Benefit Cost Analysis of RD&E in Action

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Contributed paper presented at the 53rd Annual Conference of the Australian Agricultural and Resource Economics Society, Cairns, February 11th – 13th, 2009

Abstract

Since 2004, the Queensland Department of Primary Industries and Fisheries has embarked on a rigorous evaluation of its R&D Programs, with Benefit Cost Analysis being a cornerstone of this work. The analyses conducted to date have proved to be powerful tools in internal resource re-allocation. However, the process used has been time consuming, partly because there needs to be adequate time allowed for consultation both with scientists and with senior staff. Experience has highlighted the need for strong organisational support to the analysts carrying out the work.

Keywords

Benefit Cost Analysis, management, research and development

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1 Background

The use of Benefit Cost Analysis (BCA) in evaluating RD&E projects has become well accepted over the last 30 years or so. It is arguably the most important contribution made by the economics profession to the management of RD&E Programs in a whole range of research organisations worldwide. It is not the purpose of this paper to review the vast volume of literature that has been published on the subject.

The textbook by Alston, Norton and Pardey (1995) and its accompanying software program DREAM have possibly been the most significant developments for evaluation practitioners in the last 15 years. The advent of computers has, of course, provided the tools to promote and expand the use of BCA in the RD&E management field.

A major organisational restructure of the Queensland Department of Primary Industries and Fisheries (DPI&F) in 2004 resulted in an increased need to critically evaluate our RD&E activities to ensure they were producing acceptable levels of benefits in comparison to costs. The developments in the theory and practice of RD&E evaluation by the economics profession provided the basis for a greatly expanded work program in this area.

The objectives of this paper are:

1. To discuss (briefly) the main features of the 2004 organisational change in DPI&F.
2. To discuss the approach that has evolved in evaluating RD&E Programs.
3. To discuss what we have learnt from our experiences.

2 DPI&F organisational structure since May 2004

The re-organisation that occurred in 2004 was the most radical of any change that has occurred in the senior author's 40 years with DPI&F. The introduction of what is called an Investor: Delivery model greatly altered the way RD&E is managed. This model effectively divided DPI&F staff involved with RD&E into two teams – an Investor team responsible for making recommendations on how RD&E should be funded and managed, and a Delivery team responsible for carrying out RD&E projects. This latter group is, naturally enough, by far the largest group numerically. The authors are attached to the Investor Group.

To quote from the Research and Development Strategy (2005), a document that was prepared following the restructure:

> *In May 2004, DPI&F announced a redesign of its governance of RD&E investment. This new model:*
>
> 1. *Separates DPI&F's R&D investment management (R&D Strategy group) from its R&D delivery management (Delivery division).*
> 2. *Ensures R&D is more strategically driven and greater emphasis is placed on maximising economic return on investment.*
> 3. *Focuses both on innovation derived from investigator-driven R&D (that is, R&D initiated by the scientist) and strategic impacts achieved through outcome-focussed science investment.*
> 4. *Results in more transparent decision making.*

Accompanying the change, the DPI&F vision and mission became very economically focussed:

> *Vision: Profitable primary industries for Queensland.*
> *Mission: Maximise the economic potential of Queensland's primary industries on a sustainable basis.*

RD&E project activities were arranged into Programs. Currently (January 2009), there are 12 Programs, mostly arranged along industry lines e.g. Intensive Animals, Beef, Grains and Pulses, Aquaculture, Lifestyle Horticulture etc. The total annual RD&E budget is somewhat over $100 million.

The sequel to the Research and Development Strategy was a Research and Development Strategy Implementation Plan (2005) that stipulated that we would carry out *reviews* of three RD&E Programs a year. Since the end of 2005, the emphasis has been to conduct whole Program evaluations. The Programs evaluated to date have been Beef, Feed Grains and Fodder, Intensive Animals (Dairy, Pork, and Aquaculture) and Lifestyle Horticulture.

As a consequence of the emphasis on achieving economic outcomes and the role of the R&D Strategy Group (renamed the Innovation Group in 2008) in overseeing RD&E, Benefit Cost Analysis of RD&E activities has become a major part of our work. Not only that, it is being used extensively to provide direction to RD&E Programs.

