SUSTAINABLE RESOURCE USE AND THE EVALUATION OF AGRONOMY R&D

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Summary. The likely economic returns of an agronomy research project (introduction of pasture leys to reduce soil degradation) are calculated in this paper, using cost-benefit analysis. While the project appears to be profitable, the case study raises some issues complicating project appraisal in practice. Among these are: subjectivity in parameter estimates, long-impact technology and attribution of benefits to projects building on past results.

INTRODUCTION

Several Australian R&D Corporations (e.g. Grains Research and Development Corporation) now require research providers to submit an economic cost-benefit analysis (CBA) with research proposals to justify financial support. Others (e.g. Land and Water Resources Research and Development Corporation) have used CBA to evaluate recently completed projects (8). This reflects a desire to compare the likely payoffs of various options for resource use from both an industry and a social perspective. CBA (7, 9) is well suited for such across-the-board comparisons, as it uses a common measure for all analyses (constant value dollars). But it is not possible to quantify the payoffs of all projects, and its applicability is questioned by non-economists (and by some economists!). The problem with applying CBA is usually that of measuring the benefits and costs in dollar terms, and in assigning the benefit and cost streams to particular projects. The less applied or production-oriented a research project, the more difficult it is to identify either financial or social benefits: viz. basic research and environmental effects (5). Long-term projects are also borderline cases for the application of CBA due to uncertainty associated with forecasts. This paper provides an example of calculating the costs and benefits of an agronomic research project that investigates the economics of sustainable resource use, and highlights some of the potential pitfalls associated with this kind of analysis.

COST-BENEFIT ANALYSIS

In the context of agricultural production, sustainability is primarily about the maintenance of the underlying resource base to support the long-term profitability of farming and preserve access to other options including conservation. If resource conservation for its own sake is introduced, the analysis becomes messier as there may be conflict between the objectives of radical conservation and agricultural production. To quantify tradeoffs between potentially conflicting objectives, a common measure is needed. CBA is one way economists do this. It is rarely a simple financial investment analysis as it needs to accommodate a range of social preferences. Progress in the valuation of resource and environmental attributes (5) is reducing measurement problems.

CBA is not a self-contained method. Rather, it is an add-on technique that requires a quantitative model of the system under analysis. The model is used to follow developments in the system and to identify discrete states, e.g. with or without a technology, so that outcomes can be quantified and compared (2). The most obvious models for agronomic research projects are farm budgets (either partial or whole-farm) and production functions. Simulation or mathematical programming models may also be used. CBA seeks to specify the size and timing of both the cost and benefit streams associated with an intervention, and uses a discount rate to bring these back to a present value so they can be compared. Several investment criteria are used to compare the expected return on investment with other projects. These include: net present value (NPV), internal rate of return (IRR), benefit cost ratio (BCR), and payback period. NPV is the preferred criterion; the other criteria do not reflect the size of the project, and IRR can give multiple solutions. Those projects that are likely to give higher returns on investment on the basis of these criteria are usually selected. Economic CBA differs from financial analysis in its use of shadow prices (which are corrections to market prices to allow for market failures of various sorts); the possible use of a different discount rate (really just another shadow price reflecting the discrepancy between the private opportunity cost of capital and the social rate of time preference); and exclusion of taxation and other social (transfer) payments (4). In social CBA, the cost and benefit streams may also be weighted, depending on who owns them, in order to incorporate equity considerations. Investment in agricultural R&D is, in principle, no different to any other investment. In practice, it is often difficult to specify the cost and income streams very precisely. Risk can be incorporated e.g. by constructing cumulative probability density functions (CDFs) of the NPV which capture the relative certainty about the return on investment. CDFs of the NPV associated with different projects can be compared using stochastic dominance analysis (1).

CASE STUDY: PASTURE LEY/SOIL MANAGEMENT RESEARCH PROJECT AT APSRU

The rate at which wheat yields have increased in Australia has lagged behind that recorded in most other wheat-producing countries (6). The fact that this has been accompanied by declining protein contents suggests insufficient nitrogen supply and declining soil fertility. Unsuitable cultivation practices exhaust soil fertility and may result in structural degradation. For a while, structural deterioration can be arrested or reversed; eventually it may become irreversible.

A research project conducted at the Agricultural Production Systems Research Unit (APSRU) modelled the long-term trends in soil structure associated with different management practices on the main soil types of the eastern Australian dryland cropping zone and explored the difference in economic returns (3). This suggested that maintenance of the structure and nutritional status of agricultural land could eventually allow crop producers to achieve higher gross margins from a pasture ley rotation than from one based on wheat monocropping. The annual costs of the research project amount to $90,000. It started in 1991/92 and is expected to run for five years.

Production benefits were estimated by APSRU scientists. Simulation runs for Wallumbilla (near Roma, Queensland) were used to construct gross margins from a pasture ley rotation and monocropped wheat, using partial budgeting. Expected trends in soil structure and nutritional status were combined with historical weather data to derive trends in gross margin. Gross margin streams were calculated over 100 years of simulated weather, using current prices for agricultural inputs and outputs. It was assumed that there will be no change in the relative prices of inputs and commodities over this period. Cumulative gross margins of the ley rotation begin to exceed those of monocropping after about 14 years. Over 100 years, the expected cumulative gross margins for the ley rotation and wheat monocropping are $11,305 and $3,361/ha, respectively. The present values of the gross-margin streams, discounted at 8%, are $1,093 and $639/ha.

