EVALUATION OF RESEARCH ACTIVITIES

Gary Stoneham, Loris Strappazzon, James Soligo, Bill Fisher, Mark Eigenraam and Rukman Wimalasuriya[1]
Economics Branch, Agriculture Division, Department of Natural Resources & Environment, PO Box 500, East Melbourne Vic 3001.

Contributed paper to the 44th Annual Conference of the Australian Agricultural and Resource Economics Society, The University of Sydney, 23-25 January 2000.

[1] The views expressed in this paper are those of the authors' and may not reflect the policy of the Department of Natural Resources and Environment or the Victorian Government.

Abstract

In this paper we explain the economic evaluation system developed by economists—in conjunction with senior managers—for the Department of Natural Resources and Environment's Agriculture Division. This evaluation system has two components: qualitative and quantitative. The former focuses Departmental activity on areas where there is market failure. The latter measures the gross benefits from Departmental activity by using linear programming models.

We also document the implementation of the system to a recent Victorian Government intiative—*Growing Horizons*. We explain the process, impact to date, and lessons learned by undertaking this exercise.

Contents

1. INTRODUCTION

The purpose of this paper is to explain the system developed by the Department of Natural Resources & Environment (DNRE) to evaluate the Agriculture Division's proposed activities and to describe our experience with its application.

DNRE's evaluation system is the result of the efforts and experience by economists, both within and outside the Department, about appropriate methods to evaluate research. This follows a long history of earlier work. The system described here is designed to overcome many long-standing concerns about current methods and approaches to the evaluation of research projects. These include: sources of inconsistency in benefit-cost applications between organisations which reduces the value of assessments prepared for external organisations such as the Rural Industry Research Corporations, and institutional issues which act to discourage all necessary information being revealed for decision making. These and other issues have been discussed by Bardsley (1997,1999), Kingwell (1999) and at workshops, such as that convened by the REGAE[2] (Brennan and Davis 1996).

Strong support to develop improved methods of evaluation has come from the Executive Director of the Agriculture Division. This Division has partially funded the development and implementation of the system described in this paper, as well as other work on evaluation systems. The Division is responsible for an annual research & development budget of around $ 50 million per annum.

Like other publicly funded organisations, the need to develop improved methods of resource allocation in DNRE has been prompted by increasing competition for public funds, both within and between Departments; and increasing scrutiny of budget outlays by Central Agencies. These influences have heightened the need for well-developed evaluation systems.

2. DNRE's ECONOMIC EVALUATION SYSTEM

Investment decisions are best made with as much relevant information as possible. The objective of resource allocation decisions is to maximise wealth, or well being, in the Victorian economy. While equity via re-distribution or transfers such as social security is an important responsibility of government, this is not incorporated in the resource allocation processes documented in this paper.

DNRE's evaluation system involves two components: qualitative and quantitative. This section will explain both of these aspects, commencing with the qualitative component.

[2] Research Evaluation Group of Agricultural Economists (REGAE) is a group of members within the Australian Agricultural and Resource Economics Society.

Qualitative Evaluation: Beneficiaries and Funding Analysis

Australian government agencies are continually under public scrutiny and are often facing diminishing resources. Examinations of government activities to decide whether they address a market failure can assist decision-makers choose between alternatives.

Given certain assumptions (see Box 1) the private market will function efficiently; private sector agents will be able to handle production and distribution of a good or service and competition will spur investment in new technology. Successful investment will return the relevant firm greater profits, and consumers will receive a better quality and/or lower priced product.

Box 1: Requirements for Efficient Market Allocation

The competitive conditions that will result in optimal resource allocation[3] are (Tisdell, 1972):

- no buyer or seller is able to influence prices by individual trading behaviour
- economic agents are well informed about relevant production or consumption possibilities, and prices
- firms maximise profits and consumers maximise their level of satisfaction
- factors of production are perfectly mobile
- there are no effects external to the price system

The result of such conditions is that goods will be priced at their marginal cost (see Tisdell 1972)[4]. However, such conditions will not always prevail, so the government may need to become involved in the provision of (but not necessarily produce) goods or services.

Market failure occurs when social preferences are not aligned with those of the firm, or individual. This may occur when one or more of the assumptions needed for efficient market provision are not satisfied.

One of the assumptions required for efficient market provision of a good, or service, is broken if a firm is large enough to influence prices significantly (a monopoly supplier). In this case, excess profits can be made. Since there is a lack of competition, the supplier is not forced to reduce prices to the level that would eventuate in a competitive environment. Further, product supply will be restricted (see Box 2). This is optimal from the monopolist's point of view, but not society's; the firm maximises profit but consumers pay an excessive price.

