optimising congruence in the face of this divergence of interest. This in turn requires a strategic approach to the knowledge economy and innovation policy.

[Ref: Zerbe, R. and McCurdy H 'The Failure of Market Failure' 1999]

(iii) Innovation Strategy Framework model: technology maker vs technology integrator vs technology taker

An effective innovation strategy requires the development of a framework within which mutually consistent and reinforcing policies can be developed, and actions taken, by both government and industry. Such a framework requires that Australia have a clear mental model of its positioning relative to other countries' strategic innovation system frameworks.

The scale of Australia's annual investment in R&D at approx A$13bn, compared with say that of the USA at over US$250m, clearly precludes Australia from positioning itself as a broad based maker of fundamental science and technology. Nevertheless, nor should it assume the default position of being a technology taker ie fast follower or adopter: without labouring the point, such a strategy may be viable for one round of technology acquisition – (even assuming that a knowledgeable purchase can in fact be made by those not actually engaging in any form of technology development) – but the inability to earn a premium, on what will be effectively a me-too technology based product/ service, will limit the ability of the firm to re-enter the market and afford the next and succeeding generations of the technology.

What Australia has repeatedly demonstrated is its world class capability as a technology integrator. That is, an ability to combine early stage technologies, domestically developed and/or acquired internationally, using innovative design approaches, to produce competitive product/service bundles which command a value added premium in the market place. There is anecdotal evidence that this technology integration capability derives, at least in part, from a cultural propensity to find lateral solutions to problems. The medical devices industry in Australia (eg companies such as ResMed and Cochlear) owes its internationally competitive position to innovative technology integration – interestingly one of the core technologies being micro machining technology developed in the Australian automotive industry. Also significant in both cases was the fact that the platform in which the technology integration and subsequent commercialisation success was anchored was one of rigorous, publicly funded, basic scientific research - by Professor Graeme Clark at Melbourne University in the case of Cochlear, and by Professor Colin Sullivan at Sydney University in the case of ResMed.

Adopting a technology integrator posture in developing a strategic framework for Innovation Policy in Australia would provide a focus for public policy initiatives to capitalise on this inherent competitive advantage. These initiatives could include

- Focussing on investment in platform technologies which contribute to technology integration capability eg ICT, biotechnology (as a platform not a product), nanotechnology and advanced materials science
- Promoting multidisciplinary research models to deepen the capability in integrating at the interface between disciplines
- Enhancing the interaction between the research sector and industry particularly at the undergraduate level with the intent of encouraging the concept of iterating between research and industry product development in real time
- Actively pursuing adjacency strategies – identify fields in which Australia has a global competitive advantage and look for adjacent sectors which could become competitive through further technology integration

[Refer 'New Forces at Work: Industry Views Critical Technologies' RAND Corporation 1998]

(iv) The Cochlear story: Australia's innovation system at work

The question is often asked “why can’t Australia produce more companies like Cochlear?”

The answer lies in the fact that Cochlear represents an example of an extraordinary conjunction of factors – elements in the innovation system- which could not have been predicted or planned and which drew on the benefit of decisions made by individuals over decades. In complex systems terms, it was the result of autonomous players making (local) choices that resulted in collective value.

