Council of Rural Research and Development Corporation Chairs

Guidelines for Evaluation

May 2007

Contents

1 Purpose

This document sets out the guidelines for evaluation of the impact of the Research and Development (R&D) programs funded by the RDCs.

The evaluation process has been established by the Council of Rural Research and Development Chairs (CRRDCC) to report on the:

- Overall returns from the RDCs collectively to industry.
- Public and spillover returns from the collective program.
- The public and spillover returns that are conditional on public contributions to the RDCs.

It is intended that the processes and procedures set out in this framework will apply to a systematic evaluation of a sample of investments that will form a pool of evaluations from which an analysis of the overall returns will be estimated on an annual basis. The evaluation will be in terms of economic, social and environmental impacts.

It is expected that these processes and procedures will be a minimum evaluation requirement for each RDC. The RDCs may undertake additional evaluations and include in the evaluation analysis as much additional information and data collection as their needs require.

This document details the common approaches that are required by each RDC to follow as part of their overall evaluation processes, however, individual RDCs will need to incorporate these standards into their own evaluation processes.

The evaluation process detailed in this paper will not work without a commitment from the RDCs to adopt the minimum requirements of this approach into their own reporting and evaluation systems.

Excellent additional reading for this paper is the recently released LWA evaluation report and methodology summary, *A methodology for evaluating return on investment from natural resource management research and development*, which can be found at http://www.lwa.gov.au/downloads/publications_pdf/ER071255.pdf

LWA has as one of its strategic objectives the measurement of ROI and has instigated a process to assess its entire portfolio over a number of years.

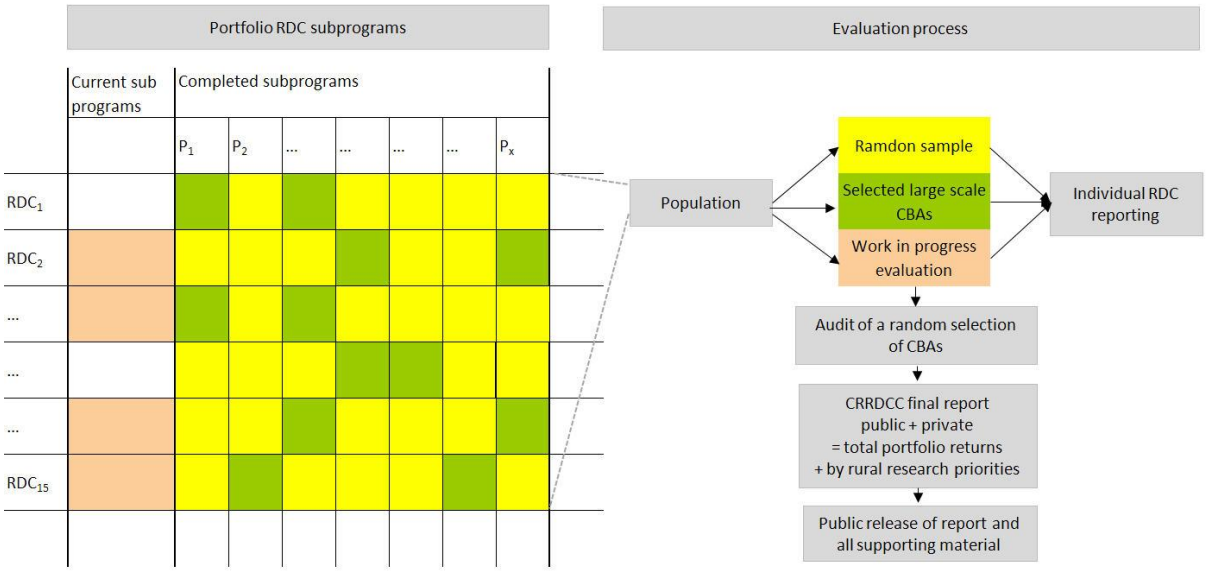
2 Structure and process

There are three elements in the evaluation process:

1. Representative sampling of R&D projects in each RDC, to build a pool of consistent Cost Benefit Analysis studies (CBAs) that can be used to provide an indication of the range and trends in returns from the total RDCs investments over a three year period.

