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TOWARDS A DECISION SUPPORT SYSTEM FOR ECONOMIC EVALUATION OF AGRICULTURAL RESEARCH

D.J. Pannell

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Discussion Paper: 7/94

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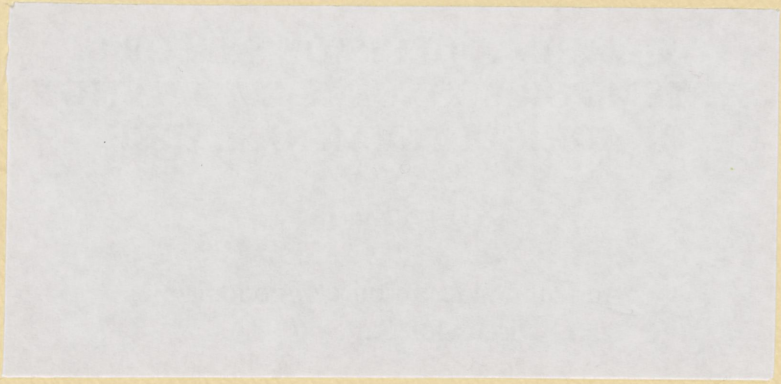

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TOWARDS A DECISION SUPPORT SYSTEM FOR ECONOMIC EVALUATION OF AGRICULTURAL RESEARCH

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Towards a Decision Support System for Economic Evaluation of Agricultural Research

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Abstract

Estimation of on-farm benefits is highlighted as a critical but complex issue in research evaluation. We identify many different potential impacts of research, many of which do not fit into the standard supply-shift framework for research evaluation. Given the difficulty and complexity of benefit estimation, we see a renewed role for farm-level economic models (such as whole-farm linear programming model) in this area. The benefits of undertaking a more sophisticated and detailed analysis to estimate research benefits include not just greater accuracy but also greater credibility with researchers and greater relevance through representing factors which they perceive to be important. We discuss how, if such respect is engendered, a formal research evaluation this can yield additional benefits by improving the design and conduct of research.

Introduction

Changing government philosophies and reduced public funding for agricultural research institutions (which reflect the changed philosophies) have combined to produce an unprecedented interest in formal economic evaluations of agricultural research. In Australia this is apparent in state Departments of Agriculture, the

CSIRO, and several of the national agricultural research funding bodies (the Rural Industry Research Corporations).

In applying Cost-Benefit Analysis (CBA) to research, a range of types of information is needed. For farm level research, one type of information is notable for being both critical to the analysis and difficult to obtain. This is the estimation of net-on-farm benefits from the research. This very complex issue has often been handled in an oversimplified way. Our first aim here is to provide guidance on the various factors which need to be considered when estimating net-on-farm benefits. We will provide a detailed classification of the types of benefits which may result from agricultural research and a check list of important factors to consider when estimating their magnitudes.

The motivations of research administrators in supporting economic evaluations of research are (a) to obtain evidence which will support cases they make externally to maintain current levels of funding in the face of threatened cuts, and (b) to help prioritise areas of research to identify low return areas for cuts and to identify high return areas and new opportunities for increased funding. However, we believe that the benefits of undertaking formal research evaluations are not confined to these areas. Our second aim is to suggest how to involve and influence the biological and physical scientists so that the research evaluation is successful and productive and so that it is most likely to generate the spin-off benefits which can occur.

Our ideas in both these topics are strongly influenced by our experiences in evaluating and prioritising research for the Department of Agriculture, Western Australia (DAWA), the Grains Research and Development Corporation (GRDC), the Centre for Legumes in Mediterranean Agriculture (CLIMA) and the International Centre for Agricultural Research in the Dry Areas (ICARDA).

General Methodological Issues

Underlying all which follows is our assumption that the objective of research evaluation is to increase the benefits from research. This can happen in various ways:

(a) by culling unbeneficial research;

(b) by directing funds to beneficial research;

(c) by changing the emphasis or design of a research project;

(d) by changing the variables which are measured;

(e) by facilitating information flows between research scientists, economists, research leaders, research managers, extension specialists and farmers; and

(f) by providing an appropriate focus and paradigm for research leaders/managers and researchers who usually have a scientific rather than an economic background.

We will emphasise that directly influencing the allocation of finance to different areas of research is not the only, nor even necessarily the most important benefit of involving agricultural economists in the planning of research.

In this paper we are concerned with tangible financial or social benefits, not with knowledge for its own sake. This does not mean that we reject a non-utilitarian role for research. In principle the considerable benefits obtained through the pleasure of just "knowing" could be measured using contingent valuation methods, but we will not address that issue here. Although the term "research evaluation" is used, the paper's scope is broader, dealing with evaluation of the inter-related activities of research, development and extension (RD&E).