Briefly, the factors in Cochlear’s success include

- Paul Trainor and Nucleus Limited: Paul Trainor was a true entrepreneur who had a vision for a medical technology industry in Australia. He acquired very early stage pacemaker technology, which became the basis of the Telectronics Pty Ltd business, and established Nucleus Ltd in the mid 1970s to be the holding company for Telectronics and the other medical technology business he started and/or acquired;
- “One in Ten” survivor: Cochlear was nurtured under the Nucleus Ltd umbrella and is the stand alone commercially successful survivor from the portfolio of technology businesses once owned by Nucleus. It benefited from the knowledge, management capability and funding capacity within Nucleus which protected it in the early stages of its technology development during the first half of the 1980s;
- Excellent science: Cochlear arose from the excellent scientific work undertaken at Melbourne University and initiated by Professor Graeme Clark in the early 1960s.
- Established hearing healthcare capability: Australia is one of the hearing healthcare centres of excellence in the world with deep capability in audiology and hearing assessment. This capability was the result of a conscious government initiative, (led by a far sighted bureaucrat), in the first half of the last century to address the hearing impairment suffered by Australian servicemen during the First and the Second World Wars. The unintended consequence of this decision was that both the Melbourne University research and Cochlear were able to draw on a sophisticated audiological skill base during the science and technology development phases.
- Government Support (via grant) at early stage: the Federal Government recognised the groundbreaking nature and social benefit possible from the Melbourne University research and effectively sought to establish a risk sharing partnership between the University, which contributed its IP, the government, which contributed a significant public interest grant, and a commercialisation partner which would contribute the cost of product development and subsequent commercialisation and pay royalties to the government and the University on revenue generated. A tender seeking a commercialisation partner was issued in 1978/9 and Nucleus Ltd was the successful tenderer.
- Rigorous market knowledge: in preparing its submission to the tender, Nucleus invested significant effort in understanding the market potential for cochlear implants (CIs). Such potential was not obvious: CIs involve surgical penetration of the inner ear, which was an anathema to ENT surgeons and their training because of the fragile structures of the inner ear or cochlea. Nucleus had to assure itself that it could overcome this structural impediment and convince enough leading ENT surgeons in the USA and European markets to become champions of the new technology. In the event, Nucleus decided to take on the market development risk and proceeded with its tender submission. It is instructive to note that from the outset Nucleus/Cochlear was intent on establishing a global niche.
- Technology integration skill: Cochlear was able to leverage the engineering and technology integration skills in the Telectronics (pacemaker) division of Nucleus, including biocompatibility and hermetic sealing technologies. It is no accident that the early cochlear implants looked like mini pacemakers!
- Benefit of business expertise and networks: Paul Trainor was a businessman, rather than a scientist, and had established access to business and government networks which enhanced access to scale up funding;

- Business model established before IPO: Operating under the Nucleus umbrella enabled Cochlear to establish its business model and reach above breakeven financial performance before pursuing the IPO path.

There is more detail underpinning the above broad outline, but the key aspects to note are the long time frames involved, the contribution of the significant investment in publicly funded research, the value added by technology integration within Nucleus, the unpredictable sequence of events and individual's decisions, and the critical role of government acting as a catalyst in bringing elements together and in explicitly recognising the need to share risk initially, because, left to itself, the market would assess the risk as unacceptably high.

(v) Australia's market gap in BERD: the reality of Australia's industry structure and risk bearing capacity

There is much focus on the low level of BERD in Australia and on measures to secure its increase. However, an analysis of BERD expenditure patterns in terms of industry structure suggests the following approximate breakdown of contributors to BERD:

MNCs	40%
SMEs	50%
MLEs (domestic)	10%

Even if this analysis varies marginally from year to year, what it does reveal is that Australia's industry structure results in a market gap in terms of large domestic corporations with significant research facilities providing sustainable research capability in Australia:

- Multinational corporations will adjust scale and location of R&D investment according to their global strategies, often to Australia's detriment, as was the case after the technology sector collapse and the withdrawal of R&D capability from the Australian ICT sector by Ericsson and Lucent, and significant downscaling by Alcatel and others. To suggest to MNCs that they should spend more on R&D because of Australia's national need will not be a compelling argument.

- SMEs characteristically suffer from both lack of scale and tenuous sustainability, and therefore exhorting them to spend more on R&D will be problematical – they are often already spending at or beyond their means.

- Domestic MLEs are the subgroup that can and do invest consistently in R&D, but even if they were to commit to a significant increase, the overall in increase in Australia's BERD is constrained by their limited proportion of total BERD. Further, a more granular analysis of the R&D investment being made by domestic MLEs would reveal an increasing component of offshore-based R&D as part of their total R&D spend.

- Further, larger corporations (MNCs and MLEs) are withdrawing from the higher risk end of the R&D value chain ie from the R and the early stage D, leaving these high risk research and early stage technology activities to be borne by governments through publicly funded research. This decision to withdraw is evident globally in industries such as pharmaceuticals, mining, medical devices, telecommunications – because the complexity and specialisation of the technology elements in products is increasing exponentially and hence so too is the risk in their development. These corporations seek to offset this risk through collaboration with governments via publicly funded research –through engagement with knowledge infrastructure institutions and/or government funding of corporate R&D.

The investment in publicly funded R&D in Australia addresses the issues raised above in two ways:

(i) by providing sustainable research capability at scale, from which industry can draw, it compensates for the BERD market gap in Australia's knowledge infrastructure resulting from the SME dominated industry environment;
(ii) more importantly, it provides the basis for risk sharing between government and industry in terms of the development of new science and technologies. Put bluntly, unless government is prepared to underwrite significant risk through the support of publicly funded research, thereby compensating for the increasing risk aversion in larger industry participants, the resulting low risk capacity in the economy will deliver a low return outcome. The risk- return relationship will prevail.