2. Analysis of a sufficient number of significant, successful, large scale projects or programs to demonstrate that the entire RDC portfolio is producing positive private and public benefits.
3. An analysis of two early stage collaborative R&D projects per year, which are expected to have major areas of public interest in order to measure the value of work in progress and the private and public opportunities early stage research creates.

Figure 1 **Schematic representation of the evaluation framework**



3 Outputs

The CRRDCC secretariat will analyse the pool results each year and prepare a report addressing:

- the counterfactual (the likely outcomes in the absence of the R&D);
- public benefit spillovers; and
- additionality (that government funding has added to the research and development undertaken).

The report will outline the overall performance of the RDC program to:

- discuss marginal areas and the implications; and
- identify any strategic issues that arise for the RDCs as a whole.

The secretariat will draw together the results of the evaluation process by:

- examining the distribution of the returns (public and private) of the pooled CBAs and infer the likely range of returns from the total portfolio of RDC investments.
- Collate the results of the large scale successful projects undertaken by the RDCs to report the 'lower bound' returns from the entire RDC portfolio.
- Use additional sources of information and analysis to link the results of the evaluation process to measures of productivity undertaken by ABARE and other researchers such as the Australian Farm Institute.

- Report on the value of the work in progress of the RDCs and the opportunities this work creates for future innovation.

It is likely that the Australian Government will want to undertake independent reviews of the industry centred RDCs to test the proposition in the Productivity Commission's report that there is a weak rationale for the current level of government funding of their programs. It is intended that the data and analysis produced by this process will provide the evidence for an independent review.

4 Governance

It is important that in implementing this framework outcomes are achieved that ensure that the results of the evaluations are verifiable and based on a consistent approach across the RDCs. The governance framework proposed is based on consistency in the application of the methodology and transparency of the analysis.

Consistency will be confirmed by an internal audit of the outcomes by ACIL Tasman supported by peer review across the RDCs.

Transparency will be achieved by ensuring that:

- the methodology proposed is publicly available;
- all of the results of the ACIL Tasman audit, peer review are publicly available on the CRRDCC website; and
- all of the CBAs and any other evaluation material are publicly available.

All of the CBAs must report on the key variables of the claimed benefits and how sensitive the results are to identified variables.

4.1 Independent review requirements

The Productivity Commission report on Public Support for Research and Innovation proposed that the evaluation of returns from investment by the industry-centred RDCs be subject to independent review. One of the aims of this framework is to provide robust assessments of performance that will meet this requirement.

It is not possible at this time to determine whether the above governance framework will meet the requirements for independence as proposed by the Productivity Commission. A possible approach to meeting this objective is the establishment of an independent reference group to audit methodology and the results. Such a group might be comprised of three emeritus professors with economic policy, agricultural and research policy experience.

The references group's brief would be to:

- evaluate and make comments on the methodology;
- review any analysis conducted by the secretariat including the two large scale work in progress studies;

- review the final report prepared by the secretariat to ensure that the conclusion drawn are consistent with the data collected; and
- take account of the audit results.

Independent auditing would be conducted by an organisation at arms length from the Secretariat. The auditing body would also need the detailed knowledge of relevant agriculture sectors to enable it to examine the details of the CBAs it is auditing. Such an organisation could be ABARE.

The audit process could:

- review the assumptions and quality of analysis of a random sample of the pooled CBAs; and
- review the assumptions and quality of the analysis of the entire large scale successful project CBAs.

Resolution of this matter is not a prerequisite to implementing the framework and would depend on the expressed needs of Government.

4.2 Transparency

The second theme of the governance of the evaluation process will be to ensure that all stages of the process are transparent. This will require that:

- the methodology proposed is publicly available;
- all of the results of the peer review, auditing and reference group reports are publicly available on the CRRDCC website; and
- all of the CBAs and any other evaluation material be publicly available.

All of the CBAs must report on the key variables of the claimed benefits and how sensitive the results are to each variable.

5 Administration

The evaluation process will be administered by the CRRDCC through its Secretariat and the results will be reported at the September CRRDCC meeting each year.

Cost benefit analyses are to be undertaken and funded by each of the RDCs. RDCs may use common consulting services when appropriate to reduce costs. The RDCs should consider conducting the CBAs analysis through an open tender system.

The two large scale collaborative project evaluations per year will be undertaken by the secretariat under the secretariat contracts with the CRRDCC.