Market failure can also occur if there are effects external to the price system. Clean air, for example, is not sold at the local corner store. Since it is not priced, the socially optimal level of clean air may not prevail (see public goods and externalities definitions in Box 2).

[3] Optimality is usually defined in a Pareto sense, *viz,* no individual can be made better off without anybody being made worse off.
[4] The first and second welfare theorems prove that competitive conditions will lead to an optimal allocation of resources, and that any optimal allocation can be attained through appropriate redistribution of initial endowments. See, for example, Varian (1992).

Box 2: Public Goods, Externalities and Failure of Competition

Markets fail because of three main reasons: Public goods, externalities and failure of competition. Firstly, private sector agents may not be able to appropriate the benefits from investment, because the results can't be restricted from competitors' access. Therefore there is relatively less incentive to invest (public goods). Secondly, private sector activity might (say) cause problems to society that the agent does not take into account (negative externalities) and so the volume of production may be excessive; the full (social) "costs" differ from those incurred by the firm. Thirdly, an activity may be relatively amenable to large-scale operations, which inhibit competition (failure of competition).

Public Goods

Public goods are not efficiently provided by the market because they are *non-rival* and *non-excludable*. Knowledge, in general, is *non-rival*; that is, consumption by one individual does not diminish the amount available for others. Further, if knowledge is easy to absorb it is hard to *exclude* people from obtaining it. A casual conversation between two people might transfer such knowledge. However knowledge that is relatively difficult to comprehend becomes relatively *excludable*, a trait that is more closely associated to private goods.

Externalities

Externalities occur when an economic agent undertakes an activity which imposes costs (or confer benefits) on others, and no compensation (or payment) is given (received). For example, if pollution is discharged into a river affecting production downstream, then a *negative* externality is generated. If individuals tend to lavish gardens at the front of their houses, then others benefit from the aesthetic improvement but do not pay for this; a *positive* externality. When an externality exists, agents do not face the full consequences of their actions. For example, a polluting firm profits from production, but residents living nearby inhale contaminated air.

Failure of competition

Where production is characterised by increasing returns to scale (decreasing average cost as scale of production increases), the competitive outcome (price equals marginal cost) may not eventuate; it may be more efficient to have one supplier of the good. For example, co-ordination of one industry's agricultural research might be carried out relatively efficiently by a central agency. Having two would duplicate administration costs and perhaps research effort.

Investment Incentives

When an industry's productivity improves, it successfully competes for more resources, and hence production increases. This has a positive flow-on effect for related industries. For example, expansion in dairying requires more trucks that can transport milk. Further, if the price of milk falls (as would be expected with increased supply in a free market), then industries that use milk as an input—like cheese manufacturers—benefit from reduced costs. These flow-on effects will occur whenever there is growth in any industry—agricultural or not.

Consider a technology breakthrough in the textiles industry that reduces the cost of production. Sewing machine operators, designers and distributors may benefit from increased demand for their services. Consumers may benefit from a fall in the price of clothes. However, this does *not* provide a rationale for government involvement anymore than a productivity improvement in milk production.

The important question to consider is: do the relevant producers have an incentive to fund the activity, even in the absence of government intervention?

To answer this question, it is necessary to consider the nature of the products of research. If the product of research, development and extension (RD&E) is such that once it is available to one individual, it is difficult to restrict other people accessing it, then there may not be an incentive to fund the activity[5]. Others will capture the benefits of one producer's actions, without paying for it. They will *free ride* on the knowledge generated by the investor. Competitors can mimic the innovation, without undertaking any outlay. Any profits made by the investor will only be maintained in the short-run. Profits may be eroded so quickly that

[5] Patent and copyright laws are one way to enable investors to extract profit from innovative ideas, even if they can be mimicked.

the investor does not recoup the cost of innovation. Knowing this, the (potential) investor will not invest and the socially beneficial product will be forsaken.

When the product of investment can be excluded from others then the investor will be able to capture the benefits, in terms of profit, from an innovation. Therefore, there is an incentive to invest, even when others benefit from (say) price flow-on effects. Producers further down the process chain may benefit, by receiving cheaper inputs. However, *the innovator benefits as well*. This is the fundamental point: if the result of investment can be appropriated so that profits can be made, then government need not intervene, even if there are flow-on benefits.

