NSW Government Submission to the Productivity Commission's Study into Public Support for Science and Innovation

September 2006

Executive Summary

Australia's science and innovation system plays a critical role in supporting the nation's economic prosperity and social and environmental wellbeing.

A strong research base occupies a central role in the innovation system, by creating, and supporting the adoption of, innovation. The knowledge it provides can generate improvements to service delivery, evidence-based decision-making and economic productivity. This base further develops the nation's knowledge and skills stock by training and educating students and industry, and diffusing new knowledge gained from its linkages to international research networks.

The NSW Government believes that Australia requires an effective innovation system to meet its key economic, social and environmental challenges. This submission raises a number of issues and recommendations aimed at improving the effectiveness of this system:

- The need for improved Commonwealth-State consultation and collaboration as to priorities for science and innovation that will fuel areas of comparative and competitive advantage. The NSW Government believes that this can lead to improved outcomes in a number of areas, from program design to improvements in the current system oversighting clinical research.
- Removing barriers and developing mechanisms to encourage greater engagement by potential clients, especially small and medium enterprises, with publicly-funded research centres. Key concerns include the need for research organisations to balance their commercialisation goals with broader innovation system support requirements, contractual complexity and negotiating appropriate access to intellectual property.
- The need to improve evaluation measures of research centres and projects. Developing a consistent and comprehensive method of evaluating performance is critically important to giving confidence to government and the community about the value of public support for science and innovation. Such measures need to appropriately consider the time lag between commencement of research and the adoption or commercialisation of its results, the issue of attribution, and the difficulty in measuring environmental and social impacts.
- The importance of "patient capital"(i.e. investment that recognises the long timeframe required for many science and innovation projects to produce commercial returns). The Commonwealth Government needs to be prepared to not only invest in long term science, but also to provide funding stability, with appropriate performance measures. This will allow better alignment of funding with research activities and timing of outcomes, allow research centres to focus on their core strengths, and support the development of critical mass in personnel and facilities.

1 Introduction

The NSW Government provides support to science and innovation activities in NSW across a range of subject areas and in a number of ways. The benefits of, and outcomes from, such investments include the creation and commercialisation of new innovations, improving the local skills-base, establishing and maintaining linkages to international research and networks, improving decision-making in business and government through better understanding and knowledge, and ultimately improving the productivity of the State's economy.

Resources need to be provided to facilities that create new knowledge, as well as programs that diffuse or promote the uptake of research and technology.

Australia has recognised research strengths in a number of 'traditional' sectors, such as agriculture and resources. Continuing research and development in these sectors should be supported, given Australia's comparative advantage in these primary industries, the clear impacts of increased productivity arising from research findings, and the support of the industry base, which co-funds such research in many cases.

Public funding is also required to support the development of emerging technologies and the service industries which now dominate the State and national economies. The strategy settings must be oriented to a balance between current research strengths and support for developing new capabilities.

The NSW Government is currently engaged in a process to identify those industry sectors where innovation is driving productivity improvements and economic growth. With advice from Professor Jonathan West (School of Management, University of Tasmania and Director, Australian Innovation Research Centre), the NSW Government is looking to further improve the linkages between its industrial comparative advantage and research and development support.

Research has to be diffused to ensure maximum community benefit. This can be achieved through a number of mechanisms, including commercialisation by spin-offs or licensing, or through extension programs, publications, alliances, collaborations, staff secondments, contract research or consulting services. These activities should be facilitated by initiatives to support the uptake of new technologies by companies.

This submission provides an overview of the support the NSW Government provides to the State's innovation system. A number of issues that are inhibiting the national innovation system are raised. Finally, it provides a brief discussion of the NSW Government's experience in project and program evaluation. A number of case studies have been included throughout the submission to provide further details of various science and innovation related activities and processes undertaken by NSW Government agencies.

2 NSW support for science and innovation

The NSW economy is the largest sub-national economy in Australia and is critical to the country's competitive position in the global economy. The NSW Government's investment in science and innovation makes an important contribution to Australia's knowledge economy.

NSW has acknowledged research strengths in:

- Information and communications technology, including high performance computing, informatics, high capacity communication networks, complex, intelligent and autonomous systems, digital content, and financial markets and business systems.
- Biotechnology, including medical devices, medical and biopharmaceutical, and environmental science.
- Agricultural sciences, including plant and animal sciences.
- Nano-materials science, such as advanced materials, nano-electronics, nano-biotechnology and quantum computing.
- Sustainability technologies, including energy generation and storage, photovoltaics, water quality and waste recycling.
- Physical sciences including astronomy and astrophysics, physics, chemistry and engineering.
- Planning and implementation of large scale international and multi-centre clinical trials across a range of clinical indications.

The NSW Government plays an active role in supporting research and innovation by:

- Undertaking direct research in a number of Government agencies, and providing a platform for new technologies and techniques developed by the private sector in many others.
- Promoting industry access to the research sector and commercialisation activities, including establishing market-based mechanisms to support the uptake of new technologies.
- Providing directed financial and in-kind support to researchers throughout NSW in universities, and various research institutes and centres.

The Commonwealth Government is well placed to determine national research funding priorities, as well as providing overarching support for science and innovation. However, States and Territories, also have a critical role, as this level of governance is closer to the science and innovation research centres, the businesses and the special interest communities that benefit from public support.

Attachment A provides some examples of NSW Government programs and projects.

2.1 NSW Government involvement in research

The NSW Government recognises the important role that science and research plays in supporting the core business of Government. Science in its broadest application, and the outcomes it generates, are crucial to equipping NSW Government agencies with the requisite knowledge and expertise to inform such activities as service provision, leading-edge engineering and construction applications, policy development, preparedness for major incidents, and in driving economic development.

Science activity is undertaken within a number of NSW Government agencies including:

- The Department of Primary Industries.
- The Department of Commerce.
- The Australian Museum.
- The Royal Botanic Gardens.
- The Department of Environment and Conservation.
- The Sydney Catchment Authority.
- Sydney Water Corporation.
- The Department of Natural Resources.
- The Department of Health.

These activities range from strategic basic research through to applied and translational research.

Supporting science and innovation in NSW: Department of Primary Industries

The primary industry sector, which includes the agriculture, forestry, fisheries and mining sectors, is important for both the NSW and Australian economies. Whilst it represents only 3.9 percent and 8.7 percent of the NSW and Australian economies respectively, it generates nearly 29 percent of NSW's, and over 46 percent of Australia's, export income.

The Department of Primary Industries (DPI) provides support for the development of primary industries that enhance the NSW economy through the sustainable use of natural resources. DPI has a significant science and innovation capacity and has recently been ranked in the top 1 percent of world research institutions in agricultural science, and plant and animal science.[1]

This capacity is predominantly located in the Department's Division of Science and Research. This Division has a budget of $131.7 million, manages a portfolio of over 700 projects, and has over 900 staff, including over 300 scientists based in a network of 31 Centres of Excellence, institutes, research and field stations across NSW.

The extension of science and innovation to industry from the Department is predominantly conducted by its Division of Agriculture, Fisheries and Regional Relations. With a budget of $118.5 million and over 300 staff, it represents the largest extension service in Australia.