The general framework for research evaluation is provided by CBA which involves estimation of costs and benefits over time and discounting them to obtain valid comparisons of their present values (Mishan, 1982). We assume that the reader is familiar with CBA and with the concepts of producer and consumer surplus.

The Difficulty of Estimating Research Benefits

Information needed to evaluate an agricultural research project using CBA includes the following components:

(a) The projected biological, technical and/or management changes from implementing research outcomes.

(b) Any negative or positive side-effects (internal or external to the farm) resulting from implementation of the research.

(c) Costs to the farm firm of implementing findings from research.

(d) Given (a), (b), and (c), the potential economic benefits per hectare or per farm (net of costs to the farm firm but not of RD&E costs).

(e) The scale of potential benefits: the number of hectares or farms potentially affected.

(f) The probability that the research will successfully generate these benefits.

(g) The likely level of adoption and implementation over space and time.

(h) Direct costs of undertaking the RD&E over time.

(i) The discount rate.

In our experience, the most complex and difficult aspect of CBA for most agricultural research is usually estimation of item (d), the potential net-on-farm benefits. This is the area where economists most frequently resort to

heroic simplifying assumptions of dubious validity. This is unfortunate because (d) and (e) are the issues which are most important in determining the relative merits of alternative research projects. Of course, (f) to (i) are important in determining the level of net benefits for a given project, but in our experience, the factors which vary most between projects are (d) and (e).

The difficulties in estimating net-on-farm benefits arise for a variety of reasons, including the following:

- RD&E can have various possible impacts on agriculture (listed in Table 1 and discussed in the next section) which are different in nature and must be estimated by different means. There is no single simple method which can be prescribed for benefit estimation in practice.

- There is usually considerable uncertainty about what any given project will achieve biologically and about what would have happened without the research.

- Even if we could foresee the biological outcomes of the research it would still be difficult to foresee all the implications for farm management and for potential economic benefit. There are often interactions between enterprises, so that changes in one aspect of the farm can generate changes in management of other aspects. For example, successful RD&E may lead to expansion of an enterprise which will draw resources away from other enterprises. These interactions may need to be considered in some detail to obtain a valid estimate of research benefits.

  Another case where it is difficult to place an economic value on a biological outcome is where the research affects a product which is not sold but is used as an input to another enterprise on the farm. The main example in

agriculture is the production of feeds for livestock, including pastures, crop residues, hay and grain. The shadow price of a feed (i.e. the value of increased availability of the feed) depends on the time of year when it becomes available, the timing of livestock demands, the feed's quality and the availability and cost of substitutes.

- Commonly the outcome of research is information rather than a new technology. In practice, the difficulty of estimating the value of information can be considerable.

- For products sold in a free market, if RD&E causes shifts in the supply or demand curves, prices received for the product may be affected.

- For products which are subject to government controls on price or production, the level and distribution of benefits from RD&E will depend on the types of controls used (Alston et al., 1988).

In principle, net-on-farm benefits from RD&E are approximated by changes in the level of producer surplus (Mishan, 1982; Gittinger, 1982). In practice, the complexities listed above mean that these changes are often extremely difficult to quantify. In complex cases, direct estimation of profit changes on representative farms may be more practical and accurate than attempting to identify shifts in supply and demand curves.

(Table 1 here)

Categories of Research

Table 1 shows a categorisation of various impacts of research. The major division in the table is between research which results in a new physical product or technology and research which produces information on an existing technology

or for improved management decisions. It is recognised that there is not a clear-cut dichotomy (e.g. a new technology must be accompanied by information at least on how to apply it).

1.1 New enterprise

Item 1.1 is perhaps the most complex due to interactions with existing enterprises through substitution and competition for resources and possibly through biological complementary or competitive effects. It is also unusual in that there is no producer surplus from this product without the RD&E and consequently the benefit of the RD&E equals the whole surplus from this product. Moreover there are likely to be impacts on other existing products caused by substitution, complementarity and competition with the new enterprise.

To illustrate these interactions between enterprises, Figure 1 shows some results from MIDAS, a whole-farm optimisation model of crop-livestock farming in Western Australia (Kingwell and Pannell, 1987). The graph shows the farm-level supply curves for wheat (smoothed by simple linear regression) with and without the inclusion on the farm of lupins, a legume crop grown in rotation with wheat. The results simulate the impact on wheat supply of the introduction of lupins to the farm.

(Figure 1 here)

Lupins affect the supply curve for wheat in three ways:

(a) To some extent lupins are grown instead of wheat, which tends to move the supply curve to the left.

(b) Wheat grown in rotation with lupins gives a higher yield than wheat following wheat. This tends to move the supply curve to the right.