Beneficiaries and Funding: a Rating System

By applying some simple economic principles, we have developed a rating system that helps to identify the beneficiaries of a given project. This information can then be used to determine the appropriate balance of funding required from project collaborators: government, the private sector and industry bodies. We classify NRE projects as follows:

> ***Private*** – indicates no market failure exists and the private sector has sufficient incentives to fund profitable projects. An example of a *private* rated sub-project is one that assists Australian producers draw up contracts with foreign purchasers.
>
> ***Industry*** – market failure exists at an industry level. This suggests that projects generate benefits that accrue to an industry or some subset of the industry. The Rural Industry Research Corporations (RIRCs) were developed specifically to provide a mechanism for funding research with an *industry* focus[6]. An example of an *industry* rating project is one that provides information on improved crop rotations. By conducting experiments using different rotations, scientists can pinpoint the effects on output. The beneficiaries of this research, and the subsequent extension, are clearly grain growers. There is little scope to use the information generated in other agricultural industries or any other sectors of the economy.
>
> ***Community*** – projects with benefits to the community exhibit some form of market failure described above. The market will not provide the activity efficiently (if at all), even if institutional arrangements are altered. An example of a *community* rated project is one that gathers information about surface water run-off. By learning how water moves off farmland, appropriate government policy can be implemented to prevent the external effects—fertiliser flow into (say) a river. The general public (or community) benefits from improved plant and animal health in, and surrounding, the relevant river. For example, via improved recreation (fishing, swimming and animal watching).

For projects that generate private benefits, it would be logical to expect mostly private funding of research and development costs. Projects that are classified as generating *Community* benefits have an *a priori* claim to government funding because private markets may allocate insufficient funding to these activities. Government involvement is justified if the benefits are greater than the costs.

---

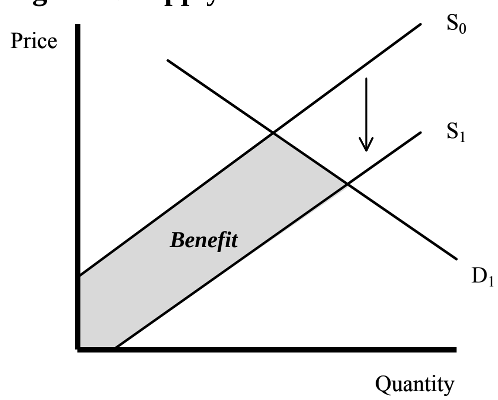
[6] RIRCs provide a ready-made mechanism to fund agricultural research.

Sub-projects do not always fit into just one of the above categories. For example, animal welfare research projects benefit *industry* and *community*. Industry has some incentive to perform animal welfare research. Firstly, to allay consumer fears about the effect of farming practices on animals (often called 'market protection'). Secondly, animals in good health are often relatively productive. However, the incentive for industry to fund animal welfare research to the socially optimal level is, most likely, lacking. When there is a trade-off between animal welfare and productivity, industry is likely to sacrifice the former, especially if the industry thinks that this information can be kept hidden from consumers. Government involvement may help correct this.

Quantitative Analysis: Economic Surplus Measurement

NRE's quantitative analysis attempts to measure the gross benefits derived from (say) a research-induced technology change. Economists often use the sum of consumer and producer surplus as a measure of benefit from some policy—or other type of—change[7]. A research-induced technological change is a shift of the supply curve downwards (Figure 1)[8]. Each farmer is able to produce every amount of output at *lower cost*, due to the new technology.

Figure 1: Supply shift from research-induced technological change



Following Alston *et. al.* (1995), the cost reduction from a technological change is denoted by the letter *k*. The *k* associated with the *first round* of a technology impact, that is, before any alterations to the farming enterprise take place, is denoted k_1. It is the impact that occurs when a technology is adopted, but the *use of (other) inputs remains constant*. Since the purpose behind research is to prompt a change in practices, a more satisfactory description of the technology's impact is one that takes account of the altered producer behaviour. This is measured by k_2, the cost reduction *after input use has changed* (Figure 2).

Consider the case of an improved wheat yield. k_1 measures the cost reduction that occurs when a new seed is used but when, *inter alia*:

- the rotation stays constant; and
- the amount of area planted to wheat stays constant.

---

[7] For a more complete exposition about Economic Surplus and related concepts see Alston *et. al.* (1995)
[8] For an explanation of demand and supply, see Tisdell (1972)

On the other hand, if the farmer adjusts input use to cater for the new technology—changing rotation so that wheat is included more regularly or increasing the area sown to wheat—then the measured cost reduction would be equal to k_2.