3 Approach that has evolved

This section discusses the framework that is guiding Program evaluations, the communication chains important in carrying out the work, and presents some technical details on how we go about the BCA work.

3.1 Program evaluation framework

The Program evaluation process follows steps that are both sequential and iterative. The framework for the process is shown in Figure 1. A Program evaluation typically takes around six months to complete, with an average of two economists assigned to the task. The steps are:

Identify and engage stakeholders
The intention is that Program evaluations will be undertaken for all DPI&F Programs over an extended period. Once a Program evaluation has been ear marked to commence, the Investor group works with Program management in Delivery to identify the stakeholders critical to the evaluation. The key stakeholders consulted are generally internal to DPI&F. Their expectations of the evaluation are clarified and shared. External stakeholders e.g. industry representatives, R&D corporations, are also contacted as part of a consultation phase in most evaluations.

A major component of the stakeholder engagement is the establishment of both a Program evaluation steering committee to guide the evaluation, and an evaluation team to conduct it.

The steering committee is responsible for overseeing the process and making the final recommendations for the future direction of the Program. It comprises senior managers from both the Investor and Delivery groups. The Director-General is not a member but senior managers from the next tier of management are.

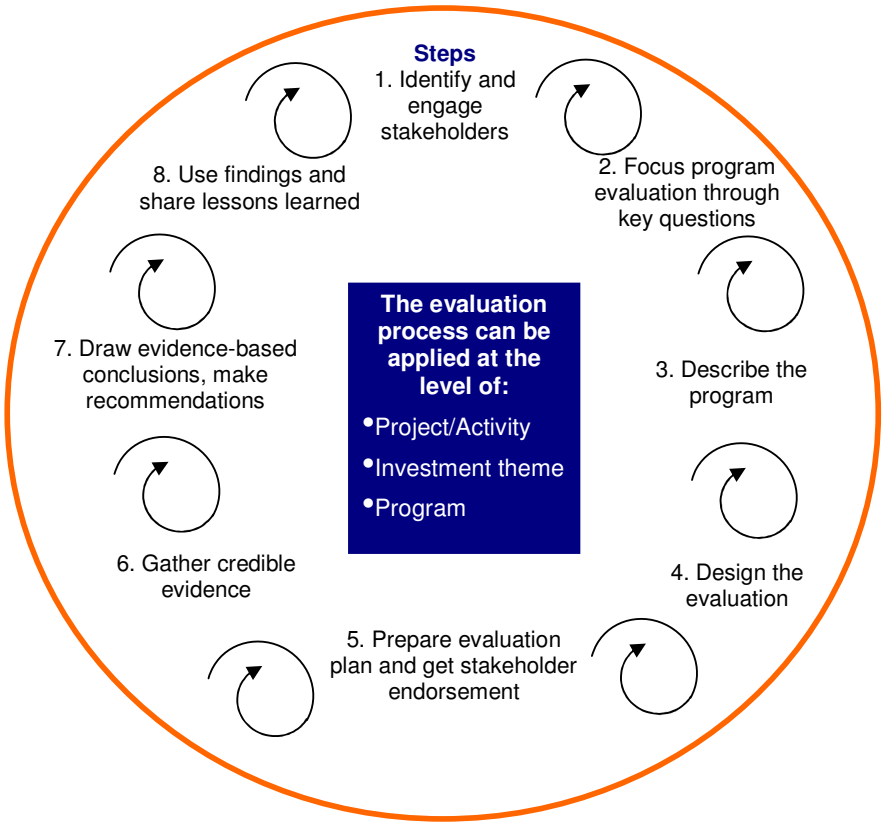

Figure 1 Program evaluation framework

The steering committee meets only two or three times over the course of a Program evaluation. They meet initially to approve the Terms of Reference and the evaluation design. They may meet again to receive a progress report. Most importantly, they meet at the end of the process to provide comments on the final report and to formulate recommendations.

The implementation of a Program evaluation is the responsibility of an evaluation team led by a senior agricultural economist from the Investor group. Additional staff from the Investor group, particularly agricultural economists, provide direct support. Data collection is carried out by the evaluation team, with a major input from science leaders, managers and project leaders from the Program in question.