(c) It is not feasible to grow lupins in a rotation which does not include a cereal, so on soil types where lupins yield well, there is a tendency to grow wheat even if the wheat is not profitable in itself. This means that at low wheat prices, the availability of lupins tends to move the wheat supply curve to the right.

The combination of these factors means that the two supply curves cross. There are several points to note about this example.

(a) In estimating the impact of a new enterprise, account must be taken of the implications for other enterprises.

(b) The impacts on other enterprises will be reflected in their supply curves, but the net benefit of the new enterprise is not even approximately equal to the sum of the changes in producer surplus for all products.

(c) The reason for (b) is that the producer surplus for the new product will include any positive and negative impacts of the product on other products[1].

This also has implications for the good's price. In cases where the new product has an inelastic demand curve, the equilibrium price of the new product will be affected by the product's on-farm interactions with other enterprises via the effect if these interactions on the supply shift.

(d) If other affected products have inelastic demand curves, it may also be necessary to estimate their supply shifts as a result of a new product. The nature of these supply shifts for other products is by no means obvious, especially in rotational farming systems.

(e) In order to understand the position of the supply curve for the new product and the shifts in supply for existing products, it is necessary to undertake a fairly detailed analysis, such as running a whole-farm optimisation model. This is illustrated in Figure 2 which shows supply curves for lupins calculated with and without allowing for biological interactions between lupins and other enterprises. The interactions include: fixation of atmospheric nitrogen by lupins, improved soil structure following lupins, reduced cereal disease levels following lupins, use of lupin grain and lupin crop residues as sheep feeds, and increase efficiency of machinery use. Figure 2 shows that a failure to represent these biological interactions leads to major errors in the calculation of economic benefits from lupins; the producer surplus calculated without interactions is very much smaller than the value calculated when interactions are considered.

(Figure 2 here)

(f) If such a detailed analysis is conducted, there is no need to resort to the use of producer surplus to approximate changes in profit, because the analysis will provide profit calculations directly. If appropriate, the analysis should allow for demand prices of products being responsive to quantity sold.

1.2 Increased production and 1.3 Decreased production costs

Items 1.2 and 1.3 are equivalent from an economic point of view in that they both result in a shift in the supply curve downwards/to the right (e.g. Duncan and Tisdell, 1971). In practice there is a much greater expenditure on research targeted at category 1.2 (e.g. plant breeding) than 1.3.

Most discussions of economic research evaluation (especially the simpler ones) have focused to a large extent, or even exclusively, on these two categories. We

believe that this narrow focus is not warranted; it cannot be argued that almost all research falls within these categories. Many of the other categories in Table 1 account for large levels of research expenditure. For example, a large proportion of research conducted by state Departments of Agriculture in rural areas of Australia is testing, measuring, and demonstrating existing technology, with the aim of generating benefits in category 2.1. Even where research involves technology which is new to a region, there is often a high demonstration/information component of the research which may affect the timing of adoption more than it affects the size of the supply shift. The narrow focus on these categories has resulted in some notable misguided attempts to squeeze other types of research into an analysis based on supply shifts.

Despite the attention paid by economists to categories 1.2 and 1.3 of research benefits, the difficulty of estimating their magnitudes remains considerable. Even such apparently simple issues as the appropriate nature of the shift (parallel, divergent, or convergent) have been debated at length (e.g. Lindner and Jarrett, 1978; Rose, 1980) but not satisfactorily resolved, in our view. In practice many economists resort to Rose's simple expedient of assuming a parallel vertical supply shift. We feel that this simple formula of what to do when you don't know what else to do, has attained a status of a generally appropriate methodology well beyond that which it deserves. Or perhaps it is just that economists often don't know what else to do. In our view, the results of this approach often have extremely large error margins, much greater than could be achieved by more detailed assessments at the farm level.

If the effects of 1.2 and 1.3 are sufficiently great to increase the resource allocated to an enterprise significantly, there will be a need to account for the substitution for other enterprises which is discussed in 1.1. There may also be biological interactions; research which increased nitrogen fixation by a legume

crop would be expected to benefit both the legume crop and subsequently grown cereals.

Again, these opportunity costs and biological interactions should be reflected in calculations of the change in producer surplus for the product which was the subject of the research[2]. The situation for other affected products is more complex this time. If the research results in reallocation of resources among enterprises, the case is similar to category 1.1; the producer surplus for each other product is affected by this reallocation such that it does not reflect the change in profit for that product. However if there is no reallocation of resources, the change in producer surplus for a product would approximately equal the change in profit for that product. Nevertheless even in this case, the change in producer surplus for other affected products should *not* be added to that for the researched product to obtain the total net benefit. The producer surplus for the researched products already already includes all spin-off effects from the product and substitutions resulting from the research.