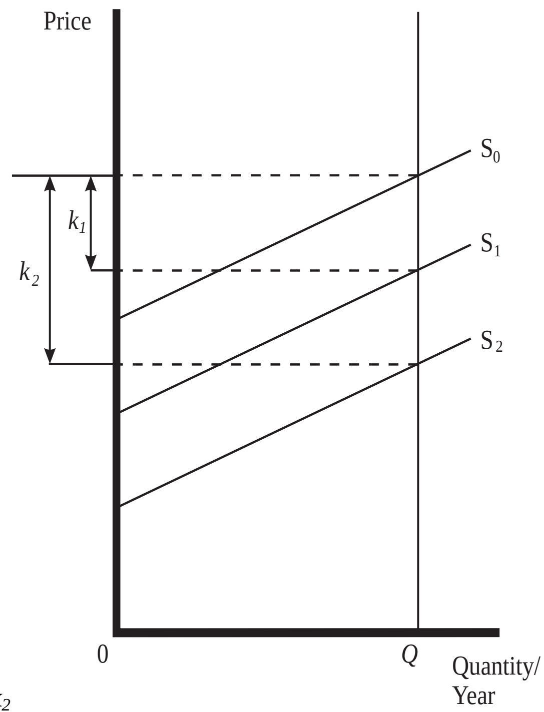


Figure 2: k_1 versus k_2

Productivity

The Economics Branch uses Linear Programming Models for representative farming systems around Victoria (called Complex Activity Budgets, or CABS) to analyse the effect of technological changes (or *shocks*) on farm[9]. CABs summarise scientific, technical and agronomic information that describes the conversion of inputs to outputs. CABs are an ideal way to identify k_2. Since they represent farming enterprises, CABs will substitute towards relatively cheaper inputs, and produce a relatively more profitable output. After this substitution has occurred, k_2 can be measured.

Practically, k_2 is found by measuring the change in *productivity*. Basically, productivity change is the difference between the rate of output and input growth. Productivity change is a physical concept; it is concerned with the *quantity* of outputs and inputs.

The process of measuring productivity change using CABs involves running two different scenarios: the base-case, or the without new technology, scenario; and the 'with new technology' scenario. The 'with' scenario is determined by translating technology into an appropriate parameter adjustment. For example, the promotion of better fertiliser use to increase pasture production can be translated into a greater volume of dry-matter production per hectare—a variable that can be directly altered in the dairy CAB.

[9] For a simple description of CABs, see NRE (1998a)

With a given *state of technology*, productivity varies as output increases[10]. In order to avoid productivity variations due to changes in the level of output, the NRE Economics Branch holds the CAB level of output constant in the 'with' and 'without' scenario. Therefore, the *measured productivity changes reflect a reduced use of inputs*.

CABs use a measure of profit, specifically gross margin, as their objective function. In order to proxy a constant level of *physical* output, total revenue is held constant in the 'with new technology' case. In other words, the CAB must find the mix of inputs and outputs that will maximise gross margin, and take account of the fact that the state of technology has altered—a new parameter value, like increased dry matter per hectare, is embedded in the CAB's database.

The magnitude of a research shock will depend on the significance of 'improved inputs'. An improved input is one that is directly affected by research. For example, consider a beef production system. If a research shock affects pasture production by *x* per cent, then pasture is the improved input. If pasture is a large proportion of total costs, the on-farm productivity impact will be relatively large. Conversely, if there is an *x* per cent improvement in stock trading efficiency, which is a small proportion of total costs, there will be a relatively small on-farm productivity improvement.

Index Numbers

Productivity can be measured in various ways however one of the simplest, and therefore most popular, is via index numbers.

In the simplest case, where there is only a single output and input, productivity is easily calculated as the rate of growth in the former minus the latter. However, since there are many outputs and inputs in most farming systems, a *productivity index* is used to measure the change from a research-induced technological shock. This allows a multitude of outputs like wheat, barley and wool, or factors like land labour and capital, to be *aggregated* into a single quantity index.

A quantity index measures the movement of all (say) outputs, and weights each according to their significance. Usually, 'significance' is gauged by using prices in combination with quantities. If a relatively expensive (highly priced) output, which is made in relatively large volumes, rises it will drag the overall quantity index in the same direction. A price index is analogous but with quantities used as weights.

Since measurement of productivity change uses information from two time periods there is an issue about the appropriate weights: should first (base) period, second period, or average prices be used? The Economics Branch uses a Fisher index (see below), which uses information on prices from both periods, and weights them geometrically (see, for example, Alston *et al.* 1995).

Although there is a range of indices available, Diewert (1992) argues strongly in favour of the Fisher index relative to alternatives such as the Tornqvist-Theil. This conclusion is drawn after analysing indices using a "test" approach and an "economic" approach. The test

---

[10] This is due to the assumption of diminishing marginal product when there are fixed factors. See, for example, Tisdell (1972).

approach involves logical or accounting tests which index numbers should satisfy. The economic approach analyses which indices conform to basic theorems about economic agents' behaviour. Diewert finds that the Fisher index satisfies all 20 tests in the former and the appropriate theorems in the latter.