Focus the Program evaluation through key questions

The Program evaluation process takes a wide view and includes consideration of the relevance, efficiency and effectiveness of DPI&F Programs in meeting Queensland government objectives. There is an opportunity at the beginning of each Program evaluation for the steering committee to identify key questions specific to the Program that need to be considered during the evaluation.

The key questions, together with consideration of the overall role of the Program evaluation process, form the terms of reference (TOR). All TORs for Program evaluations to date have contained provision to assess the likely economic impacts of RD&E projects, hence the emphasis on Benefit Cost Analysis.

Describe the Program dimensions
This is essentially the current Program specification statement (an internal DPI&F reporting document) and any additional information deemed necessary to understand the Program's resources, activities and objectives, and expected outputs, outcomes, and impacts.

Design the evaluation
The key questions may need additional interpretation and the information needed to answer the key questions has to be identified. All the issues involved in designing research, both quantitative and qualitative, need to be considered here.

Prepare evaluation plan and get stakeholder endorsement
The evaluation plan documents the steps to be followed during the evaluation and is revised in consultation with the Steering Committee as new information comes to light.

Gather credible evidence
The evaluation plan is implemented. Generally this includes the evaluation team:

- Collecting relevant Program data, industry statistics and compiling representative industry models.
- Reviewing the information from project proposals, progress reports, relevant published papers and other material. Complete project budgets on an annual basis are constructed from these documents.
- Interviewing project leaders, Program management and other relevant persons.
- Providing feedback to project leaders and Program Management on data collected and analysis. Draft BC analyses of individual projects are part of this feedback. Some analyses proceed through several drafts.
- Compiling a draft report.

Reports prepared by the evaluation team include:

- Program evaluation summary
- industry and Stakeholder consultation
- individual investment analyses i.e. BC analyses
- draft recommendations.

At all times, transparency is maintained in the analyses undertaken, with alternative views supported by suitable evidence.

Draw evidenced-based conclusions, make recommendations
Recommendations for the future conduct of the Program are derived from the data and observations contained within the Program evaluation reports.

Recommendations encompass the following:

1. specific areas that DPI&F should target for future investment, including both high and low priority areas
2. opportunities for co-funding with other providers and industry players
3. future human resource and infrastructure requirements.

Draft recommendations arising from a Program evaluation are formulated by the evaluation team and submitted to the Steering Committee for approval and comment. Once finalised, they are included in a briefing note for the approval of the Senior Executive Team (SET) of the DPI&F.

Use findings and share lessons learned
Once approved, implementation of the recommendations is the responsibility of Investor and Delivery Managers. It is expected that the three to five year plan prepared by these managers will provide details of how the recommendations are to be implemented.

3.2 Evaluation communication chains

The main groups and individuals involved in Program evaluations are shown in Figure 2.