There are opportunities for the RDCs to collaborate strongly in this process in the following ways:

- sharing costs of developing research on adoption, and common assumptions such as currency projections and input costs;

- development of common project database software;
- some of the smaller RDCs may consider jointly employing evaluation project officers or similar;
- meeting regularly to share information on the implementation and development of the process; and
- peer reviewing data collection, internal evaluation processes and evaluation results.

A sub-group of the RDC business managers has been formed to coordinate the evaluation process and provide a forum for RDC collaboration on this topic. Each RDC will have to make a decision on how much it pools its resources with other RDCs or other research organizations undertaking R&D evaluation.

6 Selection of projects for review

6.1 Sampled projects

The aim of the first element of the evaluation framework is to collect over time a pool of CBAs which will provide an estimate of the distribution of returns for the collective program. In order to keep the costs appropriate to the size and complexity of the program it will be necessary to create a representative sample of independent investments in R&D (i.e., projects that are not substantively reliant on the results of others in the pool).

The population of sub-programs from which the random sample would be drawn will be based on a population that conforms to the following characteristics:

- A series of 'clusters' of projects commissioned to contribute to a particular defined area of investigation that was established to produce a particular product, service or other outcome. These may be subprograms or simply related projects leading to a specific outcome.
- The sampling process should be random, that is all defined sub programs or their equivalent should be put into the population from which the pooled samples will be drawn from.
- The 'sub-program' or cluster of projects must have reached (but not necessarily achieved) a significant milestone within the last 2-5 years.
- The time frame for the population from which the sample will be drawn should be long enough for some confidence in the technology to be built (usually indicated by early adoption rates) and for sufficient data to be available (such as ABS or ABARE survey reports).
- The pool of CBAs proposed will be based on a three year cycle. This means that the pool of sampled projects will initially be built up over three years once the process has been implemented. Once the pool has been established, each subsequent year will be added and a year dropped off. This will provide a three year moving average with results published each year.
- The program can be of either an off farm or on farm orientation (supply or demand focus).

The population from which the pooled CBAs will be drawn must include as close as practically possible the entire external delivery program investments of the RDC divided into sub programs or their equivalent.

6.2 The number of CBAs required

The number of sub programs or their equivalent that will need to be the subject of the CBAs is dependant on two things:

- the cost of preparing the CBAs; and
- the level of confidence that is sufficient to ensure the sample is adequate to provide a reliable indication of the returns from the total program.

It is important to ensure that cost of the evaluation process is commensurate with the benefits of conducting it for each of the RDCs. As a general rule, the RDCs that are investing in evaluation processes have been allocating around 0.5 per cent of their annual budgets for this purpose. This provides a useful benchmark for this exercise.

To balance the budgetary concerns of the RDCs with the need to have a statistically robust sample, the sample mean will need to be within a maximum of 0.35 standard deviations of the population mean and have a 90 per cent degree of confidence. As a general rule the smaller the population the greater the proportion of the population that needs to be sampled.

For an RDC with 40 sub programs or the equivalent; where the sample mean needs to be within 0.35 standard deviations of the population mean; and where 90 per cent confidence is required, a sample size of 14 sub programs (built up over three years) will be required.

As the sample is built up some bias may emerge such as large projects or specific areas of investigation may be producing higher returns. If bias does eventuate it may be necessary to introduce some stratification into the sample. However, this will only become apparent once a sufficient number of pooled CBA results are collected. Stratification can be done at the population level or at the aggregation stage. Possible areas of stratification may include large and small programs by value, or programs initiated to produce public, private or a combination of both types of benefits.

The secretariat will work with each of the RDCs to develop their sampling methodology to ensure consistency.

Costing of the methodology is difficult as each of the RDCs will combine external and internal resources differently. There is also a wide divergence between the levels of evaluation already underway with each of the RDCs. The information below is intended as a guide only and each RDCs will have to reach their own conclusions as to how much this evaluation process will cost in addition to what is already being done.

These estimates will be refined as more information is provided to the secretariat from each of the RDCs.