Fisher himself argued for the use of (in his terms) the *ideal* index number formula using two tests: factor and time reversal. The time reversal test argues that an index number formula should be invariant to the base period; if quantity is measured as doubling from period one to two, measurement from period two to one should show quantity halving. The factor reversal test ensures if both a price and quantity index were calculated, then their product would equal the value ratio[11].

In order to use index numbers for measuring the change in farm-level productivity from a technology change, information on prices and quantities—for both inputs and outputs—is collated. This is done for both the 'without' and 'with' scenarios.

Quantity indices, such as the Fisher index used by the DNRE Economics Branch, are unresponsive to relative price changes[12]. If this were not the case, productivity would change due to relative prices. The state of technology does not alter when relative prices change so this would be misleading. This also means that output-quality changes cannot be modelled by looking using a simple price change in the 'with' scenario.

Productivity is important because output and income can be viewed as synonymous. Therefore, more output per unit input means more income. Even though income is not the only source of well being, it is an important one, and it is often correlated to other measures such as education and life expectancy (Industry Commission 1997). The Industry Commission found that productivity was the major determinant of Australia's real income per person over the 1964-65 to 1995-96 period. It contributed 65 per cent whereas the second most important factor, capital deepening (more capital per person), contributed 36 per cent. Demographic change and labour force participation contributed nine per cent.

But to make the measure of gross benefits complete, the productivity change that occurs on farm must be scaled up to the relevant value for the farming region, or industry, etc. In other words, the on-farm productivity change must be converted to a dollar value by taking account of the number of individuals affected by the change. Those affected are often known as the 'target audience'. An on-farm productivity change can be converted to a total gross benefit figure for an *industry* by multiplying by the value of production generated from the target audience. Therefore, a dairy on-farm productivity change of 2% can be scaled up by $100,000 if this is the value of production of the target audience—and hence the gross benefit measure is $2,000.

3. IMPLEMENTATION OF THE EVALUATION SYSTEM

In Victoria, a sub committee of Cabinet examines the allocation of government funds to Departments. Line Departments (such as Natural Resources and Environment or Health and Community Services) internally prioritise, and then submit, bids for funding to this sub committee. In early 1999, DNRE submitted a bid called the *Growing Horizons Initiative*

[11] For a more thorough explanation, see Fisher's (1923) seminal book.
[12] For a more complete discussion of Divisia indices, see Alston *et. al.* (1995)

(GHI) to this committee of cabinet. The bid was successful, and an additional $12 million was allocated to the Department in May 1999.

Given the public's concern with government accountability, the evaluation system described in section 2 was used to support a request for additional Victorian Government funds for agricultural and environmental research. Economists were actively involved in the development of the submission and gave presentations on the evaluation system to key staff in the Departments of Premier & Cabinet and Treasury and Finance.

Institutional settings

After the allocation of funds to GHI, DNRE's Agriculture Division—under the guidance of its Executive Director—decided to implement a new system of project selection and funding for this part of its budget.

Prior to GHI, while funding was guided by strategic plans for each industry, the funding for projects was largely driven by successful submissions to the RIRCs. Scientists applied for funding from the RIRCs and if successful both in-kind and direct state government funding was used to undertake the specified activities.

GHI provided a strong boost to the government contribution that could be made to agricultural and environmental research. However, the evaluation system outlined in Section 2 required that there be an appropriate rationale for *Government* funding of any project. Therefore, the Executive Director set up a GHI *Steering Committee* to set broad policy directions and approve projects. This Committee is chaired by the Executive Director and includes senior representatives from other Divisions and Branches with a stake in the Initiative. The Chief Economist is a member of this Committee. Key policies established at the outset were:

Within the GHI framework (DNRE 1999), implementation commenced in July 1999.[13]

(i) Funding would be directed to projects not readily funded from other sources (which reflects the 'market failure' argument outlined above)

(ii) Project areas (and indicative funding from the Initiative) were specified. These were: Science Capability (40%), Developing Social Capability (20%), Productivity Improvement (20%), Increasing Market Share (10%), and Policy, Planning and Strategy (10%). (Types of work that might be funded under these headings is shown in Appendix 2).

(iii) Purchasers were nominated to specify outcomes from broad areas of research.

(iv) Project Teams were expected to devote time to a planning phase that would identify research areas for some years ahead. Funding would be provided for the planning phase.

(v) All projects were expected to meet selection criteria covering science quality and economics, and provide information on evaluation methods, communication, and project risk.