DPI seeks to be responsive to industry needs as well as develop and introduce scientific innovation. Its close interaction with industry and other partners is reflected in the fact that 45 percent of direct investment in science and research at the Department's centres comes from these sources. The Department has found collaborative funding models, such as those of the Commonwealth's Rural Development Corporations, provide effective mechanisms for linking industry and research agencies.

The Department's activities play an important role in adapting agricultural innovations to local conditions. This is critical, as most agricultural technologies are sensitive to local climate, soil and other biophysical attributes, making them less easily transferable.

Australian agriculture operates in highly challenging climatic, soil and water environments. These challenges are likely to be exacerbated by climate change and emphasise the importance of Australia maintaining a strong, local R&D capacity for its primary industries.

[1] Thomson ISI (an international science indexing company).

2.2 Promoting commercialisation and industry access to research

Various agencies of the NSW Government are involved in programs which support and enhance the NSW innovation system. For example, the Department of State and Regional Development (DSRD) supports the research and development of new ideas and technology products and services by:

- Linking innovative NSW companies with universities and research organisations, thereby helping these firms explore new solutions and opportunities for investment or partnering.
- Assisting NSW companies to access public sector funding by contributing cash and in-kind to project proposals under Commonwealth programs.
- Assisting with commercialisation of technology-based products by identifying market opportunities in the public and private sectors.

The assistance provided to NSW researchers and firms by DSRD and other Departments covers a range of industry sectors and technology areas, and is predominately focussed on bringing science and technology companies closer to markets.

The NSW Government has also established a number of 'technology-pull' initiatives, such as the NSW Greenhouse Gas Abatement Scheme. The Greenhouse Gas Abatement Scheme establishes a local market for emissions reductions and greenhouse credits. While it aims to achieve reductions in total emissions at least cost to the economy, the Scheme also helps create a market for the development and deployment of innovative technologies in this sector, without favouring particular technology solutions.

Supporting Commercialisation and NSW Technology Companies: Department of State and Regional Development

Support for early stage commercialisation is provided through a number of business development programs such as the *Australian Technology Showcase*, *BioBusiness* and *Innovation Clusters*. In addition, there are targeted business initiatives, such as the *New Export Opportunities* program and the *Stepping Up* mentoring program, as well as the promotion of ICT excellence through expositions such as CeBIT Australia.

The *Australian Technology Showcase* began in NSW in 1997 as an initiative of the NSW Department of State and Regional Development; it is now a national program. The key aim of the program is to support the internationalisation of technology companies. Assistance is given to increase exports, license innovative Australian technologies, and attract foreign and local capital for technology development and commercialisation. Export grants are available for eligible companies to help them undertake market visits, participate in trade fairs and related activities, protect intellectual property, develop export-related promotional material, and for export/business improvement planning.

The *BioBusiness* component of the BioFirst Strategy supports the growth of companies and the commercialisation of research outcomes in the global market. A description of the *BioBusiness* program is provided in the evaluation section of this submission.

The *Innovation Clusters* program facilitates alliances and industry clusters to stimulate networking to create business opportunities, and boost the process of technology and information transfer between growing companies. DSRD supports innovation clusters in a number of areas including Sydney.NET Cluster, Northern Sydney IT Cluster and the Western Sydney IT Cluster (Australia's largest gathering of small and medium IT enterprises).

The *Stepping Up* program provides established business owners with training in current business growth issues as well as matching participants with an experienced business person who mentors the business owner.

The *New Export Opportunities* program helps rapidly growing small businesses to undertake export preparation and develop export market entry strategies. The program includes an initial free business growth consultation by a DSRD Business Development Manager, participation in trade missions/export market visits, and a one-on-one consultancy subsidy to partially offset the cost of employing a private sector consultant to develop an export development plan.

2.3 Engagement and collaboration with the research sector

The NSW Government supports leading edge research and development institutes, centres and organisations. Engagement with the research sector occurs through a number of collaboration models, including:

- Providing financial support to external research centres;
- Providing in-kind support to external research centres;
- Being a service provider; and
- Being a commissioner of research.

Examples of the research, and research and development organisations, which the NSW Government supports include:

- Nine Australian Research Council Centres of Excellence;
- Four Major National Research Facilities (MNRF);
- National Information and Communications Technology Australia;
- A number of other research facilities, including infrastructure support to the State's leading medical research institutes;
- Providing research grants and awards to build capacity in key research teams; and
- attracting researchers seeking to relocate to NSW.

NSW Government agencies participate in 21 Co-operative Research Centres (CRCs) (as at 1 July 2006), and are involved in a significant number of joint ventures, collaborative partnerships, and major science and innovation programs, such as those under the Australian Centre for International Agricultural Research, BioFirst, Natural Heritage Trust, and the National Action Plan for Salinity and Water Quality.

Government agencies, such as the Roads and Traffic Authority, NSW Greenhouse Office and Sydney Catchment Authority, commission and collaborate with established research organisations to undertake activities that develop new products, improve processes or seek to further develop scientific knowledge to underpin their decision making.

As a more detailed example, the NSW Government, through the Office of Science and Medical Research (OSMR), the Cancer Institute NSW and the Department of Health, provides significant support to biotechnology, science, health and medical research through various funding programs. The Medical Research Support Program provides infrastructure funding to institutes engaged in health and medical research in NSW. Other programs, such as the Premier's Fund to Promote Research into Spinal Cord Injury and Other Neurological Conditions and the Bio*First* Awards are focussed on supporting research excellence in NSW. The research programs of the Cancer Institute NSW have been strategically designed to specifically address issues of capacity, relevance and competitiveness raised by the Wood's Report and the Cancer Institute's own review of cancer research in NSW. The Department of Health also provides infrastructure support through the Capacity Building Infrastructure Grants program.

Innovation in NSW: Department of Commerce, NSW Water Solutions unit.

The NSW Water Solutions business unit actively partners with clients to provide NSW communities with innovative design approaches, cost effective measures and integrated water solutions to manage the State's limited water supply and to protect and enhance NSW's natural waterways.

The "deep water" access facility at Warragamba Dam is an example of its innovative activities. The Department of Commerce (commissioned by, and working with, the Sydney Catchment Authority) conceived, investigated, designed and project-managed the delivery of the infrastructure work to enable access to previously inaccessible water stored at depth within Warragamba Dam.

NSW Water Solutions has also:

- Developed a compact modular wastewater treatment plant configuration for small communities, with consequent capital cost savings and operational simplification;
- Contributed to further development of an Algal Bloom Warning System; and
- Co-ordinated specialised computational fluid dynamic modelling for research into measures to reduce vertical slot fish way construction costs on behalf of the Murray Darling Basin Commission.

Innovation has also been evident in projects aimed at managing risk within water infrastructure projects, such as:

- WS-SPEC (a master suite for water services specification) setting best-practice guidelines to procure strategic products for water infrastructure, especially cement and concrete;
- Manly Hydraulics Laboratory's monitoring of environmental water data that feeds into planning and logistical risk management of natural resource events such as floods, coastal storms, pollution events;
- Expertise for NSW Government concerning earthquakes; guidelines authored by SWS after the Newcastle earthquake;
- Advice and solution development for emergency drought measures; and
- Advice and solution development within the Snowy Mountains National Park regarding sewage contamination and emergency solutions after recent bush fires.