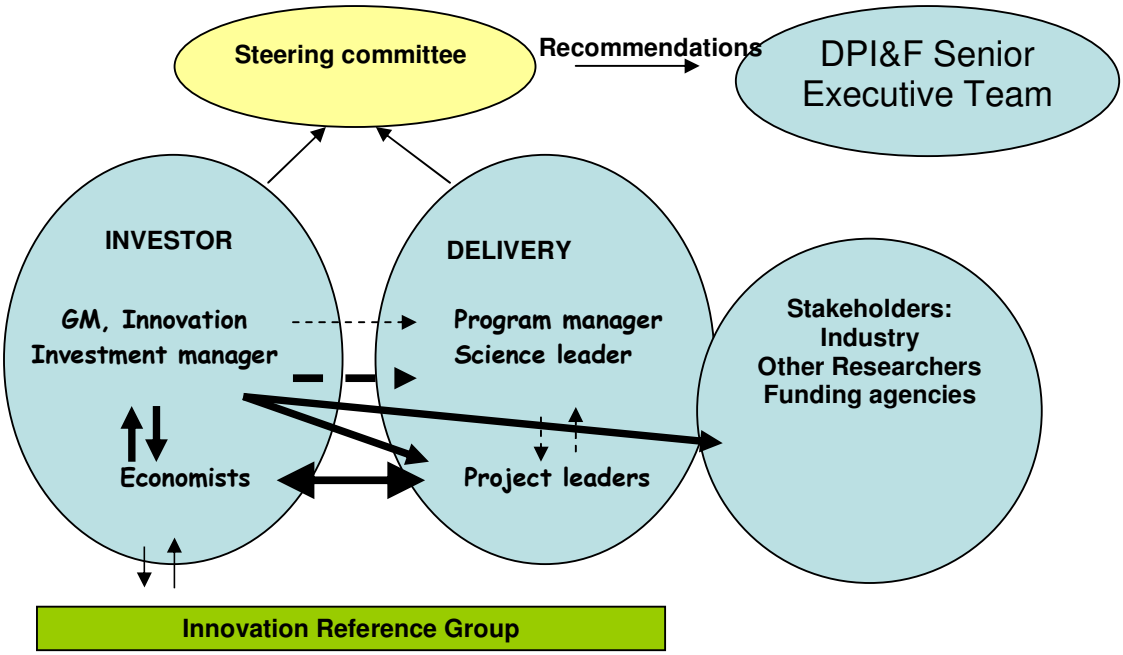

Figure 2 Communication chains in Program evaluations

The General Manager, Innovation, is responsible for setting the sequence for Program evaluations plus keeping Program evaluation steering committees informed of the commencement, progress and finalisation of Program evaluations.

3.3 Guidelines for carrying out economic analyses

It is important that the results of Program evaluations are verifiable and based on a consistent approach. Benefit Cost Analysis (BCA) has been the analysis technique applied. The approach used is compatible with general guidelines from the Department of Finance and Administration (2006) and from the Council of Rural Research and Development Corporation Chairs (2007).

The role of economics in the evaluation process
BCA has been a key component of all Program evaluations carried out to date. The following points are important:

1. The economic analysis has a constructive role in generating ideas and highlighting knowledge gaps rather than facilitating decision making based only on a numerical analysis.
2. The economic analysis supports what will always be subjective decisions about research directions. However, without the analysis, decisions would rest almost entirely on data not subject to the broad critical review made possible by making assumptions explicit.
3. It is recognised that the economic analysis will not be based on perfect information but on the best estimates available at the time.
4. The economic analysis relies on transparency in its assumptions so that validity can be assessed.

The intent is that the economic analysis be approached by economists and other DPI&F staff as a collaborative and cooperative process.

Bottom up or top down

The emphasis has been to use individual projects and activities as the basic unit of analysis and to aggregate up to an investment theme (See below). This is a *bottom up* approach. It is time consuming and involves the collection of a lot of data about individual projects and activities working mainly from original project proposals and progress and final reports. RD&E Programs typically have from 20 to 50 current individual projects and activities.

The alternative is to use a *top down* approach where arbitrary assessments are made of the industry productivity change that might result from larger *chunks* of the Program e.g. from a research theme. This is a much more efficient process in terms of time. However, because the assessments are very arbitrary, it is more difficult to have confidence in the results. With the *bottom up* approach, there is some connectivity between individual projects and their likely effect on farm productivity, adoption rates and economic outcomes.

All current and some recently completed projects and activities have been included in the BCA process to date. Projects or investments that are unlikely to produce identifiable economic benefits have been noted in the final report, with the reasons why economic benefits could not be identified made clear.

Investment themes

Projects are grouped into investment themes to facilitate economic analysis and to identify the economic impact of the outcomes identified in the Program specification. Investment themes are comprised of projects that have common or similar impacts. For example, a group of projects may contribute to maintaining or restoring land condition in grazing systems, thus allowing them to be grouped into one theme for analysis e.g. grazing land management. Another group of projects may all contribute to providing improved barley varieties. They could be combined for economic analysis.

A number of separate analyses may be undertaken within an investment theme to consider the impact of separate projects that make up the theme. Grouping projects and activities into investment themes improves the understanding of the Steering Committee and other stakeholders of the likely magnitude of the outcomes targeted by the Program.