[13] As part of the development phase of the evaluation system, the Beneficiaries and Funders criterion was applied to some agricultural research projects funded in 1997/98. However, this criterion did not form part of project selection as it now does with the *Growing Horizons Initiative.*

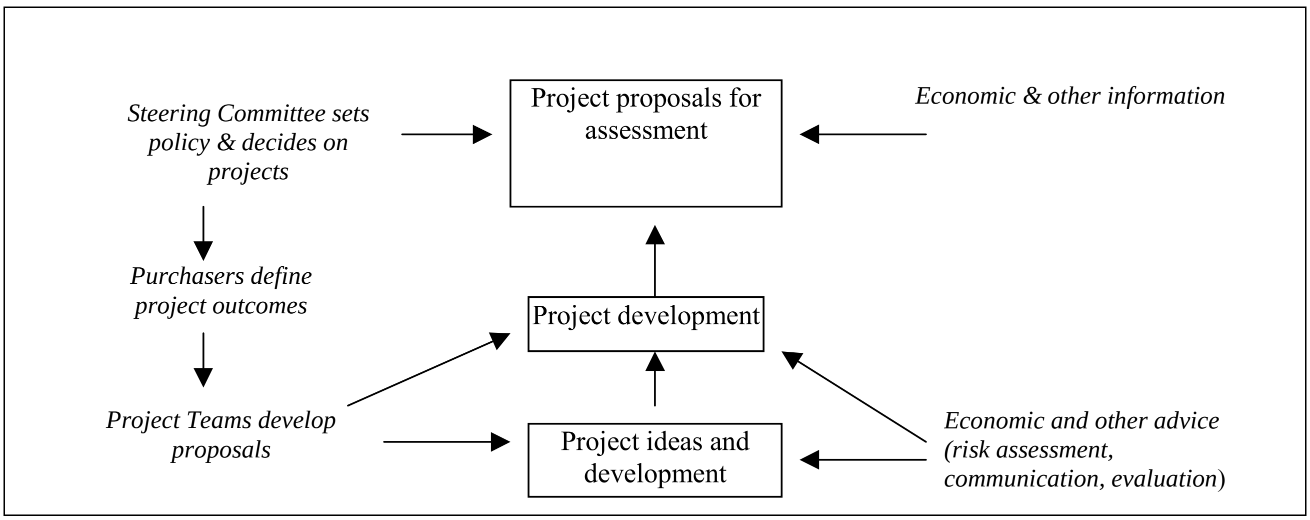
(vi) In the productivity improvement area, emphasis would be given to cross-industry and cross-discipline issues, such as those concerned with improved farming systems, and soil/water issues.

Purchasers and Project Teams were given until 1 December 1999 to develop and submit projects to the Steering Committee. Purchasers were expected to ensure that all projects met selection criteria standards before they were submitted.

A *Working Group* was established to ensure that technical support was available to project teams in the areas of communication, economics, evaluation and risk management, and that all projects are assessed in terms of NRE's economic evaluation system. The reporting arrangements and the relationships described here are depicted in Figure 3.

The Department is expected to report regularly on implementation of the funding initiative to the Department of Treasury & Finance.

Figure 3. Arrangements for the development and assessment of project proposals for DNRE'S GHI.



Economic assessment

At an early stage economists met project staff to explain the selection criteria. This involved discussing the Beneficiaries and Funders criterion, the use of CABs to estimate the benefits of proposed research (see above) and a discussion of the circumstances when a benefit cost analysis would be undertaken. To date, most work has involved the Beneficiaries & Funders criterion since most project teams have been involved in project planning. *Ex ante* benefit cost studies will commence for applied projects in 2000.

A great deal of time has been spent by economists identifying the incentives that exist for beneficiaries to fund research. This is a crucial step if we are to establish whether externalities are present and hence if there is a role for government. Those projects with a mix of industry and community benefits would be considered for GHI funding. Projects with industry benefits were expected to have external funding, or a strong likelihood of obtaining external funds.

In some GHI work areas, particularly Productivity Improvement, the CABs have been used to estimate productivity improvement from proposed research. These estimates, combined with gross value of production, were used to calculate an estimate of gross benefits for the project. This information, combined with an assessment of Beneficiaries & Funders has been placed before the Steering Committee to assist decisions on each project. The style of report used to present economic information to the Steering Committee is shown as Attachment 1.

The Purchasers met the Steering Committee to explain and discuss completed submissions for proposed activities.