3 Impediments

3.1 Interaction Issues

NSW Government agencies' experience in dealing with various research organisations has been mixed. While some arrangements have been very positive, others have been difficult. NSW businesses have reported similar experiences.

Concern has been raised that the emphasis of certain research organisations on commercialisation has a detrimental effect on potential collaboration. While the NSW Government supports commercialisation as an aim of research, commercialisation of products and services should be seen as part of the research organisation's broader role as a storehouse of intellectual capability for industry and the community. Additional concerns also centre on contractual complexity, including inconsistent policy with respect to intellectual property.

Over the last few years, Commonwealth Government policy has required an increasing number of grant recipients in the public research arena to demonstrate commercial outcomes from their research activity. Commercial outcomes can be realised through three main mechanisms:

- Licensing of intellectual property to industry.
- Development of a commercial spin-off company to hold and develop the intellectual property.
- Traditional extension programs that enable the benefits to be disseminated to the respective industries and broader community rather than the agency involved.

The first two of these mechanisms have downsides for those business or community organisations that may be unable to meet the price of participation in such arrangements.

Of related concern is feedback provided by some businesses that a number of research organisations, or parts thereof, are beginning to view local businesses as competitors, rather than beneficiaries or collaborators to solve problems and enhance performance.

The Commission should investigate the costs and benefits to the broader innovation system of the Commonwealth's requirement that centres are to achieve a certain commercial return or level of self-funding. A renewed emphasis on measuring the quality of centres' collaborations across the innovation system is suggested. Likewise, a greater role for extension as a method of innovation transfer should be implemented.

Contractual complexity has also been raised as a problem inhibiting collaboration, especially for small and medium enterprises (SMEs). The issues relate to the multiple parties involved in contractual negotiations, as well as differences in the approach to intellectual property management, and the pressures on research bodies to obtain the highest possible price for the intellectual property (IP) generated.

3.2 Access by SMEs

Access and interaction issues with research organisations are of special importance to SMEs, who have limited financial, staffing and other resources to prepare applications and maintain collaborations. In addition to contractual complexity, specific issues relate to fairly valuing intellectual property and the difficulty that SMEs have in meeting demands for substantial and/or upfront payments for the use of intellectual property. As commercialisation of intellectual property

involves significant costs and risk, an approach that focuses more on the requirement to diffuse outcomes should be investigated.

In addition, SMEs report that they have encountered some difficulties in preparing applications to access Commonwealth funding. For example, the NSW Department of State and Regional Development has assisted AusIndustry to organise seminars devoted to filling in applications for its 'Commercial Ready' and similar programs. This should not be necessary, nor should special consulting services be required to prepare a successful bid for funding.

Similar issues also apply for access to major research facilities. Whilst the NSW Government generally supports an element of cost recovery, it is important that fees do not prohibit SMEs from approaching these facilities.

3.3 Role of CSIRO

CSIRO carries out the widest scope and quantum of research, relevant both to the public and private/industry sectors, of any single agency in Australia. While there are a number of other Commonwealth Government funded organisations, including ANSTO, AIMS, and DSTO, the CSIRO is a fundamental component of the research and development landscape of Australia, and has the potential, through some realignment of its commercialisation and intellectual property protection policies, to play a greater role in the economic, environmental and social landscape of Australia.

In this context, the national innovation system could benefit from a clear description of the role of CSIRO and its Institutes, particularly in terms of commercialisation and access/provision of research to external parties.

3.4 Oversight of clinical research

The Commission should note concerns with the current system for oversight of clinical research, which forms the basis for most commercial biomedical innovations. The current Therapeutic Goods Administration Clinical Trial Exemption scheme has failed to provide a timely and cost-effective review mechanism. It has placed a burden on State Governments to establish state-based mechanisms for scientific review of human clinical trials to ensure scientific validity, safety and efficacy. The lack of a nationally robust scheme of scientific review, particularly of early phase trials, may have the potential to impact on Australia's ability to become globally competitive in attracting research activities.

4 Program Design

4.1 Improved Commonwealth-State Government Engagement

Commonwealth Government funding programs for science and innovation increasingly seek co-investment from other sources, particularly State and Territory Governments. This approach can be flawed if it fails to recognise the differing roles of the two levels of Government under Australian federalism. As major investors, the Commonwealth should leverage State involvement based on critical mass and research excellence, not the level of State funding available.

To date, co-investment has been sought on an *ad hoc* basis, as there has not been a mechanism for engagement between the Commonwealth and State and Territory Governments to discuss funding programs and develop collaborative approaches. Until the development of the National Collaborative Research Infrastructure Strategy (NCRIS) process, participation by States with Commonwealth science funding programs tended to be through the channel of the researcher bidding for the grant, rather than through direct contact with the Commonwealth.

Commonwealth funding agencies should work in close consultation with relevant State and Territory agencies if State-level funding is to be sought and the design of Commonwealth funding programs seeking State Government co-investment should also incorporate reference to the strategic and service delivery priorities of State and Territory Governments. Developing programs in isolation is unlikely to deliver the best results for either the Commonwealth or State Governments to achieve their respective policy objectives. The NSW Government would like to see a greater commitment to consultation with the States at the design stage of funding programs for science and innovation.

Commonwealth-State interaction would also benefit from improved alignment with State Government planning and budget cycles. For example, the NCRIS process does not match State and Territory budget cycles.

Comment on National Collaborative Research Infrastructure Strategy

NCRIS, which is currently under development, aims to establish a coordinated national system of accessible and priority research infrastructure. The Commonwealth has sought input from State and Territory Governments. This input will help identify current research capabilities and issues in each of the jurisdictions and will be used in assessing NCRIS investment proposals.

The NSW Government encourages the consultative approach used to date in development of the NCRIS program, as it will give greater confidence to State and Territory Governments considering co-investment. However, the design and investment architecture of NCRIS will not be known until late 2006. It is evident at this stage that the program is being developed over a very constrained timeline and that this is unlikely to give funding organisations sufficient time to assess investment proposals.

As the NCRIS process has not yet been finalised, there also remains concern that the quantity of State funds available will count for more than the quality of State research infrastructure and existing State capabilities in national priority areas.

4.2 Funding to Support Excellence

NSW has argued that Commonwealth research funding should be provided to institutions that are best able to carry out the research. Skewing decisions based on the ability to leverage funds, rather than national research capacity, is inefficient from a national perspective. Resources are expended in developing capabilities that are already in existence at other sites, rather than on enhancing the capabilities of the established research leader. Fragmenting resources to multiple sites in the same

field risks an erosion of Australia's knowledge base, as scarce skills are likely to become dispersed as centres compete for talent.

The NSW Government considers that the Commonwealth's programs should seek to enhance Australia's existing research facilities. It should build, where possible, on existing infrastructure, critical mass of scientists, and collaborative arrangements between state departments, universities, R&D corporations, industry and/or other Commonwealth major research bodies.

This is not to say that new facilities and regional capabilities will not evolve or develop, but the movement of resources to these areas should be based on deliberate strategic policy drawn from a critical analysis of local needs and competitive strengths, rather than the availability of matching funds.

NSW Science Leveraging Fund

On 23 February 2006, the NSW Government announced the establishment of a Science Leveraging Fund. The Fund will support NSW science investment proposals seeking funding for research and development, infrastructure, and capacity building. The Fund was established in order to attract greater Commonwealth, international and philanthropic funding support for the NSW science community. From 2006-07, $40 million will be available over four years to position NSW as the headquarters for major scientific research projects and Cooperative Research Centres.