Ex post or ex ante

The intent of Program evaluations is that they be used to support resource allocation decisions. The expected returns from the current portfolio of projects or activities

have been the focus of attention. In a sense, the analyses are somewhere between ex ante and ex post studies. The intent is that the analysis provides some indication as to how the current suite of projects and themes could be re-arranged in the future to produce higher net benefits. Ex post evaluations have been carried out from time to time in conjunction with Program evaluations but these have been very selective and have focussed on large completed projects.

With and without scenarios

The approach recommended by Marshall and Brennan (2001) has been useful in this area. There are two critical questions that must be considered in a Benefit Cost Analysis.

1. What is likely to happen in terms of productivity gains with the investment?
2. What is likely to happen without the investment? (The *counterfactual* or *baseline scenario*).

With and *without* scenarios are utilized to measure the net benefits of the investment. They may come into play in an analysis in a number of ways:

- In estimating the productivity gains from the research. For example, what additional improvement in (say) yields will result from the research over and above present varieties or varieties from other researchers?
- In estimating the economic life of the project. For example, if it is believed that it is likely that a competing product will arrive eventually in the absence of any investment; this expected outcome will affect the selected project life.
- In estimating the size of the benefited area. For example, if it is believed that the outcome will affect only half of the area currently served by the existing product, then the lower area will be used in the calculation of benefits.

Use of the *with* and *without* principle forces formal consideration the net impact of the investment. Similarly, costs are measured as the difference in the costs between the *with* and *without* scenarios.

Discounting

Standard discounting procedures have been used. All benefits and costs are expressed in constant dollar terms (i.e. nominal values adjusted for inflation where necessary) and discounted or compounded by the discount rate to the current year. The discount rate used has been five per cent.

There seems little point in overloading decision makers with decision criteria. Because the aim is to maximise returns to limited research dollars, the criterion of choice has been the Benefit Cost Ratio. Net Present Values (NPVs) for individual projects have occasionally been converted to annuities and presented as *the net annual economic benefit generated during the next x years*. Internal Rates of Return (IRRs) are not reported.

The major purpose of a Benefit Cost analysis undertaken within a Program evaluation is to estimate the net benefits of the different components i.e. of themes and projects. Addition of the NPVs of benefits and costs across projects and investment themes to calculate a Benefit Cost ratio for the entire Program does not reveal useful information about Program direction and has not been carried out. Investment choices are not made between Programs but between investment themes and projects within a Program.

Benefits
All benefits that have a causal link to the Program have been identified and, where possible, described and/or quantified. Benefits will be generally of three types: economic, environmental and social.

The emphasis has been on measuring economic benefits that contribute directly to increased growth in Queensland industries. Where environmental and social benefits are identified by DPI&F staff as outcomes of investments, they have generally been noted and valued where suitable data are available.

Benefits have been assessed using measures of the additional economic surplus (benefit) resulting from changing a commodity's supply schedule, normally measured at the farm gate. The actual technique used has varied, depending on the type of commodity and production system.

For commodities with a perfectly elastic demand curve e.g. some export commodities, the short cut method of *incremental profit* has been used (See Gains for Grain 1992). Under this situation, all benefits accrue to producers and the benefits are measured as the extra profits accruing to them on the assumption that prices do not change. Further, where there are a number of commodities involved e.g. in farming systems RD&E, the *incremental profit* method has been the only feasible option.

For commodities with a sloping demand curve, estimates of economic surplus have been based on the cost reduction per unit resulting from the new technology. Models that combine cost reduction estimates with the elasticities of supply and demand have been used where possible.

We have not made extensive use of the DREAM program to measure benefits. We consider that the transparency of a spreadsheet is a feature we require when negotiating benefit parameters with scientists.

Royalties represent a transfer payment. They have been included as a benefit of the project, i.e. added to the top line, when calculating a B/C ratio only when they have been incorporated in producers' costs when assessing incremental profits or unit cost reductions. The two entries therefore cancel one another out. Royalties have not been subtracted from costs on the bottom line.

Distribution of benefits and costs
The primary purpose of the BCAs is to calculate the economic benefits (increase in consumer and/or producer benefits) from the resources, human and other, used in undertaking an activity or project. Our BCAs initially measure the return to Australia from the resources used, irrespective of the funding source. This focuses attention on the broad economic outcomes of the total investment.