4. EXPERIENCE TO DATE

Our experience in applying the evaluation system reveals a number of lessons. These are likely to be of interest to economists involved in developing and applying evaluation systems in other organisations. They are:

(i) **The Beneficiaries & Funders criterion:** More time has been spent on this phase than anticipated since there are often many dimensions to understanding the incentives (or lack thereof) for beneficiaries to fund the area under discussion. Also, the thinking involved is quite different to the usual project environment faced by scientists preparing proposals for external funding bodies [14].

However, over time a benefit from the application of the Beneficiaries and Funders criterion should be the development of stronger projects for government funding bodies, where market failure considerations are important (Agriculture, Fisheries and Forestry 1999).

(ii) **Over optimistic estimates of success:** As Kingwell (1999) explains it is natural for staff to be optimistic about their work and its relevance or possible impact. The competitive environment for research funding can encourage over optimism. We have encountered this and it is time consuming to elicit important information and to check project realism. The Purchaser Provider structure can help to do this.

(iii) **Hidden information issues:** Research staff may choose not to reveal all useful information to an evaluator. As Bardsley (1997) explains, risk averse individuals will only propose projects that are likely to succeed.[15] When applying the evaluation system we have developed there has been a tendency for scientists to "bundle up" a proposed project with work which was already externally funded in order to meet Beneficiaries and Funders criterion. As most research is incremental such an approach is not necessarily incorrect. However, it can overstate the extent of external funding.

[14] For example, projects attractive to funding organisations such as the RIRCs often have industry benefits alone.

[15] Bardsley (1997, p 45) explains that scientists have incentives to "grow" a project until it starts to look good, at which time it will be put forward for funding. Because the past (sunk) costs of such work are not included in a BCA, the returns to the research are overstated.

The above examples highlight the importance of institutional arrangements that encourage all necessary information to be revealed. There are many dimensions to this issue as explained by Bardsley (1999).

(iv) **Importance of senior support:** This is needed if the evaluation system is to be successfully implemented (Morrison and Thomson 1996). The evaluation system will result in a redirection of funding away from work which has industry benefits alone towards work that has a mix of industry & community benefits. Scientists can view this as a negative development. However, in our case strong support from the Executive Director of the Division, combined with good working relationships across the Division, has enabled implementation to proceed.

(v) **The need for new skills:** The focus of the GHI has highlighted the importance of cross industry/discipline skills in some areas. For example, research on soil/water issues and on farming systems.

(vi) **The role of government needs to be defined:** In some work areas the issues are complex as are the institutional arrangements. This has highlighted the need for studies to explain the technical issues and define the role of government in promoting efficient outcomes. Such work will guide future policy and science effort. An example is food safety.

(vii) **CABs are being used to help establish research priorities:** The Linear Programming models are an efficient means of establishing priorities for research with scientists. They are starting to be used for this purpose in examining the potential to improve farming systems in the Mallee and to examine ways to overcome feed gaps in the dairy, beef and prime lamb industries.

(viii) **Ex ante benefit cost studies have not been undertaken:** To date quantitative BCA has not been necessary as a large proportion of the funds have been directed towards basic/applied research where the benefits are relatively diffuse (across industries and to the wider community) and difficult to estimate. A conscious decision was taken not to undertake studies for work in the basic/applied areas. Therefore, an important part of project selection for work in these areas has been the involvement of *Chief Scientists*—well respected state and national scientific researchers—who analyse and comment on the feasibility, methods and importance of projects.

In many other areas, project teams have been engaged in planning activities Here, as with basic/applied research projects, it is not appropriate to undertake quantitative benefit-cost analysis. We envisage a number of ex ante studies commencing in 2000 using the system described in Section 2. These studies help inform decision makers about the relative benefits from different areas of research.

Useful information on adoption, for use in benefit cost studies, continues to be a concern. We are encouraging and supporting the development of work by DNRE staff using ABARE survey data.

5. SUMMARY

Greater scrutiny of public funding of activities, both within and between Departments has prompted the development of DNRE's evaluation system. In developing the system, the lessons of economists who have previously worked in this area has been important (for example, Alston *et al.* 1995; Brennan & Davis 1996; Kingwell 1999).

DNRE's system has been designed to provide improved information on which to base investment decisions. Investment decisions are best made with as much relevant information as possible. Well defined aims are needed in order to make investment decisions and here the aim is taken to be wealth generation. Therefore, NRE's system is two tiered and concentrates on economic efficiency: scrutiny to identify market failure (the Beneficiaries & Funders criterion) plus quantitative analysis to develop improved estimates of benefits for use in benefit-cost studies.