This evaluation process has been developed following considerable concern expressed by the RDCs of the potential costs of a comprehensive evaluation process. The secretariat estimates that the cost per annum of each phase of the project to be approximately:

- 15 RDCs x 14 CBA conducted over 3 years at $25,000 each = $1,750,000
- 15 x 2 (average) 'successful' project evaluations at $35,000 each = $1,050,000
- Evaluation component of the secretariat budget (includes the two work in progress evaluations to be conducted by the secretariat = $130,000
- **Total estimated direct costs per annum for evaluation = $2,930,000**

This amount is 0.6 per cent of the average annual RDC expenditure per year. Experience of individual RDCs reported to the secretariat on the actual costs of preparing the CBAs vary considerably, it appears that the key variables are amount of work done internally on the CBA as part of the RDCs overall evaluation process and the information already captured on the program or project being analysed.

The CRRDCC believes that this is the minimum expenditure required to provide the level of evaluation required to meet minimum governance and reporting standards for the RDCs.

However, this is not entirely new expenditure, for several of the RDCs are already investing at least this much of their annual budgets in evaluating performance. Thus, for some RDCs there will be negligible additional costs. This process has also been designed to assist in streamlining the RDCs reporting obligations which will further reduce the net financial impact of the proposed process.

The RDCs should investigate ways to share costs as much as possible by:

- jointly tendering programs evaluations that are likely to share common data requirements;
- jointly tender for two or more CBAs to increase buying power; and
- share information and data sets between RDCs as much as practical.

6.3 Major projects

The purpose of conducting a limited number of major successful projects (or programs) is to demonstrate at least a minimum positive return on investment on the total portfolio of projects has been achieved. The following criteria should be applied to these projects:

- Sufficient major projects should be analysed to demonstrate a positive return on the RDC investment over the specified period.
- The RDCs should collate a list of potential large scale successful projects and work down the list until a positive rate of return on the entire RDC investment is reached.
- Major projects should be selected based on the following criteria:
    - ⋯ Projects or programs that demonstrate combinations of significance (good scientific results) and impact (high prospects for adoption).
    - ⋯ A high level of information available on the project and likely impact and/or adoption rates.

- How suitable the benefits generated are for valuation.
- Whether a boundary could easily be placed around the innovation in terms of inputs over time and across funding organizations.
- The size of the RDC investment in the innovation.
- High levels of public benefits where possible.

The major projects selected for this tranche of the evaluation process should use the same standard measures and approaches as the pooled CBAs (described in more detail in section 7 of this paper).

6.4 Collaborative projects

The questions being asked in this phase of the evaluation process are quite different from the ex-post CBA evaluations. The principle questions being answered with this analysis are:

- what is value of a sample of the RDC work in progress;
- what are the future private and public opportunities this work is creating;
- in some instances what the insurance value of R&D is, such as the value of contingency plans for the management of exotic pests and diseases, drought management tactics and projects aimed at climate change mitigation; and
- are large scale collaborative projects increasing RDC R&D efficiency?

In most instances the results of this material are not likely to be directly additive to the results of the ex-post CBAs but they will add an important dimension to the evaluation of the portfolio of investments of the RDCs.

Two large collaborative project or program evaluations of work in progress with significant public interest will be analysed by the secretariat each year. The projects will be selected by the secretariat based on advice from the collaboration working groups currently working on increasing RDC collaboration. The secretariat will use an options framework, where necessary, to incorporate the potential for adaptive management of the programs under examination. This has been outlined in an earlier report see attachment A.

7 Cost benefit methodology

7.1 General

The following are general guidelines for the conduct of the CBAs:

- CBAs should be on clusters of investments where outcomes can be reasonably estimated taking into account the likelihood of adoption or implementation.
- All projections and calculations should be in real terms (without escalating benefits and costs for inflation)