The distribution of benefits and the composition of funding may well affect the viability of an activity from a funding agency's point of view. A project with substantial spill-over benefits to (say) another state without appropriate funding from the other benefited party may well lead to a questioning of the project's priority even though, from a national viewpoint, the project shows excellent returns. Therefore, the distribution of benefits and costs among states and sectors is important. This will be particularly important when aligning DPI&F investments with priorities to be identified under the National R&D Strategy (Department of Agriculture, Fisheries and Forestry 2009).

The process for an economic analysis undertaken as part of any Program evaluation has been as follows:

1. Undertake a Benefit Cost analysis that identifies all returns at the national level and all costs contributed by all investors and incorporates a *with* and *without* scenario approach. The question addressed is – *What are the likely economic benefits compared with the total costs of the investment?*
2. Examine the distribution of benefits among states or jurisdictions of interest.
3. Examine the distribution of anticipated funding sources - Queensland taxpayers, producers, private sector, Rural Development Corporations.
4. Identify Queensland benefits and the Queensland contribution through taxes and producer levies.
5. Where the Queensland benefits are lower than the Queensland contribution, identify the funding shares for the investment activity that makes the investment viable for the state.

Benefits have not been attributed to one source of funding for the project or investment to calculate some form of *leveraged* Benefit Cost Ratio.

Measurement of social and environmental benefits
During past Program evaluations, considerable emphasis has been placed by some scientists on the social and environmental benefits provided to the industries impacted by the Program outcomes. For these benefits to be included in an analysis, not only does the outcome need to be measureable, a causal link needs to be established between the Program investment and the outcome claimed. This has proved difficult to do in most situations.

Likelihood of research success
We endeavour to put realistic estimates on likely improvements in productivity. This means that we don't always accept the scientists' estimates. However, we are possibly being somewhat generous in that we mostly assume a likelihood of success of 100%.

Costs
The approach taken by many organisations with publicly funded activities and projects is to identify only those costs that directly vary with the size of the individual investment or project. Costs such as overheads, general administration or management costs are not included in their BCAs.

The approach we have taken to allocating costs to projects in a Program evaluation is to include the contributions from all sources, including corporate overheads. Costs are – salaries, salary on-costs, operating expenses (including travel), capital expenses and corporate overheads. Currently, salary on-costs are calculated at 0.27 times salaries and corporate overheads as 1.77 times salaries. This provides a realistic estimate of the true economic cost of making the investment.

R&D corporations and other funding agencies normally contribute to salaries and operating, and sometimes for capital by paying directly to the organisation undertaking the investment activity. Rarely are contributions made by funding agencies to cover the corporate overheads incurred by partner organisations for externally funded positions. The appropriate allowance for overhead costs is added to the costs of the organisation holding the externally funded position, in most cases DPI&F, not the agency funding the position.

Where the innovation produced by an investment or project will not gain adoption without expenditure on extension activities by DPI&F or other interests, those costs have been identified and included. If an innovation is likely to gain adoption without extension activities, then the projected rate of adoption reflects the lack of extension activities.

It has been necessary in some investment analyses to include an estimate of the cost contribution from commercial players. For example, in sorghum breeding, private firms play an important role in getting the DPI&F developed germplasm to the commercial release of hybrids. The only costs included are those costs identifiable as necessary to undertake the activities and/or extra expenses aimed at gaining adoption of the product. Costs associated with the normal marketing activities of the commercial player have not been included.

4 What have we learnt?

Our experience over the last three years in carrying out Program evaluations has highlighted a number of issues that could affect the outcome. These include:

1. *Critical analysis* has become the cornerstone of the economic evaluation of Program Evaluation. It relies on a *bottom up* approach and not taking claimed RD&E outcomes at face value. The bottom up approach is very time consuming as it involves coming to terms with the science of individual projects and requires close interaction with individual project leaders. This critical analysis by economists of the outcomes identified by project leaders leads to lengthy *discussions*. The time delay in completing Program evaluations is causing frustration for senior managers. However, we consider that a bottom up approach is necessary if the analysis is going to be *critical* and provide support for recommendations.
2. There is an almost complete absence of any effort on the part of project leaders and scientists to routinely monitor adoption or benefits. This makes the evaluation task more difficult. Scientists are not accustomed to thinking in terms such as benefits per hectare, likelihood of success, scale of the industry, adoption rates etc. However, since we are interested in applying a standard of *reasonable* proof across analyses, it is critical that these estimates are made with at least some basis in fact.
3. The wording of the TOR for the evaluation is terribly important. Our later Program evaluations have contained both economic and non-economic components. To provide the economists carrying out the evaluation with a clear direction, it is very important that there is a separation of the two components in the TOR. Ideally, it may be desirable that the two components be integrated. In practice, this is difficult to achieve.
4. The *organisational effort* involved in carrying out Program evaluations has increased greatly over the last three years e.g. through having evaluation teams and high level steering committees. Senior management are now taking the process very seriously. There is nothing like a strongly supported economic analysis showing a low BC ratio to arouse scientists' and RD&E managers' interest. It is also fair to say that the economic components of the evaluation process have been critical in supporting the more difficult recommendations coming out of the evaluation process.
5. Our discussions with scientists have raised a number of controversial issues. Some of these have been:

- There was a certain amount of disbelief initially that our project evaluations could have implications for the future funding of their projects.
- Agreeing on productivity gains is often tricky. We consider (naturally enough), that project staff often overestimate the gains possible.
- Scientists object to our approach of including corporate overheads in costs (*These are not my costs*).
- The measurement of environmental and social benefits can cause a lot of discussion. We have found an attitude such - *If I work on this component of this industry, then I should be able to claim the environmental and social benefits of the whole industry.*
- There is also a difficulty in linking claimed environmental and social benefits to RD&E activities.
- The use of the counterfactual scenario that the innovation would have occurred at some future time, or at the same time but to a lesser extent without the investment, is not popular.

6. Similarly, our interaction with Delivery management has thrown up a number of issues:
   - There is sometimes a desire to use some type of leveraged BC ratio, rather than focussing on total costs and total benefits. In particular, to use total benefits in relation to costs contributed by the Queensland government, thereby raising the BC ratio. We steer away from that approach. The Rural Development Corporations appear to have a different view, as evidenced by their recent evaluation of projects (Council of Rural Research and Development Corporation Chairs 2008).
   - There has been a gradual acceptance of the high costs of publicly funded RD&E. The inclusion of corporate overheads as a legitimate cost means that DPI&F managers are being presented with much higher project budgets that they are accustomed to.
   - RD&E managers in Delivery have mostly been very optimistic of the prospects for growth of their particular industry. These views have sometimes not coincided with those of the analysts carrying out the evaluations.
7. Following the evaluation and subsequent acceptance of the recommendations, there remains the question of implementation. We do not become involved in this process. We consider it a role of senior managers from the Investor and Delivery groups to manage this process. There is certainly a need for a *champion* from the Investor camp to act as *overseer* and that person needs to understand the detail of the evaluation.

5 Conclusions

The main aim of our evaluation process is to identify investment themes most likely to produce the most benefit - after the investment has been made and when some reliable information becomes available. We can recommend that things be shut down but cannot stop things being started. The view might be that scientists can pick *winners* but we economists are good at picking *losers*. There is certainly more that we could do in carrying out ex ante analyses of major projects before they reach the funding application stage. Given our limited resources and charter to evaluate existing RD&E Programs, this has not received the attention it deserves.

The process has also highlighted a need for some type of impact assessment to be routinely completed by project staff within projects or themes. This is not economic analysis but the gathering of the precursor data that identifies objectives, outputs, impact and adoption. These data would greatly assist scientists to better understand the impacts of their work. Coincidentally, it would greatly assist our BCA work.

Successful implementation of a process like this depends on having support at the top of the organisation. The executive director of the Innovation Group, while not an economist, has wide experience on the Boards of national and international RD&E funding bodies and is quite familiar with BCA information. This support has been critical.

One thing is for sure – the process has succeeded in raising the profile in DPI&F of the economists involved. Given that the BC information provided through the process is often the most useful evidence available on which to base resource re-allocation decisions, this is not surprising. In our view, the approach has been *moderately successful*.

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