1.4 Increased quality

Increased quality has become something of a catch-cry in the Australian wheat and wool industries. Governments, marketing boards, and farmer organisations, have all emphasised its importance and there has been a growth in the use of price incentives for high quality produce. In response there has been a rapid growth in research oriented towards improving quality attributes of products. In wheat the focus is on protein content and quality characteristics suited to higher priced niche markets (e.g. noodle manufacture), while for wool it is on fineness, strength, and freedom from contamination. Benefits from this research arise from upward/outward shifts in the demand curve, not shifts in the supply curve. Quality improvements are often obtained at the cost of lower yield or higher input costs, so that there is also a supply shift, but upwards and to the left,

reflecting a dis-benefit.

1.5 Reduced risk

Another area with a high profile in recent agricultural policy discussions in Australia is risk. With the demise of price stabilisation schemes for wheat and wool and the change of approach to drought policy, broad acre farmers are exposed to greater risks than previously. Most of the new research responding to this change has been in category 2.4, information for improved risk management. However it is also possible that development of new enterprises could yield benefits from reduced risks. This could occur through (a) the new technology generating a more stable income stream for the firm due to greater yield and/or price stability, (b) a negative correlation between price and yield for the new enterprise or (c) lack of correlation between income from the new enterprise and that from existing enterprises, so that there is scope for reduced risks through diversification.

In principle, benefits to farmers from reduced risks would be reflected in a supply shift (Newbery and Stiglitz, 1981) leading to greater producer and/or consumer surplus. However the difficulty of predicting the size of shift is even greater than that for categories 1.1-1.3. A relatively detailed and sophisticated analysis may be necessary to obtain an estimate of the benefits which is even of the right order of magnitude.

1.6 to 1.8 Off-farm research

Evaluation of research into off-farm sectors of agriculture is potentially more complex than on-farm research because of the existence of market linkages in two directions. Evaluations of research in these areas have probably been relatively neglected (but see Davis 1993), perhaps due to the interests of employers of those agricultural economists working on research evaluation. However the

relevance of off-farm research to farmers has been recognised in the recent shift in the allocation of research resources within the Australian wool sector.

In category 1.8 the difficulty of economic evaluation is very great. For practical purposes, the measurement of benefits may need to be in units other than dollars. Possible criteria for measurement of benefits in these cases include deaths prevented, medical treatment prevented, the number of scientific publications, and the number of other research projects arising.

2.1 Enhanced adoption

Marshall and Brennan (1993) emphasise the importance of this category of RD&E. As mentioned above, investment in RD&E which is partly or wholly category 2.1 has been high in Australia. Activities in this category include demonstration field trials, and some government extension activities. The results of these activities are more rapid adoption and possibly greater levels of adoption. In our view, most farmers would eventually adopt available technologies if they are truly superior, so the main impact in this category is likely to be more rapid adoption. A hypothetical example is illustrated in Figure 3. The technology or management system which is adopted sooner could be from any of the other categories of Table 1: a new product, a cheaper production system, a higher quality product, etc.

2.2 Better management decisions

Category 2.2 encompasses research which generates information for input into management decisions or information about which decisions are more profitable in different circumstances. The outcome of better information is likely to include a better allocation of resources and more profitable application rates or timing of inputs.

Australian agricultural economics has a tradition of strength in a Bayesian approach to the value of information (e.g. Anderson, Dillon, and Hardaker, 1977) but this strength has not usually been applied in the area of research evaluation. This is understandable to some extent given the relative complexity of the required analysis.

(Figure 3 here)

One thinks of research generating information of direct benefit to farmers, but off-farm institutions (transport companies, marketing bodies) can and do obtain similar types of benefit from research into their own operations. Where benefits are generated in the off-farm sector, the extent to which these are passed on to farmers will depend on market structure. Benefits passed on to farmers would be through shifts in the farm-level demand curve.

2.3 Reduced risk

RD&E in this category includes research aimed at predicting weather conditions, simulation modelling to predict yields and economic research on optimal management in the face of production risk or market risk. Such RD&E has two sources of benefit to farmers: a higher expected value of returns and a lower cost of risk for risk averse farmers. Both would shift the supply curve for the relevant product and so would have a measurable impact on producer surplus. However any analysis detailed enough to give meaningful estimates of the extent of the supply shift would also be able to provide directly estimates of the change in certainty equivalent, which is the item of interest.

2.4 Facilitation of other research

Category 2.4 refers to research which is not applied itself but facilitates further research which leads to benefits. The unpredictability of the outcomes of such research may mean that formal ex ante evaluation is not worthwhile.

Multiple impacts of research

As already noted, research often has impacts in more than one area.

(a) Improvements in one or more categories can be partially offset by a decline in another category.

- Higher quality (category 1.4) may be achieved at the cost of lower yields (1.2) or higher costs (1.3).
- Increased yields (1.2) or quality (1.4) may be at the cost of higher risk (1.5).