The key question for Australia then becomes not how to increase BERD but how best to achieve the knowledge transfer from the research sector to industry.

[For further discussion on knowledge infrastructure refer to the Submission to House of Representatives Standing Committee on Science and Innovation into Pathways to Technological Innovation – Professors Keith Smith and Jonathan West, 2005]

(vi) The Knowledge economy: from R&D intensity to Knowledge intensity via knowledge transfer

The study commissioned by the Australian Business Foundation: 'Innovation and the Knowledge economy in Australia' by Professor Keith Smith, 2005 highlights the concept of knowledge intensity and makes the clear distinction between that and R&D intensity. The study argues that innovative firms are those which are knowledge intensive, where that knowledge may be R&D based as well as including non R&D inputs such as market research. It is the use of the knowledge and learning by doing which is the key to innovation, not the accumulation of the knowledge alone.

Given the nature of Australia's industry structure and its consequences for BERD, the innovation effectiveness of publicly funded R&D could be increased by measures which facilitate the transfer or flow of knowledge from universities and PFRAs - to SMEs in particular- thereby enhancing their knowledge intensity. Such measures could include further promoting the engagement between the research institutions and industry on a sectoral level, such as achieved through Australia's successful RDC model, or public policy measures specifically targeted at the impediments of scale- mismatch and financial capacity often faced by SMEs and universities /PFRAs when interfacing with each other.

It is important to note in the context of knowledge transfer, that SMEs play a critical translational role in the economy, taking science and early stage technologies from the research sector and developing them further, (thereby reducing the risk attaching to those technologies), such that they are attractive to larger corporations, either as inputs into their product development process or filling a gap in their product portfolio. This process can result in significant value addition if the SME survives the risk-bearing phase and secures the premium on transfer into the value chain of the larger corporation. Conversely, should the SME fail, its intellectual property (IP) becomes stranded and vulnerable to acquisition at distressed valuations, often by non-Australian interests. There is therefore an imperative for public policy to mitigate the leakage from Australia's innovation system of publicly funded IP during this SME translational phase.

Australia's biotechnology industry sectors are a clear illustration of this translational phase in action – and also of the reality of the IP leakage risk.

(vii) *The distinction between science and technology: the critical role of innovation technology tools*

Science alone will not yield innovation. It is a necessary but not sufficient condition for technology based innovation.

Science is about knowledge; technology is the application of that knowledge to a way of doing things – an 'invention'; innovation is the creation of value (either revenue generated or costs avoided), often, though not always, from technology. Nevertheless, services innovation, too, often relies on embedded technology. Australia must not fall into the trap of regarding itself as moving towards a services based economy and therefore one less dependent on technology. Sustainably competitive services are increasingly technology based.

Thus, to achieve science- based innovation there must also be a healthy capability in developing technology from that science. Such capability draws heavily on engineering and industrial design skills generally – and is most effective when applied in an iterative way in conjunction with the scientific process.

In this context, there are critical innovation technologies which can be applied to the innovation process to make it more successful and reduce the cycle time to outcome eg grid based computing, modelling and simulation tools, artificial intelligence, visualisation technologies including virtual reality, instrumentation, data mining and rapid prototyping.

[For further discussion of innovation technology and examples of this dynamic working in practice refer to 'think, play, do – technology, innovation, and organization' Dodgson, Gann and Salter].

One of the key benefits of publicly funded research has been the development of innovation technology tools which can then be accessed by other researchers and industry. Many of these technologies themselves, of course, derive from fundamental science, and are a very effective form of knowledge transfer from the research sector.

The role of publicly funded research in the creation of new instrumentation was specifically identified by Salter & Martin ['The Economic Benefits of Publicly Funded Basic Research: A Critical Review' 2001]. The calibre and sophistication of the innovation technology tools developed from publicly funded research is a contributor to the rate of productivity, (measured in terms of both the rate of successful outcomes and reduced cycle times), of the delivery of innovation from invention.

Examples of the range of such tools developed by CSIRO include an atomic absorption spectrometer, the VICCU telemedicine technology and a forestry analysis methodology.