The Science Leveraging Funding will be competitive and merit based fund, coordinated across Government and allocated according to State priorities. The Fund will ensure that NSW has the resources to invest in important research and development activities and demonstrates the NSW Government's commitment to locating major scientific programs and facilities in the State. The fund also provides the flexibility to ensure resources can be made available outside the State Budget cycle.

4.3 Communication between States, Territories and the Commonwealth Government

There are a number of forums that combine representation from Commonwealth Government and State and Territory Governments. In the area of science and innovation, these include the Commonwealth States and Territory Advisory Council on Innovation (CSTACI), the National Science Forum (which has only met once), the Biotechnology Roundtable, the Biotechnology Liaison Committee, Committee for Marketing of Australian Biotechnology, Primary Industries Standing Committee and the Australian and New Zealand Biotechnology Alliance.

The discussions from these meetings, while productive in terms of information exchange, would be significantly enhanced if linked to funding program input and Ministerial Council agenda.

The Australian Chief Scientist should be encouraged to engage with State and Territory Governments, both through forums such as CSTACI (as has occurred in the past) and on specific issues such as the development of major programs.

4.4 Compliance Burden

Governments have a responsibility to ensure the public receives value for the investment in science and innovation made on taxpayers' behalf. Clear program goals, rigorous and well developed projects, and ongoing performance monitoring, are the critical components of this process. Without compromising this, Governments need to ensure that processes and obligations do not over-burden recipients.

Significant time and resources are invested by public sector researchers in applying to the various different Commonwealth funding programs that support research. Feedback received by the

Government is that the costs in terms of time and money can be significant, especially where the standard of application sought requires specialist consulting input. It has been estimated that the cost of developing the Stage 2 – Full Business Case for a proposal under the CRC program is between $200,000 and $300,000, and the process that can take up to a year to complete. Likewise, the process of seeking funding renewal can significantly distract a Centre's management and researchers.

Similarly, a major concern of the NCRIS process to date is the significant amount of time that has been, and will continue to be, invested in the development of the proposals for the 16 capabilities. State Government officers, public research agencies and university researchers and management, as well as Commonwealth Committees and consultants have all been engaged in a complex process.

The NSW Government recognises that the recipients of public sector research funds should be required to undertake submission and reporting activities that demonstrate prudent management of funds, and outcomes from the investment. However, the quantity and frequency of reporting should be in step with the funding levels, and the projects' scale.

The NSW Government acknowledges that a reworking of reporting requirements attached to CRC funding has recently been undertaken, with the result that the evaluation and reporting burden has decreased. The number of CRC reviews has been decreased, and the amount of information required in the annual reports to DEST has also been reduced. This activity of re-examining the required reporting mechanisms should be a continuous process to find further opportunities to reduce the compliance burden on research organisations.

4.5 Appropriate Funding for Research Centres

In its submission to the NCRIS Committee, the NSW Government strongly supported funding being made available for recurrent costs for a variety of core services associated with major facilities such as maintenance costs, technical support, management, marketing and community interface. Without funding for these unavoidable tasks, the investment in the facilities themselves is at risk from lack of supporting operational expenditure. The submission noted that the provision of recurrent funding would achieve improvements in:

- Quality of infrastructure – through provision of good technical support, experienced managers, and good internal research programs;
- Accessibility of infrastructure – the provision of some recurrent funding will ensure that access costs are kept at a reasonable level, thereby improving the accessibility of the facility to all researchers; and
- Sustainability of infrastructure - support for operational costs will markedly improve the ability of facilities to achieve self-sustainability in the longer term.

An example of the impact of funding limitations is apparent in the MNRF program. The program expects the facilities it supports to become self-supporting, or at least achieve a measure of operational self-sufficiency (these facilities provide access to expensive equipment and expertise which should benefit Australian researchers and commercial organisations). Providing funding to support activities aimed at attracting new clientele would significantly assist these facilities in generating contract and other revenue to achieve the goal of self-sufficiency.

4.6 Funding Stability

Commonwealth Government support for science needs a stable, long-term framework with appropriate milestones to measure and maintain performance.

A number of studies have highlighted that commercial returns may not be apparent within the timeframe of current Commonwealth programs. Benefits from commercialising new knowledge typically require long timeframes, as products need to be successfully financed, developed, demonstrated and marketed. For example, the results of the recent Allen Consulting Group Report into the economic impact of CRCs observed that the time lag between commencement of research and realisation of a measurable economic impact for CRCs averaged 9 years, with a range of 4 to 12 years.[1] This finding is broadly consistent with a number of other studies of commercialisation timeframes, which found a time lag averaging between 5 to 9 years, depending on the industry.[2]

The Commission should consider the alignment of funding programs with the likely achievement timetable of research outcomes. Program design needs to be realistic and take into account these lags. Program design should also consider the impact that program funding timeframes have on the development of critical mass of personnel and infrastructure. The Commonwealth should consider extending program funding timeframes, or the development of other measures to provide longer-term support.

[1] The Allen Consulting Group (2005), *The Economic Impact of Cooperative Research Centres in Australia: Delivering benefits for Australia*, Report to the CRC Association, (December). Page 31.

[2] See Dowrick, S., (2003), *A Review of the Evidence on Science, R&D and Productivity*, prepared for the Department of Education, Science and Training. (August); Association of University Technology Managers, Inc. (2000), *AUTM Licensing Survey: FY 1999 Survey Summary*; and Canadian Expert Panel on the Commercialisation of University Research of the Advisory Council on Science and Technology (1999) *University Research and the Commercialization of Intellectual Property in Canada* (March).

5 Program Evaluation

5.1 Methodology and Measurement

There have been a variety of methodologies used to measure impacts of research organisations' activities on Australia's economic, social and environmental well-being. The diversity of techniques and assumptions used by different research centres, mean that the results are not consistently comparable between centres, and benchmark indicators are not developed.

Performance measures must recognise the long-term nature of the impacts from research, and that many benefits, especially environmental and social impacts, are difficult to track and measure. A measurement system will also have to resolve the issue of attribution and the broad span of the commercialisation or adoption pathways. Performance should be assessed at various points along these development timelines against the contribution validly invoked by funding.

Measures should also acknowledge the discovery nature of R&D, which means that a significant proportion of research outcomes will not necessarily result in a commercially usable discovery, or where commercialisation occurs it may be over a long term that cannot be reasonably tracked, or in a context that is quite different from the predicted result area.

To meet these challenges, performance criteria must incorporate realistic expectations of returns to individual programs, over timeframes that reflect the complexity of the activity being undertaken.

Considerable expertise has been developed in a number of NSW agencies to measure the financial or commercial returns from investment in research projects. An overview of DPI's activities in five program areas showed that for an investment of $114 million up to 2003, the industry return was conservatively assessed at $1,311 million, giving an average benefit-cost ratio of 11.5-to-1.[3] Further information of DPI's evaluation is provided in Attachment B.

In the Department of State and Regional Development, a comprehensive economic evaluation methodology is employed to assess projects both before and after State funds are expended (see box below).