- All CBAs should report present values (NPVs) of net benefits (benefits minus costs); internal rates of return (IRRs)[1]; and benefit-to-cost ratios (BCRs) calculated using the present value of benefits and costs. The Commonwealth Guidelines for benefit cost analysis should be followed in calculation of the net benefits (Handbook of Cost-Benefit Analysis 2006 found at http://www.finance.gov.au/FinFramework/fc_2006_01.html)
- Adoption rates should be estimated conservatively and be tested for their sensitivity:
    - ⋯ the RDCs should keep a database of adoption rates used in past CBAs, and over time use these to cross-check and revise adoption rates.
- CBAs should include sensitivity analysis on key variables or parameters once a benefit stream and costs have been calculated (e.g., if a project involves overseas markets, sensitivity analysis around exchange rate assumptions).
- A common discount rate will be adopted for all CBAs:
    - ⋯ the long term bond rate plus 3 per cent for projects whose main output is private
    - ⋯ the long term bond rate for projects whose main output accrue to the public.
    - ⋯ These rates will be established at the commencement of each reporting period.
- Common project horizons will be adopted:
    - ⋯ current year, 5, 10 and 20 year horizons (these are the minimum horizons and more can be added if required). It is noted that some R&D particularly natural resource management is often considered to have much larger time frames for the benefits to be generated and the appropriate time horizons should be included in the evaluation process
- Actual and anticipated benefit streams should also be included in the CBAs including the reference points listed in the previous dot point. The benefit streams should be charted out so that a clear picture of when they expected to increase, peak and decline is described.

7.2 Benefits

7.2.1 General

It is important from an analytical point of view that the costs and benefits be fully identified – although not necessarily all of them need to be quantified. Each project should in its approval documentation include key success factors in terms of the output of the research and the expected rate of adoption if successful. It is anticipated that occasionally a large unanticipated benefit will be identified and where this is the case an attempt should be made to measure and quantify this.

[1] Because the IRR calculation can have an inconsistency where a high IRR is calculated, a modified MIRR may also be used which incorporates more conservative reinvestment rates. The Excel IRR and MIRR calculations should not be used. A template will be developed with the appropriate calculations included and circulated by the Secretariat.

All of the benefits should be allocated where possible to the Rural Research Priorities current at the time of completion of the project.

Also, all of the benefits will need to be clearly separated into those that are private and those that are public.

7.2.2 Industry benefits

These benefits are those that are captured by the industry sector that is contributing the levy funds (often referred to as internalised benefits).

A list of industry benefits is likely to include at least some of list below:

- to the levy payers and other industries in the supply chain in Australia:
    - ⋯ the value of improvements in productivity;
    - ⋯ the value of improvements in market share or market returns;
    - ⋯ the insurance value of preventative measures;
    - ⋯ the value of improving market access;
    - ⋯ the value in reducing risk or improving the sustainability of the business;
    - ⋯ the value of improved industry awareness;
- to research capability
    - ⋯ attracting and retaining researchers; and
    - ⋯ building technological capability relevant to Australia.

Where possible, industry benefits should be partitioned between those captured by levy payers and those that spillover into other industries in the supply chain. Consideration should also be given in the report to the circumstances which effect how the benefits are shared between levy payers and others.

7.2.3 Environmental benefits

Environmental benefits generally will represent public good or spillover benefits although some may accrue to levy payers in terms of water, salinity and air quality and sustainable natural resource management generally. These benefits are likely to include:

- improvements in water quality, environmental flows and salinity in both surface and groundwater;
- improvements natural resource management including wetlands, nature reserves and cultural values;
- improvement in the sustainability of areas of conservation value;
- improvements in air quality;
- improvements in soil conservation and management;
- preservation of endangered species;
- sustainable management of biologic resources;

- reduction in emissions of greenhouse gases;
- reduction in toxic waste; and
- safer use of agricultural and veterinary chemicals.

There is a wide range of credible methods for estimating environmental values including:

- benefits transfer;
- substitute cost method;
- hedonic pricing method;
- contingent valuation;
- choice modelling;
- travel cost method; and
- productivity method.

Most economic consulting firms would be aware of the strengths and weaknesses of each approach. In addition some governments provide data for calculation of environmental benefits. The NSW Government's Envalue data base is one example of a data base of benefit assessments of environmental values[2]. The Secretariat will provide guidance on each method should RDCs require assistance.

7.2.4 Social benefits

Social benefits may be national or regional and could include:

- occupational health and safety;
- public health and mental health;
- creation of resilient regional communities;
- building innovation skills for industry;
- building research skills;
- animal welfare;
- biosecurity; and
- consumer benefits.

The assessment of the impact on society will need to take into account the following issues:

- Does the project directly or indirectly impact on the wider public in Australia? If the answer is Yes consider the following:
    - ⋯ Are consumer products cheaper as a result of the project (i.e., has consumer surplus changed)?
    - ⋯ Are new or improved consumer products available as a result of the project?
    - ⋯ Has the technology reduced the burden of disease for all or some citizens or for workers in specific industries?