(viii) Technology push vs market pull: industry, innovation and the problem solving imperative

Australia has tended to have a science -centric view of innovation and one which has emphasised transformational or breakthrough innovation, often diminishing the importance

of incremental innovation. This has resulted in a technology push model of innovation tending to predominate and a view that Australia is not good at commercialisation.

Innovation is fundamentally a problem solving dynamic, where the problem is best identified by the market which is therefore willing to pay for a solution. The more demanding the customer, and the harder the problem, often the more innovative the solution. A solution without a problem is the hardest point from which to approach commercialisation.

This is not to deny the critical value of research, but rather to highlight that the appropriate task of the research sector is to 'transfer' knowledge, not to 'commercialise' knowledge. The effective transfer of knowledge nevertheless requires a good understanding of the 'problems' needing to be solved by recipients in the market, paths to those recipients and the ability to establish collaborative relationships to achieve a mutually beneficial outcome.

The technology push model of commercialisation, by requiring that value be appropriated from IP by the research sector at its point of departure from the research sector sets up an irrevocable conflict with the market – which usually values the IP at nil at that point because of the high technology and market risk involved in commercialisation. This conflict impedes the flow of IP from the research sector and transfer of knowledge to the market.

While BAA I and II have been useful early approaches to an innovation policy framework, the three existing themes of people, ideas and technology (push) commercialisation now need to be complemented by a fourth theme which brings the market and customer clearly into the frame. This fourth theme could address lateral policy initiatives focussed on market pull knowledge transfer and avoiding the current conflict over IP valuation. It could also encompass the role of government as a demanding customer ie government explicitly driving demonstrable innovation yields from government policy investments which will be made in any event eg in health, education, environment, defence, water infrastructure.

Finally, a focus on the absorptive capacity of Australia industry is urgently needed. While investment in research and knowledge infrastructure is vital to Australia's economic well being, this outcome will only be achieved if it is possible for significant value capture from that knowledge to occur through Australian industry. Knowledge, (intellectual capital and intellectual property), is globally mobile and will respond to economic gravity. Unless Australian industry has enough gravitational pull in the form of scale, management capability and funding it will not secure the knowledge it needs to prosper.

One of the greatest opportunities facing Australia currently is to be a significant participant in the Bioeconomy. Grasping this opportunity will require intent, focus, coordination, investment and the setting of national outcome goals. This is beyond the natural capability of market forces in Australia given the risks and scale of investment involved and strength and rapid time frames of the global market.

Innovation policy will have to make investment choices – it is not a question of picking winners but rather of creating a portfolio of options. It is suggested, however, that in making these choices policy makers have regard to a complex system model of the innovation environment, rather than an econometric model.

(ix) Institutional innovation

An important element of a national innovation system is the rate at which its institutional framework innovates. In the 2005 Australian Innovations Systems report "No Simple Solutions" commissioned and funded by the ARC, ANU, ABF, DITR, DAFF,DOCITA and CSIRO, one of the key findings was that innovation strengths have as much to do with the depth and integrity of institutional innovation as with the opportunities coming from technological innovation.

In launching the report, the project leader ANU Professor Don Scott-Kemmis, noted that the rate of change of technologies and of industry sectors, as they seek to adjust to globalisation and specialisation, poses particular challenges for policy makers. He drew on the example of the internal combustion engine and the way it led to innovation through mass production systems: the technology was invented in Europe but was implemented in the USA, not because Europe didn't have the capability, but because there was a lack of vision and ossified institutions.

Australia's institutional frameworks have generally been a source of competitive advantage in a global context. There is however an increasing challenge, in the face of demands for greater regulation across many sectors – including demands being driven by regulators of other countries – of ensuring that the freedom to operate of Australian businesses is not compromised to Australia's competitive disadvantage. This issue is more complex than simply reducing the 'red tape' burden, and goes to the heart of integrated policy frameworks which have regard to Australia's national competitive advantage.

(x) Know what we already know: time to act

There is a final point to make and that is the need to acknowledge the imperative of global cycle times and the rate at which other economies are developing innovation strategies – and not just India and China.

In a frightening analysis by Prof Mark Dodgson, Director of the University of Queensland Technology and Innovation Management Centre, he notes: "I have 75 Reports on innovation in Australia published over the last 12 years. We've looked at cross-citations. There is a grand total of 22. The mode number of cross citations is 0. The maximum number of citations of a Report by others is 3."

We should focus on what we already know and act.

Catherine Livingstone,
2 August 2006.