Evaluation of programs and projects typically takes into account estimation of the impact and adoption of new technology or processes, and identifying – in both quantitative and qualitative terms – the economic, social and environmental impacts. This includes consideration of the likely alternative scenario if the project or centre had not proceeded.

There are acknowledged difficulties in measuring the social and environmental returns from public investment in science. However, it is clear that important benefits in those areas exist. The NSW Government looks forward to the contribution of the Productivity Commission to the measurement of these impacts, and the establishment of benchmark attributes that can be applied to comparable projects and centres.

[3] Mullen (2004), *Evaluation in 2003 of Five Areas of Investment in R&D by NSW Agriculture*, Economic Research Report No. 22, NSW Department of Primary Industries. This and other evaluation reports are available on the DPI website http://www.agric.nsw.gov.au/reader/10550

Evaluation Methodology: Department of State and Regional Development

DSRD's Economic Evaluation and Statistics Unit (EESU) undertakes financial and economic analysis of a range of projects, including that of research centres or organisations.

EESU's evaluations uses consistent methodology to report on the additional economic and employment benefit to NSW arising from a research organisation's activities. That is, the benefits these organisations provide over and above what may have occurred if they had not been established.

These evaluations estimate short- to long-term economic impacts arising from:

- Additional expenditure in NSW, including additional consulting and other private sector revenue that is attracted by the additional scale and capabilities provided by the Centre.
- Productivity improvements through developing the local skills-base by training students, as well as knowledge diffusion activities including experience gained by existing high-end users.
- Commercialisation or adoption of research outcomes. This includes projected benefits to the NSW economy from spin-off companies, licensing revenues, and through improving existing systems or performance.
- Other economic benefits, such as encouraging other related activity to cluster close to the Centre. The effect of this is expected to be felt in the longer term.

The evaluations incorporate both qualitative and quantitative assessments of the economic, social and environmental benefits arising from the centre's activities.

NSW BioBusiness Program Evaluation

BioBusiness is a component of the BioFirst Strategy that supports the growth of companies and the commercialisation of research outcomes. The main expenditure items of the *BioBusiness* programs are: Proof of Concept; Non-Research Establishment Costs; and High Growth BioBusiness.

The Proof of Concept program provides assistance with matching funding (up to 20 per cent of total project costs) for eligible NSW-based recipients of research commercialisation grants under the Commonwealth Government's Biotechnology Innovation Fund (BIF) program.

Non-Research Establishment Costs and High Growth BioBusiness Programs provide financial assistance to eligible companies for activities such as intellectual property protection and licensing, strategic marketing, business planning, and management development.

Utilising DSRD program evaluation methodology, Professor Michael Vitale of the Australian Graduate School of Management reviewed the impact of these areas of the BioBusiness programs on the biotechnology industry in NSW. The performance of NSW biotechnology companies receiving BioBusiness assistance was assessed along a variety of dimensions, including patents, products, revenues, employment, exports, and additional investment secured.

From 2001 to 2005, $10 million was provided to assist 118 NSW biotech companies under these three BioBusiness programs. The review found that NSW biotechnology companies have:
- Generated about $30 million in revenues for products and services developed after receiving BioBusiness support;
- Brought in at least $114 million of additional investment from the public and private sectors; and
- Created more than 175 new jobs in NSW.

5.2 Statistics

The collection and timely publication of information on the performance of the innovation system is critical to inform policy decisions and direction. Data collected as part of the Australian Bureau of Statistics core collection needs to incorporate a broader view than simply the level of funds expended upon R&D. It should also include other innovation activities and linkages between the various components of the innovation system. Statistics should cover national as well as State and regional innovation activities, and the quality of sub-national data needs to be improved. Moves to improve the timeliness of statistics would also be beneficial. Current statistical information on R&D expenditures, for example, is typically released between 15 to 18 months after the end of the reporting period.

6 Conclusions

The NSW Government believes that Australia requires an effective innovation system to meet its key economic, social and environmental challenges and supports a wide range of science and innovation activities. The benefits of this support are evident in NSW, as well as across the wider knowledge economy of Australia.

However, whilst significant benefits have been born from existing public support, there are still a number of areas were improvements could be made to further develop the national innovation system. These include improved Commonwealth-State collaboration and consultation, further consideration of how to balance commercialisation and innovation goals within research centres and research projects, improved evaluation measures and benchmarks for research centre and projects, and the development of funding processes that reflect critical mass and research excellence.

Positive developments in the above areas should lead to improved and more easily measurable outcomes from publicly supported science and innovation projects, as well as providing broader benefits to the Australia community through enhanced service delivery, evidence-based decision-making and economic productivity.

ATTACHMENT A

SELECTED EXAMPLES OF NSW GOVERNMENT SCIENCE AND INNOVATION PROJECTS AND PROGRAMS

Department of Commerce

Architecture, Engineering & Technology

- Building Price Index (2004-05 Project)
- WEB based Property Information System (2004-05 Project)
- Dam Safety Committee (2004-05 Project)
- University of NSW Embankment Erosion Research (2004-05 Project)
- Health Engineering Guidelines – TS11 (2004-05 Project)
- Lifecycle Assessment for Optimised Passive Solar House (2004-05 Project)
- Earthquake Monitoring and Management (2004-05 Project)
- Houses of the Future Exhibition (2004-05 Project)
- Development and Maintenance of the Police Building Code (2004-05 Project)
- Hydrology Subcommittee to NSW Dams Safety Committee (2005-06 Project)
- Mines Subsidence Board (2005-06 Project)
- NSW Dams Safety Committee (2005-06 Project)
- Earthquake Monitoring Network (2005-06 Project)
- Flow Characteristics for Overshot Gates (2006-07 Project)
- Flow Characteristics for Vertical Fishway Lift Gates (2006-07 Project)
- 2 Dimensional Dambreak and Surface Computer Modelling Capability (2006-07 Project)
- In-house Design Manual (2006-07 Project)
- ANCOLD Guidelines for Large Dams (2006-07 Project)
- Gross Pollutant Traps (2006-07 Project)

Environment

- Vertical Slot Fishway Modelling Using Computational Fluid Dynamics (2004-05 Project)
- Murray River Lock and Weir 11 Innovation Fishway Options Study (2004-05 Project)

Water

- Algal Bloom Warning System (2004-05 Project)
- Vertical Profiling System for Reservoirs (2004-05 Project)
- Application of IDEA Sewage Treatment System in Modular Small Towns Treatment Plants – Wyangala STP (2004-05 Project)
- Effectiveness of Membrane/Ozone/BAC treatment for algal toxins, pesticides, cryptosporidium and Giardia removal (2004-05 Project)
- Confirmation of Sewage Treatment Reactor Design Parameters (2006-07 Project)

Department of Energy, Utilities and Sustainability

- NSW Energy and Water Savings Fund
- Sustainable Energy Research and Development Fund (all funding has been committed and no further rounds to be called)

Department of Primary Industries

Systems

- Wild fisheries, aquatic ecosystems, agricultural farming systems, pastures and rangelands

Production

- Horticulture, viticulture, animal production and aquaculture industries.

Health Science, Strategic Alliances and Evaluation

- Animal and plant health, food science and safety, weeds and vertebrate pest control;
- Alliances with universities, cooperative research centres and other R&D agencies;
- Economic benefit-cost analyses.