(b) Research often has benefits in more than one category.

- Breeding of new grain legumes (1.1) has resulted in higher yields for subsequent wheat crops (1.2), lower nitrogen fertilizer requirements of wheat crops (1.3) and higher protein levels in wheat (1.4).
- Field trials of a new crop may serve to promote adoption (2.1) and to fine tune agronomic management practices (2.2).

(c) The impacts of research are often not confined to the enterprise which was the subject of the research. Improving the profitability of an enterprise tends to draw resources of land, labour, and capital away from alternative enterprises. This imposes an opportunity cost which needs to be recognised in the evaluation. There may also be positive spin-offs for other enterprises, as in the grain legume example given above.

Clearly, it is a considerable challenge to economists to identify all the impacts of research, positive and negative, and include them in the evaluation. The reality of most agricultural research is that its impacts are numerous and

complex. If we are are to do justice to the task and win the confidence of researchers, we must do better than guessing at supply shifts, and we certainly cannot expect scientists to guess at supply shifts for us. The results of asking them to do so would often be very unsatisfactory.

As a way of summarising and structuring the main ideas from the foregoing discussion, Table 2 is a check list of issues to consider when estimating the potential net-on-farm benefits of a research project.

(Table 2 here)

Interacting with Scientists

Earlier we listed six ways in which a formal economic evaluation of research may result in benefits: (a) by culling unbeneficial research; (b) by directing funds to beneficial research; (c) by changing the emphasis or design of a research project; (d) by changing the variables which are measured; (e) by facilitating information flows between biological and physical scientists, economists, administrators, extension specialists and farmers; and (f) by providing an appropriate focus and paradigm for research leaders, research managers, and scientists. Although managers of the research institution may be primarily interested in (a) and (b), we believe that the potential for benefits from (c), (d), (e), and (f), are at least as great.

The issue is similar to one in farm management. Some of the most successful farmers employ very simplistic decision rules in choosing a portfolio of enterprises, but are successful because of their expertise in technical aspects of crop or livestock production such that they consistently attain high yields. Similarly with research, even if research evaluation did not influence the portfolio of research projects, it may dramatically increase the value of the

research which is conducted by changing the research design or the variables measured.

Achieving this depends very much on there being a positive and constructive relationship between economist and researchers. One issue here is ensuring that the researcher has confidence in and respect for the economist. A substantial contribution to this end can be made if the analysis is seen to include the complexities and subtleties outlined above. A simpler analysis is cheaper and quicker and it may even be reasonably accurate for some research, but it certainly has an adverse effect on the credibility of the results in the eyes of scientists, often for good reason. Moreover by dealing with parameters of interest to the scientist, the analysis is more relevant.

Another set of issues related to confidence includes matters of interpersonal relationships, human foibles and sensitivities, rather than economics. We hope that the following observations and suggestions based on our experiences, will be of value to others. They are mainly concerned with the problem of extension of research evaluation to scientists in cases where the scientist is less than enthusiastic about participating in the evaluation. There are many possible reasons for this reticence, including a degree of compulsion, defensiveness, inexperience, or a bad previous experience. Defensiveness may arise because of perceived loss of power to the analyst, and uncertainty as to whether or not the analysis will support the scientist's preferred topic.

Whatever the cause, the symptom of the scientist's concerns is criticism of the analysis. Where the criticisms are of specific assumptions, this is a good thing to be encouraged and responded to by revising the analysis. Often it can be shown that an unwanted or unexpected result is not sensitive to the assumptions of which the scientist is critical. The key to convincing them is to get them to

participate jointly in sensitivity analysis examining plausible ranges for parameters of interest or concern to them.

On the other hand, where the fundamental basis of the analysis is attacked, some defensive arguments are needed. Some examples follow.

- Scientists who are not used to working with economists can be shocked at the level of subjectivity we are prepared, by necessity, to accept in our data. They are often very conscious of the "*garbage in/garbage out*" maxim. Some useful responses to this are:

  (a) to emphasise the constructive role of the analysis in generating ideas and in highlighting and prioritising knowledge gaps, rather than in providing absolute numerical results;

  (b) stress that the role of the analysis is to support what will always be a subjective decision about research directions. Without the analysis the decision would still rest on subjective data, but the data would not be subject to the broader review and criticism which is one of the benefits of making assumptions explicit;

  (c) use the argument that this information is not to be compared with perfect information but with the information available in its absence; and

  (d) stress the importance of transparency of assumptions and that no results should be taken seriously by anyone unless key assumptions are explicit so that decision makers can assess their validity.

- Scientists may claim that particular outstandingly successful research would never have passed a CBA conducted prior to the research. One should concede that this is possible but stress that research planning is about best bets, not certainty. Also emphasise the importance of individual skills and

motivations in influencing the probability of success of the research. In some circumstances it could be useful to point to successful projects for which CBA would show potentially high returns.