[2] www.environment.nsw.gov.au/**envalue**/StudyCnt.asp

  - ⋯ Have there been improvements to animal welfare that are valued by, for example, non-farming members of the community?
- Document quantitatively and qualitatively any other social changes which have arisen as a result of the project, such as:
  - ⋯ Health-related spillovers, for example while vaccinations against infectious disease protect those who are vaccinated the same vaccination may also reduce the likelihood of infection of unvaccinated people or animals, or improved diagnostic techniques may reduce contagion risks.
  - ⋯ Changes to community expectations, for example, changes in expectation about the extent and type of treatment that should be expected for animals with particular conditions.
  - ⋯ Changes to skill sets required to work in the industry.

7.3 Costs

As the pooled CBAs are being collected to answer questions about marginal returns and investment decisions the RDCs costs allocated to the R&D program being analysed should be on the same basis. That is the RDC costs that vary directly with the size of the project should only be included. For most RDCs this will be the direct project cost without any allocation of overheard, general administration or board costs. If required a global overhead allocation can be made once the net benefits of the projects are aggregated.

All costs should be identified, for example, in addition to the direct costs of the research additional costs such as those below will need to be included:

- Costs involved in development and extension needs to be subtracted from the benefit stream, because adoption cannot occur without these expenditures.
- If the program is aimed at increasing demand for a product then any additional marketing expenses will also need to be deducted from the benefit stream also.
- All contributions from all contributors to the project will need to be included and clearly identified.
- Any industry costs of adoption such as changes to machinery, training increased input costs will also need to be subtracted from the benefit stream.

7.4 The counterfactual

There are two critical – and often interrelated – questions that a good cost-benefit analysis must attempt to answer:

- what is likely to happen with the project, or what happened with the project? and
- what is likely to happen without the project or, what would have happened in the absence of the project (this is also known as the 'counterfactual' or 'baseline scenario')?

Many, if not most, CBAs focus exclusively on the first question, as this is what researchers who carry out the projects will primarily be focussed on and driven by. Individual researchers cannot be expected to have an overall RDC portfolio perspective, nor do they specialise in analysing industry developments. However, at a higher strategic level RDC Business Managers should, and should be able to, turn serious attention to the second question, because:

Benefits of a project = Benefits with the project minus benefits without the project

To better understand and to reflect in CBAs what might happen (or have happened) in the absence of a project, the case for market failure needs to be closely examined. Only if there is demonstrated market failure, and if there are no other R&D institutions working on the same (or similar) problems either here or abroad, can one legitimately assume that 'nothing' will happen (or would have happened) in the absence of the project. Key questions to ask are:

- would the R&D have been undertaken and/or would the benefits have been gained in the absence of the RDC involvement; and
- has the RDC brought forward a benefit?

The most obvious and commonly overlooked factor here relates to the well-known 'productivity treadmill' that is at work in agriculture. If it is known that in the past yields have, for example, typically increased at 1.5 per cent per annum, then this should be recognised in the CBA. It means that a project can rarely 'claim' the full yield increase that may have been observed following the adoption of the technology.

Studying government's and industry's existing strategies or solutions, as well as activity known to be undertaken by other R&D providers, will result in a much better understanding of the situation without a project. Use of the Internet can greatly facilitate this stage of analysis.

7.5 Treatment of uncertainty

Risk and uncertainty are likely to be identified in several ways:

- obsolescence of the technology caused by another invention or the nature of the industry changing;
- the risk that the technology will not perform as expected or the costs of implementing the technology are much higher than first thought; and/or
- adoption will not be as high as forecast.

The risk of obsolescence will be largely dealt with the inclusion of the 5, 10 and 15 years benefit reference points. Similarly adoption will be a significant variable and will need to be included in a sensitivity analysis.

The risk of the technology not performing to expectations will need to be considered at some point during the evaluation process. As all of the CBAs will be conducted on an ex-post basis, the level of risk of technology failure is likely to be small. The standard approach of this methodology is to assume a likely success rate that can be used to adjust the net benefits. For instance the net benefit described can be multiplied by an estimated success factor established on a case by case basis.