Resources

- Sustainable management of natural resources utilised or impacted by the state's primary industries including forests, soil, water, salinity, biodiversity, carbon accounting, recycled organics and environmental contamination.

Rural Innovation

- Plant and animal genetics, biotechnology, climate science and precision systems

Research Operations

- Biometrics, taxonomy, commercial diagnostic laboratories for veterinary pathology, analytical chemistry, residues analysis and plant health.

Department of State and Regional Development

Current programs targeted at science and innovation:

Business development programs

- Australian Technology Showcase **Program review undertaken*
  - Technology Demonstration Program
- BioBusiness program **Program review undertaken*
- Innovation Clusters: Western Sydney, North Sydney, Central Coast, Newcastle
- Innovation Advisory Centres
- Support for National ICT Australia (NICTA)
- Support for ten Australian Research Council Centres of Excellence
- Support for four Major National Research Facilities
- Support for one Cooperative Research Centre

Research development programs

- Medical Research Support Program, formerly known as the Infrastructure Grants Program (1997-2006) **Program review undertaken (2005-2006)*
- BioFirst
  - Awards **Steering committee review undertaken in 2005*
  - Converging Technologies
  - Bioethics
  - BioPlatform
  - BioLink
- CRC Business Case Development Support Program
- Spinal Cord Injury and other Neurological Conditions Research Grants Program
  - Spinal Exchange Program
  - Spinal Research Grants program

Industry support programs

- Support for the Australian Industry Group InnovationXchange Network

Business growth and export development programs

- New Export Opportunities Program – Export Development
- The Stepping Up Program

NSW Health

- Cancer Institute NSW
- Capacity Building Infrastructure Program

Roads and Traffic Authority

- Pavements Program
- Road Safety Program

Sydney Catchment Authority

Research projects concerning Pathogens

- Pathogen budgeting for prioritisation of land uses and rectification actions to reduce public health risks from pathogens
- Molecular methods for tracing faecal bacteria and bacteriophages in the catchment
- Molecular methods for tracing faecal viruses in the catchment
- Native animals as potential sources of human pathogens in SCA catchments
- Prevalence of Cryptosporidium oocysts and anti- Crytosporidium antibodies in animals in SCA catchments
- Cryptosporidium in the Warragamba catchment: genotypes and cell culture infectivity

Research projects concerning Nutrients, Sediments and Pollutants

- Integrated water quality planning – least cost pollution control
- Sediment budgeting: Metropolitan catchments
- Nutrient budgeting: Evaluation and enhancement of tools for nutrient budget construction and prioritisation of land uses and abatement actions to reduce nutrient loadings
- Identification of major sediment and nutrient sources in Sydney's drinking water catchments

Research projects concerning Climate Variability and Extreme Events

- Impact on water quality by post-wildfire erosion and nutrient release
- Catastrophic events and holocene sedimentation through the Special Areas
- Climate forecasting – multi-site probabilistic forecasting for the SCA water supply catchments and its use in reservoir operations
- Methods of forecasting SCA inflows on multiple timescales using simple indices of climate

NSW Greenhouse Office

- Impacts of Climate Change Research Program
- Climate Action Grants Program

ATTACHMENT B

RESEARCH EVALUATION IN NSW DPI

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July 2006

Executive Summary

- NSW DPI conducts an extensive range of research evaluations examining the economic, social and environmental impacts of significant research investments by NSW DPI and the alignment of beneficiaries with public and industry funding and DPI goals.

- The number of evaluations conducted by DPI economists approaches 100 and these have consistently shown returns in the order of 3-30:1 with the majority in the range of 10-20:1 (see attached Tables). In aggregate, the returns to public investment in agricultural research is estimated to have been in the order of 15-40 percent.

- NSW DPI economists are regularly employed as consultants to other agencies to conduct evaluation work and are recognised as Australian and international authorities in the science policy and evaluation fields.

- The nature of applied primary industries R&D is such that nearly all research projects provide a complex bundle of public and industry benefits which are economic, environmental and social in nature. The environmental and social impacts tend to have larger public good components.

- The economic benefits to industry in the form of increased yields, improved product quality and lower costs are relatively easy to value.

- Environmental and social public goods are notoriously difficult to value, hence judgements about the proportion of public and industry benefits flowing from either a project or a portfolio have been subjective. NSW DPI is applying more rigorous methodologies for valuing environmental and social impacts.

- In 2005/06, the budget for the Science and Research Division will be approximatly $81m. Half the budget is now funded from external sources, up from less than 20 percent in the 1980s.

- Primary industries R&D has been an important source of economic growth for NSW and Australia. Productivity in NSW agriculture has been rising at the rate of about 2.5 percent per annum, more rapidly than for agriculture in some other States and more rapidly than in most other sectors of the economy. Since 1953 productivity growth in NSW agriculture has been worth $483b to the State and a significant proportion of this can be attributed to R&D conducted within NSW DPI. The benefits from this research are shared by producers, processors and consumers.

- In 2004, NSW DPI was ranked in the top 1 percent of world research institutions in agricultural science and plant and animal science by the international science indexing company, Thompson ISI.

Research Evaluation In NSW DPI

Economists in NSW DPI (and the former NSW Agriculture) have been evaluating investments in research and extension by the Department for at least the past 4 decades. These evaluations have been used to publicly account for the way DPI uses its resources, to support external funding proposals, to assist in setting priorities and allocating resources and in developing and adapting research projects. Many of these findings have been reported in scientific literature. Attached is an incomplete bibliography of publications (not including contributed conference papers) reporting this research. There are two sections to this bibliography – one for publications focussing exclusively on DPI research and one for publications which have an Australia-wide or international perspective but relate to NSW DPI activities.

Evaluations Prior to 2001:

Appendix Tables 1 and 2 provides an incomplete list of 60 ex ante and ex post project evaluations undertaken by DPI economists between 1992 and 2001. Appendix Table 3 provides an incomplete list of the evaluations of the farm level and industry impacts of research undertaken by DPI that are the initial steps in developing more formal evaluations to estimating rates of return from investments.

The focus of evaluations during this time was to evaluate the economic payoffs to research. Often these evaluations were used to support research proposals for industry funding. Some evaluations were commissioned by industry bodies to support their accountability responsibilities or to assist in setting priorities.

The benefit cost ratios from these 60 evaluations ranged from 3 to 30. The economic benefits estimated are those accruing to entire industries not just to farmers. These benefits are shared by farmers, processors and consumers. Many of the benefits, at least in the short term, are captured by farmers because for many products, Australia is a price taker on world markets.

Some of these evaluations were reported in refereed scientific outlets. Economists in NSW DPI were also writing refereed scientific papers and presenting invited papers at scientific conferences about evaluation processes, and about the extent of the benefits from research and how these benefits were being shared by farmers, processors and consumers as the list of publications below attests.

Evaluations between 2001 and 2006

The importance of this evaluation work has been more formally recognised within NSW DPI since 2001 with a requirement within the Department's Strategic Plan for an ongoing process of evaluation of the economic, social and environmental impacts of at least five areas of investment in research and extension each year. In addition the importance of evaluation is recognised in the creation of a position titled Research Leader, Economics Coordination and Evaluation in the Health Science, Strategic Alliances and Evaluation Branch of the Science and Research Division.