- It is almost folk-lore among some scientists that the best and most successful science is always undirected, speculative or basic research. Again one should concede a place for this type of research and perhaps even exempt it from formal analysis, but argue that the problem is one of balance. Even the best basic research outcomes have had to be followed by applied research to yield their benefits. Having decided on the distribution of funds between basic and applied research an important question is: which of the many possible applied research topics are most likely to yield the greatest benefits? It may also be relevant to ask: which of the many possible basic research areas are likely to stimulate the most valuable applied research?

Overall, it is most important to emphasise a constructive role, not a policing role. This is primarily achieved by one-to-one contact. The economists should aim to get right inside the research: to understand the science, and be seen to understand it, to actually look at the research if possible, preferably in the presence of the scientist(s). Even if the prospect of viewing biological experiments is boring, it can yield considerable benefits for the exciting part - the economic analysis. The scientist can get especially excited and effusive in the presence of the field trials, or laboratory, and inadvertently reveal unexpected gems of information. You will also get a better feel for the quality of the information likely to be generated. In addition your presence at the trial will promote trust and respect on the part of the scientist.

Communication of the economic approach is equally important. When numerical analyses are conducted, results should be shown to the participating scientists

first to provide them with an opportunity to adjust their assumptions, or raise additional considerations, or constraints which they have overlooked. However, they must understand that key assumptions will then be open to critical review from peers and industry.

For a fully successful collaboration with research leaders and researchers, there needs to be more than good cooperation; joint "ownership" of the analysis is needed. Rather than being a defender of particular projects, the research leader or researcher needs to be interested in finding out where the highest returns to research are. This is an approach which can be foreign and difficult for many. The analysis may show that their pet area is unlikely to yield high returns, and that resources should be reallocated. Such findings can be palatable only where there is a stake in the analysis. With joint ownership of the analysis and involvement in direction setting, the researcher need not lose power with the introduction of research evaluation (unless power is narrowly perceived as keeping on doing more of the same).

In the second section of this paper we listed the different types of information needed to conduct a CBA of research. We need to be realistic about which types of information are going to be obtainable from scientists. Principally their role will be to estimate (a) the projected biological, technical and/or informational outcomes of the research, and, to a lesser extent (b) any negative side-effect of success in this research. Scientists are generally not reliable sources of other necessary information. In particular, we believe that they should not be called on to estimate shifts in supply or demand curves. Nevertheless they do need to be convinced that the other assumptions underlying the analysis are reasonable.

We observe that except when dealing with exceptional individual scientists who

are naturally interested in economics, support from senior management is critical. We are pessimistic about the chances of a successful ongoing role for economists in research evaluation in an environment where a senior scientist, or administrator, is antagonistic to the activity. Scientists find it hard enough to find the time and motivation to participate without also having to deal with the wrath of their superiors for doing so. However, this would now seem to be less of a problem, in that senior management in most RD&E organisations is now very conscious of the need for RD&E. Senior managers in some of these, now perceive that a cultural shift is required in many researchers. Research evaluation is perceived as a means of helping the achievement of this, because it questions the status quo and brings in the idea of research as an investment. It can fit in well with the new program structure (which is sweeping RD&E organisations) with its focus on program outcomes and the organisation's mission statement.

Finally, we are concerned about the trend for some RD&E organisations to make CBA a compulsory part of the process of applying for research funds. The element of compulsion is going to mean that many scientists will be unwilling and uncooperative participants in the process. Furthermore there is a clear shortage of economists skilled in research evaluation in some regions (e.g. South Australia) and some organisations (e.g. CSIRO). This means that many analyses are likely to be poorly conducted and poorly interpreted and communicated, compounding the problem of compulsion in generating negative attitudes among scientists. This is particularly unfortunate given our argument that the benefits of changed thinking as a result of participating in a good research evaluation process are likely to be at least as great as the benefits of better prioritising research topics.

Concluding Comments

Despite growing interest, there is still little effective use of research evaluation in Australia's major agricultural RD&E organisations, although increasingly there is an environment in which it could flourish. Two broad areas of improvement which could help increase its effective use are:

- A detailed decision support system providing practical advice on research evaluation methods and problems likely to be encountered. This paper is intended to provide some groundwork for such a system.

- Processes to ensure the involvement of researchers and research leaders in the analyses. Such involvement can have substantial benefits for both economist and researcher.

There are now opportunities for Australian agricultural economists to participate in the research evaluation process to an extent which has not previously been possible. It is essential that the work done is perceived as being relevant and valuable by research managers, otherwise they will turn to inferior methods, such as one of the current proliferation of rating systems.