As part of the governance of this process all CBAs should have a detailed analysis of the key variables of the expected benefits and how sensitive the analysis is to changes of them. In most instances that is likely to three to four key variables that have the most impact. This has been covered in previous sections of this paper particularly in the CBA methodology and the governance section.

7.6 Attribution of benefits

Once the benefits have been described and quantified, and the counterfactual considered, the resulting total program benefits identified will have to be apportioned the organisations that funded the project. In many instances it will be simply a matter of apportioning the benefits on the same basis as the funds were contributed. That is if the RDC contributed 50 per cent of a program's funding then 50 per cent of the benefits can be claimed.

However, this may not always be the case. In some instances the weighting may be different to the contributions due to factors that may include:

- valuable intellectual property that may not be available with the involvement of the party that owns it;
- the project may be contingent on imported technology; and
- the level and importance of in kind support for the project from other organisations.

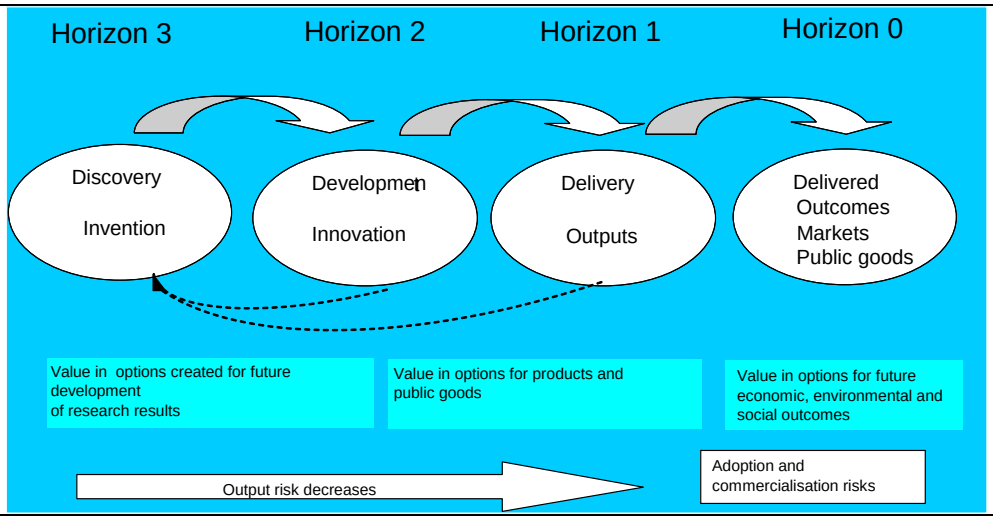
In future attribution of the anticipated benefits should be agreed to at the commencement of the program by all parties involved, and a mechanism by which unanticipated benefits be attributed also be agreed to.

Attachment A: Real options

The term 'real options' refers to the application of options concepts and theory to investments in physical or intellectual assets or in projects. It involves both a different way of viewing and comparing the merit of investments, both being planned and in place, and an expanded set of tools for designing, managing and valuing investments through their lives.

It is particularly relevant to assessing (and planning) investments with high uncertainty and scope for adaptive management where investment decisions are made in stages where the case for further investment can be considered at several points in the course of the investment project. Research and development is an obvious case in point. As research progresses through from discovery (horizon 3), development (horizon 2), delivery (horizon 1) and deployment (horizon0) stages value is created in the potential options that the research might ultimately deliver if it continues through to adoption or commercialisation.