A summary of the five evaluations conducted in 2003 is reported in Table 1 below. These projects involved streams of expenditure by NSW DPI and streams of industry productivity gains from 1980 to 2020 (though not all projects spanned this period). Costs and benefits were summed over this

period and expressed in 2002 dollars in the table below. Details of these evaluations can be found in a series of Economic Research Reports at http://www.agric.nsw.gov.au/reader/10550. At this site is Economics Research Report 22 (Mullen 2004) which summarises the 2003 evaluations.

For these five project areas, NSW DPI invested $114m, including some support from industry. The industry returns totalled $1,311m giving an average benefit-cost ratio of 11.5, providing a moderate to high return on funds invested compared to alternative uses for those funds. These industry benefits are shared by producers, input suppliers and consumers.

As tabled in a previous paper titled 'The Nature and Funding of Research in NSW DPI', most of NSW DPI's research delivers a mix of public and industry benefits. While the economic benefits flow largely to producers, processors and consumers, in line with NSW DPI's goals there were significant environmental benefits flowing from these five areas of investment, including reduced soil erosion and greenhouse gas emissions and increased water use efficiencies. Some environmental impacts are already captured in farm level economic impacts but environmental impacts on the broader community are difficult to value and, most often in these evaluations, were only identified qualitatively. In the case of the proposed Beef CRC III, it has been estimated that selection for more feed efficient cattle will lead to a reduction in greenhouse gas emissions from the beef herd (Alford et al. 2006). It was estimated that a minimum value for the saved methane output due to adoption of NFI genetics in the NSW beef herd is in the order of $28m, over the 25 year simulation period, about ten percent of the industry benefits to producers, consumers and processors in NSW (Griffith et al. 2006).

In conducting these evaluations economists have been most concerned to avoid double counting. Many of the economic consequences of research have strong social impacts in terms of income and employment flows which are largely captured in measures of industry benefits (although not indirect flows). However because of the means by which some of these research and extension programs were delivered to the farming community they had an additional benefit in building up the social capital of rural communities giving them enhanced skills to adapt to change and engage with government in planning changes to the management of natural resources.

Table 1: DPI Evaluations in 2003

Investment area	**Investment by NSW DPI**	**DPI Share of total investment**	**Benefit-Cost Ratio**	**Environmental Impact**
Net feed efficiency in beef cattle	$13.9m	70%	4.9	Greenhouse gas reductions
Annual weeds in temperate pastures	$8.7m	67%	22.2	Reduce accessions; better water quality
Wheat breeding	$43.0m	45%	8.4	Reduced dependence on chemicals
Conservation farming in northern NSW	$29.0m	68%	20.5	Reduce soil erosion; soil structure gains
Extension in water use efficiency	$19.8m	100%	4.5	Water savings for the environment
Total	**$114.4m**		**11.5**	
Evaluations since 2003:				
Ricecheck	3.8	67%	18	Water use efficiency
Beef CRC III	3.8	9.5%	66	Greenhouse gas savings
Sheep CRC	n.a.	n.a.	8.1	Reduced dependence on chemicals
Fox Control	$23,625*	4.9%	12.4	Save native species
DPI Aquaculture		n.a.		various
* Not in $m				

Some of the steps involved in undertaking these evaluations included:

- Describing the industry situation, the objectives and program of research and the rationale for government involvement;
- Estimating the investment in the research program by NSW DPI and external partners;
- Estimating the impact on the industry of the technology in terms of reducing costs;
- Assessing the potential adoption of the technology;
- Quantifying the present value of economic benefits to industry after defining 'with' and 'without' technology scenarios;
- Qualitatively identifying the environmental and social impacts of the technology;
- Comparing how the benefits from the technology and the costs of the research investment are shared between public and industry partners.

The timeliness and sophistication with which these evaluations were conducted depended crucially on the knowledge held by economists about the industries and technologies they were evaluating and their established links with the scientists engaged in these investment areas. This store of capital

was particularly valuable in carefully defining the "with" and "without' technology scenarios. Even with this level of knowledge each evaluation required at least 40 days of professional time.

Since 2003 other evaluations have been completed (some not yet published) and are listed at the foot of the table above. These too have demonstrated that DPI invests in areas of research which generate good economic returns to industry partners and significant environmental and social returns to the community.

DPI economists have an important role in economics research in several CRCs and in particular have played a prominent role in developing the business case for CRC submissions and in preparing material for the reviews of CRC achievements. Anecdotally the contribution of economists has been an important contribution to the successful funding re-bid proposals by the Weeds and Beef CRCs and to securing additional funding from agencies such as ACIAR and the QLD Smart State Innovation Fund.

Future Evaluation Program

Several areas of investment are either already under evaluation or have been identified for evaluation in the near future including:

- Research and extension in conservation farming in the central and southern cropping areas;
- Economic considerations in the use of genetic marker technology in cereals breeding;
- Research into forestry;
- Q$lus, a genetic program in the sheep industry to 'fine up' the clip.

Because of the need to more objectively assess and compare the economic or industry outcomes of research with environmental and social outcomes of research, more resources in future evaluations will be used to quantify these environmental and social outcomes. Research programs are being developed with economists and biologists at CSU and UNE to integrate farm and catchment level bio-economic modelling with ecological modelling and environmental valuation research to expedite progress in this area (Sinden and Griffith 2006).

Monash Model Impacts of DPI Research on NSW Economy

In addition to the evaluation of particular areas of research investment, NSW DPI (and other State departments) commissioned the Centre of Policy Studies at Monash University to undertake an analysis of the long run macroeconomic impacts of hypothetical 5% productivity improvements across Australia in the major agricultural and downstream processing sectors.

The results of the analysis for NSW and Australia, in terms of changes in state and national Gross Domestic Product (GDP), are reported in Table 2. Industry size relative to other sectors in the state and relative to corresponding interstate sectors, the degree of processing required, and the composition of sales between domestic and export markets, are all issues that have a major bearing on the outcomes.

Productivity gains of 5 percent in the sheep, other crops, wheat, beef cattle and beef processing sectors deliver the greatest return to the NSW economy. Overall, productivity gains in all agricultural and downstream processing sectors would raise real NSW GDP by 0.18% or by some $359 million, annually. Productivity gains in all agricultural and downstream processing sectors would raise real Australian GDP by 0.21% or by more than $1.2 billion, annually.

Table 2: Long run impact of 5% national productivity improvements on NSW real GDP by sector, $m, 2001 base year

Sector	Increase in NSW GDP ($m)	Increase in Australian GDP ($m)	Sector	Increase in NSW GDP ($m)	Increase in Australian GDP ($m)
Sheep	109	280	Other Fruits and Nuts	3	15
Barley	6	36	Premium Grapes	6	35
Wheat	34	87	Multipurpose Grapes	0	3
Other Broadacre	14	20	Pasture and Irrigation	2	7
Beef Cattle	25	133	Vegetables	2	27
Dairy Cattle	7	81	Other Crops	45	123
Pigs	5	14	Beef Processing	37	122
Poultry	5	12	Other Meat Processing	21	59
Citrus	5	15	Dairy Processing	19	65
Apples and Pears	2	12	Fibre Processing	10	47
Stone Fruits	2	10	Aquaculture	0	11

Evaluations with an Australia-wide or International Perspective

The focus to this point has been on the evaluation of research investments in which NSW DPI is either the sole or a significant stakeholder and the research is largely conducted in NSW. However partly because of the experience they have gained within DPI, DPI economists have an Australia-wide and international reputation and authority in this area of research evaluation and science policy.