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Table 1. Types of research impacts

1. Improved technology

On-farm

1.1 New enterprise (e.g. new legume crop species).

1.2 Increased production (e.g. new crop variety).

1.3 Decreased production costs (e.g. more efficient technology for application of chemicals)

1.4 Increased quality (e.g. reduced contamination)

1.5 Reduced risk (e.g. a more stable yielding crop variety)

Off-farm

1.6 Decreased handling/transport/storage/processing costs

1.7 Decreased wastage/spoilage

1.8 Improved human health

2. Information

Both on-farm and off-farm

2.1 More rapid adoption and/or a higher level of adoption of beneficial existing technology

2.2 Better management decisions (strategic and tactical) leading to higher profit

2.3 Reduced risk

2.4 Facilitation of other research

Table 2. Key issues when estimating potential net-on-farm benefits of research

1. What is the scope of the research?

   1.1 Which regions are affected?

   1.2 Which farm types or soil types in those regions are affected?

   1.3 Will the research affect biological interactions with other enterprises? (e.g. rotational effects)

   1.4 Will the research result in reallocation of farm resources? Which enterprises are affected?

2. Which of the types of impact from Table 1 will occur?

   2.1 Are there negative impacts partially offsetting the benefits?

   2.2 Are there benefits in more than one category?

   2.3 Is more than one enterprise affected? If so, for each enterprise affected, identify the relevant impact from Table 1.

3. Is the product sold directly or used as an input to production of other goods?

4. Are there relevant market effects?

   4.1 Will prices of any of the products be affected? If so remember to consider impacts on consumers as well as producers.

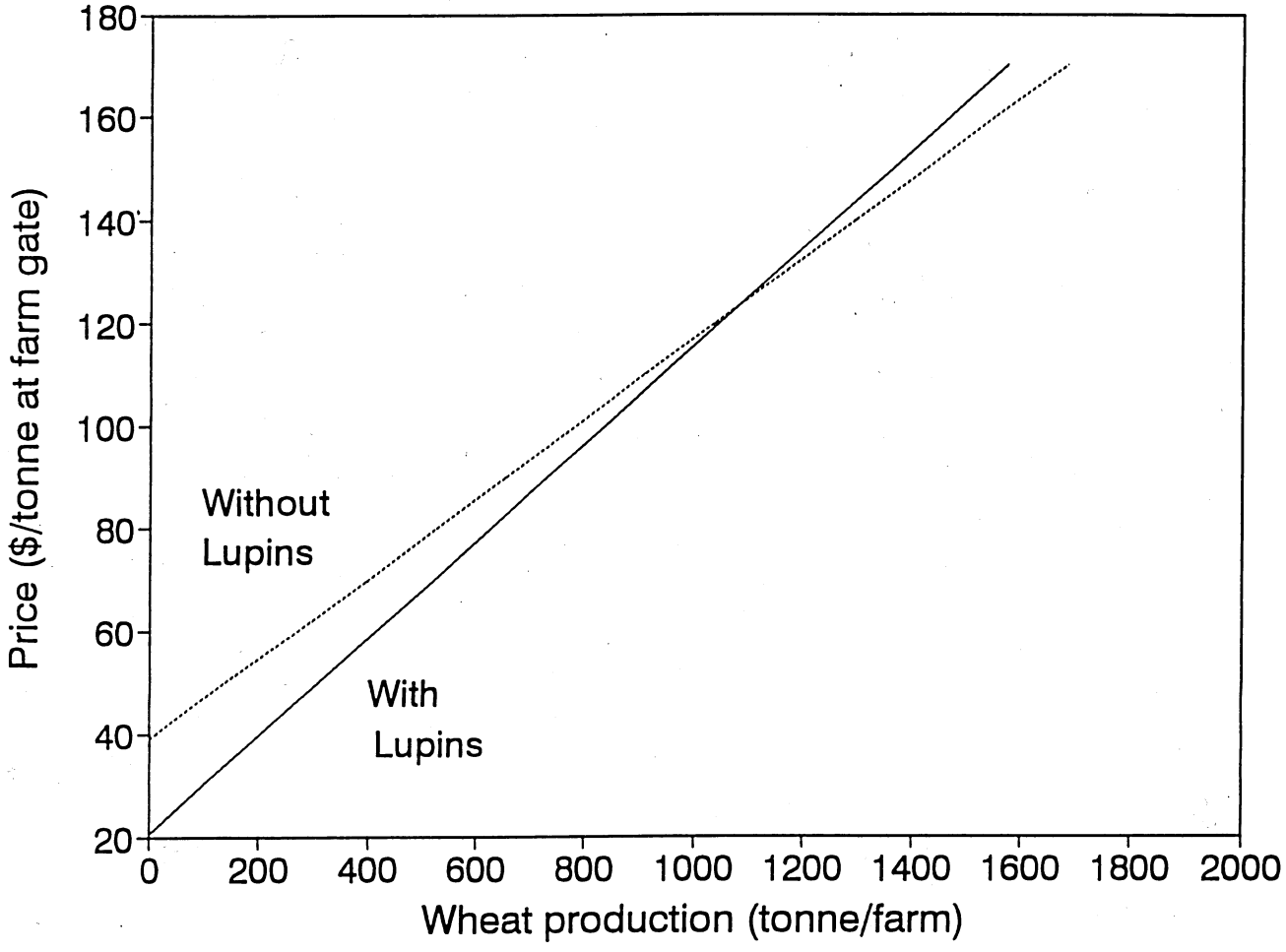
   4.2 If one of the affected products is subject to government involvement in marketing, what are the implications of this for the size and distribution of research benefits?