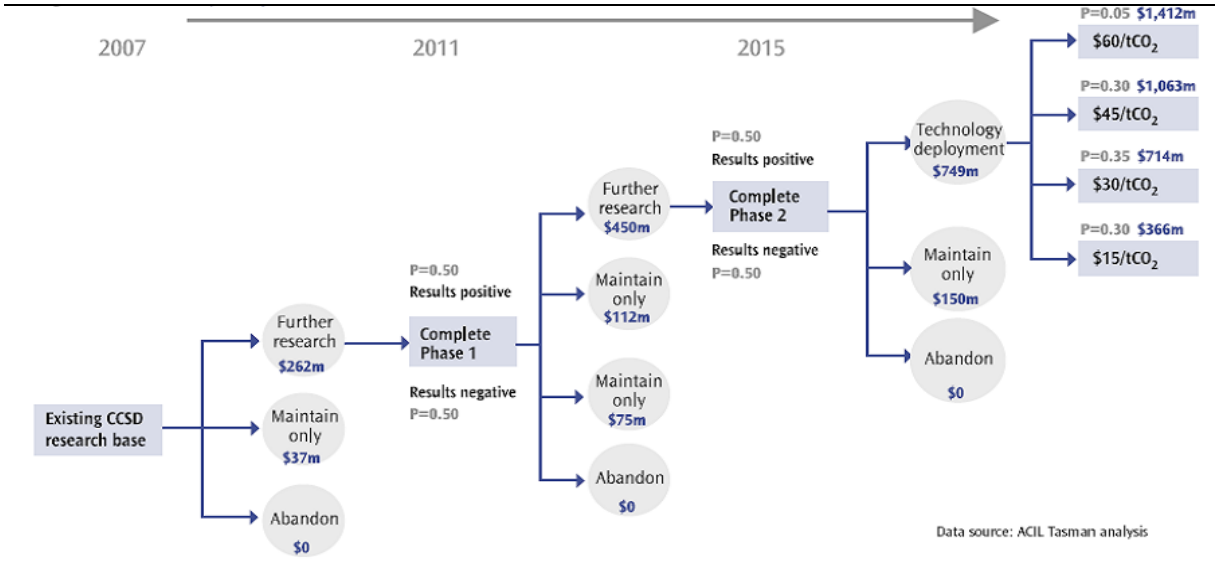
Figure 2 **Stages of research**



Data source:

Using real options as a framework for assessing the value created by R&D it is possible to estimate the value of options created at each stage. An example of such value creation is shown in figure 3

Figure 3 **Example of how value is created along the research cycle**



Data source: ACIL Tasman

In this example the value of options created from advancing research into no emission coal technology is calculated at each stage of the research program that begins on the left hand side in the horizon 2 to 3 stage and progresses through to commercialisation. Key aspects of the analysis that are relevant to valuation of research are

- the high level of uncertainty associated with commercial outcomes
  - in this case uncertainty over climate change policies expressed in terms of different levels of carbon tax; and
- The opportunities to abandon the program at several decision points along the way
  - Or to maintain the R&D capability preserving options to realise gains not justified now but possibly later.

While elements of this approach have been used for many years – more so in natural resource sectors than most others – it has only emerged, over the past 15-20 years, as a serious alternative to traditional NPV approaches to modeling and valuing investments – especially those involving high levels of uncertainty. This emergence has reflected both development of the theory and increasingly powerful computational capabilities. The application of real options concepts can, and commonly does, lead to quite different conclusions regarding investment strategy and project evaluation:

- It can provide an approach to valuing capability created by research that may not be applied such as in preparedness for exotic diseases or pest incursions;
- It may justify new investments on criteria broader than the most likely cash flow performance such as research to help adapt to climate change; and
- It will almost always point to ways of improving investment performance through active management of the options embedded in the investment.

The options approach is now becoming more mainstream and increasing recognition is given to the fact that it *redresses serious bias* in traditional methods of investment planning. The biases in the traditional investment model (i.e., the NPV model, such as is applied in most CBAs) are greatest for investments with:

- High levels of uncertainty
- High levels of flexibility to adapt the strategy
- Scope for resolving key uncertainties before irreversible commitments are made

In other words, the biases inherent in traditional valuation techniques tend to be *particularly harsh on R&D*.

7.6.1 Strengths

- Best suited to maximizing the value of ongoing and possible future projects;
- Can be used to assess a project at a different stages of research progress;
- A central feature of the approach is that it can *exploit what you do not know*. Key inputs to the approach are statements of what is not known, as well as what is;
- Useful progress can be made with *very limited information*;
- It can be carried out within relatively tight timeframes subject to access to key personnel and data;
- The initial model can then be used to help *value and prioritise* the most critical information constraints; and
- Has a high degree of inherent flexibility in that it does not focus on point estimates but on *switching points* and when decisions may have to be changed

7.6.2 Weaknesses

- Level of complexity makes it somewhat inaccessible;
- Multiple outcomes mean that the result is not a single figure, although some comparisons can be made to simple indicators;
- As a result, not as well accepted in policy or decision making circles;
- Determination of a *series* of probabilities requires advice from experts, which may be flawed.