NSW DPI economists are regularly employed on a consultancy basis to undertake evaluations of research investments by institutions like ACIAR, the CRCs, the RDCs and the Australian Farm Institute and to contribute to Enquiries by the Productivity Commission into science and research policy in Australia.

DPI Economists were responsible for the only econometric analysis of the returns to public investments in broadacre agriculture research in Australia over the period since 1953 which estimated that returns have been in the order of 15 – 40 percent. DPI economists have led the way in understanding how the benefits from research in the wool, beef and sheep industries are shared by producers, processors and consumers. DPI economists have been able to demonstrate how Australia benefits from its investments in international research through ACIAR (as part of its foreign aid), supporting grains breeding research at CGIAR centres for example.

Appendix Table 1: *Ex Ante* Evaluations of Research and Extension Proposals

Nature of Project	Evaluators	Year	BCR/IRR
Cropping Industries:			
NSW Agriculture externally funded projects			
Wheat Breeding	Brennan	1996	5
Barley Breeding	Brennan	1996	4
Variety Trials	Brennan	1996	6
Biometrics for breeding	Brennan	1996	13
Winter cereals collection	Brennan	1996	8
Soybean Testing	Brennan	1996	8
Diseases in Min. Tillage	Brennan	1996	13
Forage Legumes	Brennan	1996	27
Agronomy on Sodic Soils	Brennan	1996	17
Crop management (NW)	Brennan	1996	7
Soybean Agronomy	Brennan	1996	21
Pulses in Rotations	Brennan	1996	5
Weeds in Canola	Brennan	1997	4
MASTER trial	Brennan	1997	24
Durum quality	Brennan	1996	10
National/CRC Projects			
Chickpea breeding	Brennan	96	12
	Scott	96	23
Winter Cereals Collection	Brennan	96	8
	Scott	96	6
Durum wheat improvement	Griffith	96/97	19
Horticulture Industries			
NSW Agriculture externally funded projects			
Vine Root Growth	Brennan	2000	26
Nematode control in grapes	Brennan	2000	14
Livestock Industries			
NSW Agriculture externally funded projects			
Pasture Management	Brennan		5
Pasture Establishment	Brennan		9
Bomoxynil tolerant sub-clover	Vere		24
Biological control of Paterson's Curse	Vere		38%
National forage conservation network - dairy	Davies	1999	6
Wool Production from lucerne in N. NSW	Patton	2000	
Wool Production from mixed lucerne/perennial grass pastures in N. NSW	Patton	2000	3
Isolating genes for feed conversion efficiency - feedlot	Patton	1996	
Grazing Strategies for 400-600mm zone	Patton	1996	
Spring v's Autumn lambing in the CW of NSW	Patton	1998	3
National/CRC/overseas aid Projects			
Sub-clover breeding	Brennan		39
Improved cattle quality in South Africa	Griffith	00/01	11
Livestock disease (h. septicaemia) in Indonesia	Vere	92/94	

Broadacre Agriculture

NSW Agriculture externally funded projects

6.1 Treasury enhancements for Departmental facilities

New pathology/soils lab at Tamworth	Farquharson	2000	11/49
New pathology/entomology lab at Tamworth	Farquharson	2001	16/71
Assessment of integrated natural pest management – proposed bio-control facility at Tamworth (cost effectiveness analysis)	Farquharson	2000	
Whole farm planning	Brennan	2000	27

Appendix Table 2: *Ex Post* Evaluations of Research and Extension Proposals

Nature of Project	Evaluators	Year	BCR/IRR
Cropping Industries:			
NSW Agriculture externally funded projects			
Forage Legumes	Brennan	1999	10
DAN 303 - Pathology support for winter pulses in northern region	Scott	2000	6
DAN260NR - International Durum Wheat Cooperation-Stage 1 (95-98)	Scott	1998	2.75
NSW Agriculture Sub-Programs			
Wheat Breeding	Brennan	2000	10
National/CRC Projects			
Cotton CRC:			
Inventory of irrig-cotton soil	Farquharson		26/43
Breeding locally adapted cotton	Farquharson		65/83
Mite control work using IPM	Farquharson		19/53
Farming systems experiments	Farquharson		21/44
Improving nutrition using rotation crops	Farquharson		11/34
summary of Cotton CRC	Farquharson		10
Horticulture Industries			
NSW Agriculture externally funded projects			
High Density citrus	Brennan		10
IPM in mushrooms	Vere/Mullen	1994	
National/CRC Projects			
Viticulture CRC:			
Strategic pest management	Mullen	1999	2.4
Australian Grapevine Yellows	Mullen	1999	0.2
Increased Efficiency of Nitrogen use	Mullen	1999	10.1
Improved Irrigation Strategies	Mullen	1999	15.4
Overall summary	Mullen	1999	B>C
Livestock Industries			
NSW Agriculture externally funded projects			
Grafton crossbreeding research	Farquharson	1992	8.5
Trangie/Glenn Innes growth rate selection in beef	Farquharson	1992	3.2
Beef cattle genetics in Australia	Farquharson/ Griffith	2002	3.6 19%
National/CRC Projects			
Broadacre Agriculture			
NSW Agriculture externally funded projects			
R&D in broadacre agriculture	Mullen	1995	15% - 40%

Appendix Table 3: Evaluations of the Financial Impacts of Farm Technologies

Technology	Evaluators	Year
Cropping Industries:		
Tillage and stubble management (SATWAGL)	Brennan	2000
Forage legumes as a break crop	Brennan	1999
More competitive crop cultivars	Brennan	2000
Improving Nutritional characteristics of feed grains	Brennan	2000
Impact of semi-dwarf wheats in Australia	Brennan	1995
Impact of ICRISAT research on Australian agriculture	Brennan	1999
Impact of ICARDA research on Australian agriculture	Brennan	2001
Costs of wheat diseases	Brennan	1998
Costs of weeds	Vere/Jones	
Drip irrigation in cotton and lucerne	Singh	2000
Weed seedbank control	Jones	
IPM in cotton	Hoque /Farquharson	
Horticulture Industries		
Replanting Strategies in the Citrus Industry	Elton/Mullen	1999
Drip irrigation in citrus and grapes	Singh	1999
Drip irrigation in cherries,	Singh	2000
Use of compost in horticulture	Kaur/ Mullen	1999
Livestock Industries		
Elite Lamb Technology	Vere/Griffith	
Large Lean Lamb	Mullen	1994
Cost of weeds	Vere/Jones	
Preboosting feedlot cattle	Davies	1997
Use of silage in feedlot rations	Davies	1997
Dairy production using lucerne	Davies	1998
Twinning Technology in beef industry	Farquharson	1991
Shade for feedlot cattle	Farquharson	92/93
Forage shrubs/saltbush for drought	Patton	2000
Re-establishing Mitchell grass on old cropping land	Patton	2000
Sustainable grazing systems	Jones	
Whole Farm/Broadacre		
Clearing/Cropping/Conservation areas - S. mallee	Patton/Mullen	1999
Productivity Growth in Australian B'acre Agriculture	Mullen	1994
On-farm water storage	Jones	
Role of pastures in CW crop rotations	Patton	2000

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