The Victorian Government's *Growing Horizons Initiative* was a chance to explain and integrate economic concepts of evaluation into the decision making framework. This has enabled widespread discussion about economic concepts. The evaluation system has allowed economic information to be placed before decision makers in a consistent way. This has helped to guide work towards areas where a mix of community and industry benefits exist. Of course, economic information is not the only type of relevant information that should be available to decision makers. Information on science quality as well as portfolio issues must also be considered.

A range of lessons has emerged from the application of DNREs economic evaluation system. Among the most important are: the significance of active support from senior managers as economic assessment will result in a shift of work towards areas where industry and community benefits exist; the importance of strategic liaison between the Department and Central Agencies to explain the evaluation system; and the importance of organisational settings in promoting the availability of all relevant information (Bardsley, 1997, 1999).

REFERENCES

Agriculture, Fisheries & Forestry (1999), "Draft New Guidelines Applying to the Application of the Government's 12 Levy Principles", *mimeo,* September.

Alston, J.M., Norton, G.W. and Pardy, P.G. (1995) *Science Under Scarcity*, Cornell University Press.

Bardsley, P. (1997) " Sunk Costs and Incremental Investment in Research", in P. N. Daniel (Ed) (1997) "Economic Evaluation of Research and Extension Activities in Agriculture", *Pre Conference Workshop to the Global Agricultural Science Policy for the 21st Century*, August, pp. 43-48.

Bardsley, P. (1999) "The Optimal Management of Research Portfolios", *Australian Journal of Agricultural and Resource Economics*, 43:3, pp. 323-335.

Brennan J. P. and Davis J.S., eds. (1996) "Economic Evaluation of Agricultural Research in Australia and New Zealand", *ACIAR Monograph No: 39.*

Diewert, E. (1992), 'Fisher Ideal Output, Input and Productivity Indexes Revisited', *Journal of Productivity Analysis*, 3, pp211-48.

DNRE (1999) "Growing Horizons: Victoria's food and Agriculture Industry", *Natural Resources & Environment Proposal to the Budget Estimate Review Committee,* March 1999.

Economics Branch (1998a) "Explaining the role of Complex Activity Budgets (CABs) in NRE's Investment Assessment Framework, *mimeo*, December.

Economics Branch (1998b) " Using Productivity Measurement to Calculate the Benefits of Research", *mimeo*, December.

Economics Branch (1998c) "NRE's Economic Evaluation System", *mimeo,* December.

Fisher, I. (1923), *The Making of Index Numbers*, The Riverside Press, Cambridge.

Industry Commission (1997), *Assessing Australia's Productivity Performance*, Commonwealth of Australia.

Kingwell, R. (1999) "Institutional and social influences on R&D evaluation in agriculture", *Australian Journal of Agricultural and Resource Economics*, 43:1, pp. 115-128.

Thomson, N and Morrison, D. (1996) "Use of Research Evaluation in Australia and New Zealand", in Brennan, J.P. and J. S. Davis (eds.) *Economic Evaluation of Agricultural Research in Australia and New Zealand*, ACIAR Monograph No 39.

Tisdell, C.A. (1972), *Microeconomics, the theory of economic allocation*, John Wiley and Sons.

Varian H.R. (1992), *Microeconomic Analysis,* Third Edition, W.W. Norton & Company.

APPENDIX 1: STYLE OF REPORT USED TO PRESENT ECONOMIC INFORMATION

KEY PROJECT	EFFECT OF RESEARCH	PROJECT WILL COMMENCE	BENEFICIARIES & FUNDERS			BENEFIT COST ANALYSIS	COMMENTS
			Beneficiaries	Funding	Does funding match beneficiaries?		

APPENDIX 2: FUNDING CATEGORIES FOR THE GROWING HORIZONS INITIATIVE

Full details of the types of projects are shown in DNRE (1999). A summary of the areas of work being considered for funding is shown below.

1. **Developing Science Capability**: The most important criteria for this area are that the projects represent good science, and that the area of science is likely to generate spillovers. Includes activities to encourage visits by elite scientists from interstate and overseas; research on fundamental soil-water constraints, genomics and integrated systems modelling; improved livestock through genetics; and work on capturing the native gene pool for the development of improved plants.

2**. Developing Social Capability**: Activities that will accelerate growth through rapid adoption of technology.

3. **Productivity Improvement**: The objective is to convert the products of basic R&D into economic growth and improved living standards.

4**. Increasing market share**: The objective is to protect market share or to gain access to previously inaccessible markets. This can be achieved by removing market distortions, improving product security and quality, and by product differentiation. Includes research on rapid diagnostic probes, systems to improve import and export certification.

5. **Policy, Planning and Strategy:** The objective is to encourage mobile and flexible use of resources. Includes work on evaluation systems; and new policy approaches to handle conflicts in land use.