The soil management technology is applicable to the brigalow, semi-arid woodland plains and low hills, and flooded alluvial plains of Queensland, of which around one million hectares are currently cropped. Some farmers are already using ley rotations, but the practice is not generally accepted. In the absence of the research project, there would be a scarcity of site-specific information and a weaker case for changing production methods. Deterioration in soil structure would cause gross margins from monocropped wheat to fall progressively behind those from the ley rotation. If cattle returns are included, a ley rotation would be more profitable than wheat monocropping in the long-run, according to researchers, over some 400,000 ha. Adoption of the technology is expected, by researchers, to start in year four of the project, in 1996. Over 10 years, farmers on 10% of the suitable area are expected by researchers to adopt the new technology as a direct result of the research project, and not otherwise.

Two CBAs were carried out: the first to decide if the new technology would be profitable at the individual farm level; and the second to assess if the research resources necessary for developing a better case for change (which would result in earlier adoption) have been used efficiently. Unit benefits of applying the technology (the result of the first CBA) are projected onto differences in the total area of potential use and the expected temporal pattern of adoption in the second CBA.

It is assumed that, in the absence of the APSRU project, no similar research would have been carried out for the target area. Hence, the additional benefits from the greater/speedier adoption of the technology are attributable to the project (Table 1).

Table 1. Profitability and sensitivity analysis for the APSRU pasture ley project.

Scenario	NPV 1994 $m	IRR per cent	BCR
a. Base adoption rate (10% of 400,000 ha in 10 years)	15	26	34
b. As (a), but eventual adoption reduced to 5%	7	22	17
c. As (b), but the time for adoption doubled	5	19	13

While APSRU researchers are confident about the physical response of the two production alternatives, the adoption of the new technology is the most uncertain part of the analysis. So, the sensitivity of the results to both a reduced adoption rate and an extended adoption period was investigated in a very rudimentary manner. Research benefits are 34 times the costs in the most likely case (a), and 13 times in the most pessimistic case (c). Returns are in excess of 8% even in the most pessimistic case.

DISCUSSION

If different trends in resource depletion associated with the use of different technological components, and the implications of these for farm cash flow, can be quantified, CBA may be a suitable tool with which to estimate the potential return on investment from agricultural R&D projects. There are, however, some caveats. There are numerous estimation problems in applying CBA to natural resource management issues. Ley pasture is an old technology. Lots of other work on ley pastures has been, and continues to be, done. Only some of the benefits of the technology can be allocated to the APSRU project; assuming no shift to ley legumes in the absence of the APSRU data may be a big *leap of faith* At best, the APSRU project might bring forward the rate of adoption. The benefit is the area between the two adoption curves, with and without the intervention (Table 1, if of all additional technology use is due to the research project). However, a farm manager would be reluctant to adopt a technology with a payback period in excess of 14 years (an example of socially desirable conservation not paying off at the farm-business level). In practice, the present value of the income stream to private decision-makers is probably less than this analysis suggests: in part because of the choice of planning horizon (less remote); in part, from the choice of discount rate (higher). There may be a positive option value associated with deferring a decision in a situation characterised by technological change or uncertainty.

The potential pitfalls which emerge from this analysis thus include: (i) benefits should be ascribed primarily to the development of the technology, not to the analysis of its value; (ii) benefits can be ascribed to the analysis if this leads to speedier adoption of the technology, but this case has to be made; (iii) a technology may not be adopted because the private decision-maker faces a different situation to that considered by the analyst; (iv) the adoption rates proposed by researchers may be unrealistic because of other factors not considered by them; (v) the costs of extension may need to be included explicitly in the analysis; (vi) it is important to look at the dynamics of an investment process, not just a snapshot e.g. the rate at which the payback period shortens as soil structure declines; (vii) the starting date in the simulations is important as discounting places greater weight on benefits in the earlier years - this makes the analysis sensitive to the sequence of good and bad years; and (viii) the identification of investment *dry wells* (of which there are bound to be many) is a strength of the analysis, not a weakness.

CONCLUSIONS

There are many estimation problems in applying CBA to investment in agronomy R&D. This applies particularly when the project is an analysis of a technology, but does not itself lead to technical innovation. Benefits can accrue from such a project if it provides a convincing case for change in production practice that in turn influences the rate of adoption at farm level. Such differences in adoption rates will depend on a range of factors not directly included in the analysis. Just because the case for change is convincing to professional researchers, this does not mean that it will be any more convincing to farmers than the arguments that they are already familiar with. In any case, the analyst must be careful only to assign benefits claimed for a project to effects that can be directly attributable to that project. In many situations, the resolution of the method (looking forward into a very uncertain future) may be insufficient to distinguish the implications of different management practices. CBA is not a recipe to be applied unthinkingly.

Despite the caveats, the formal application of CBA can assist professional researchers in gaining funding for worthwhile projects by getting them to think through more carefully the ways in which social and private benefits will derive from their activities, and the need to use cost-efficient ways to obtain those benefits. Although a rather coarse sieve, it is often good enough for this purpose as it emphasises the importance of technical change at farm level.

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