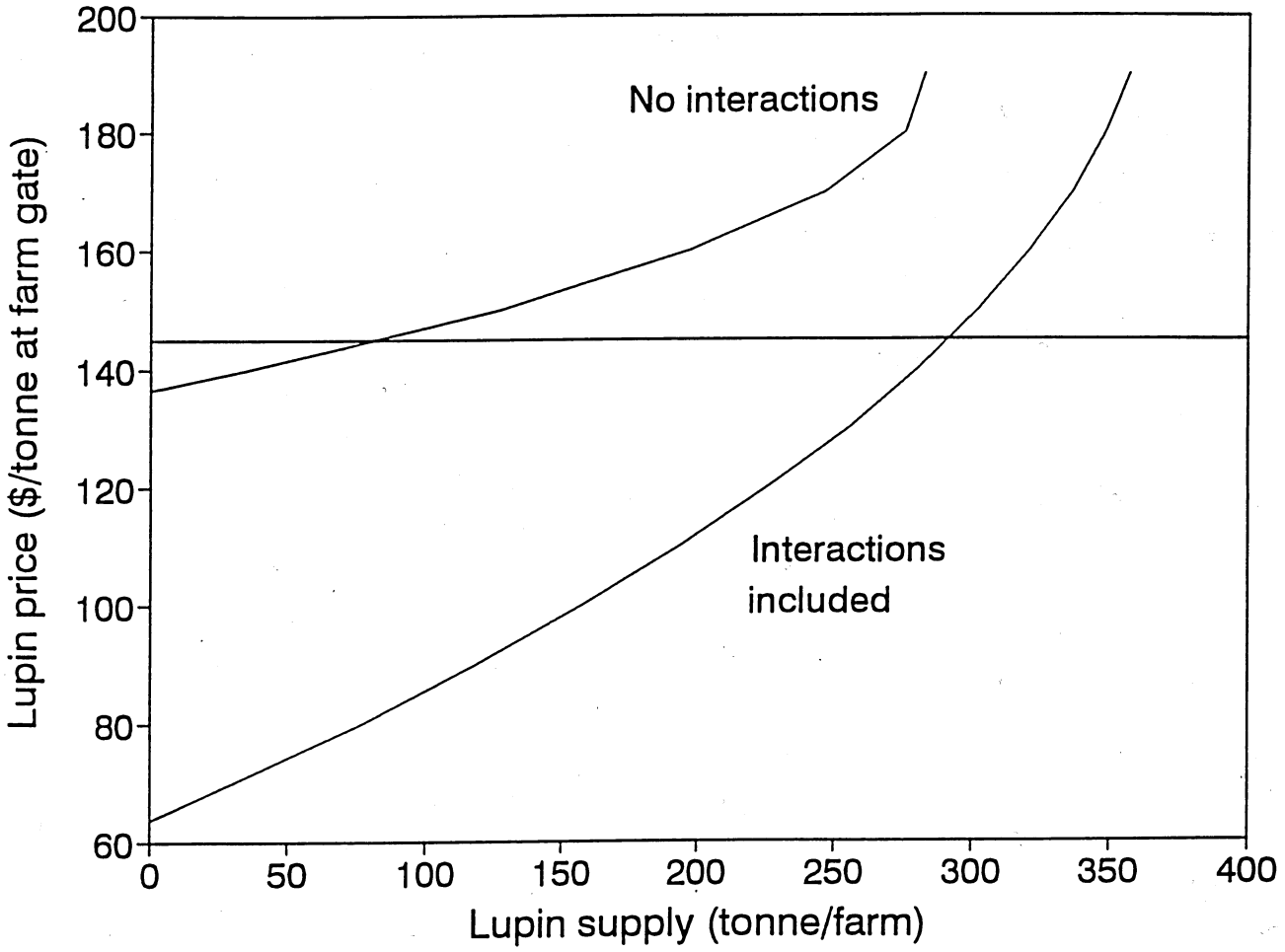
Figure Captions

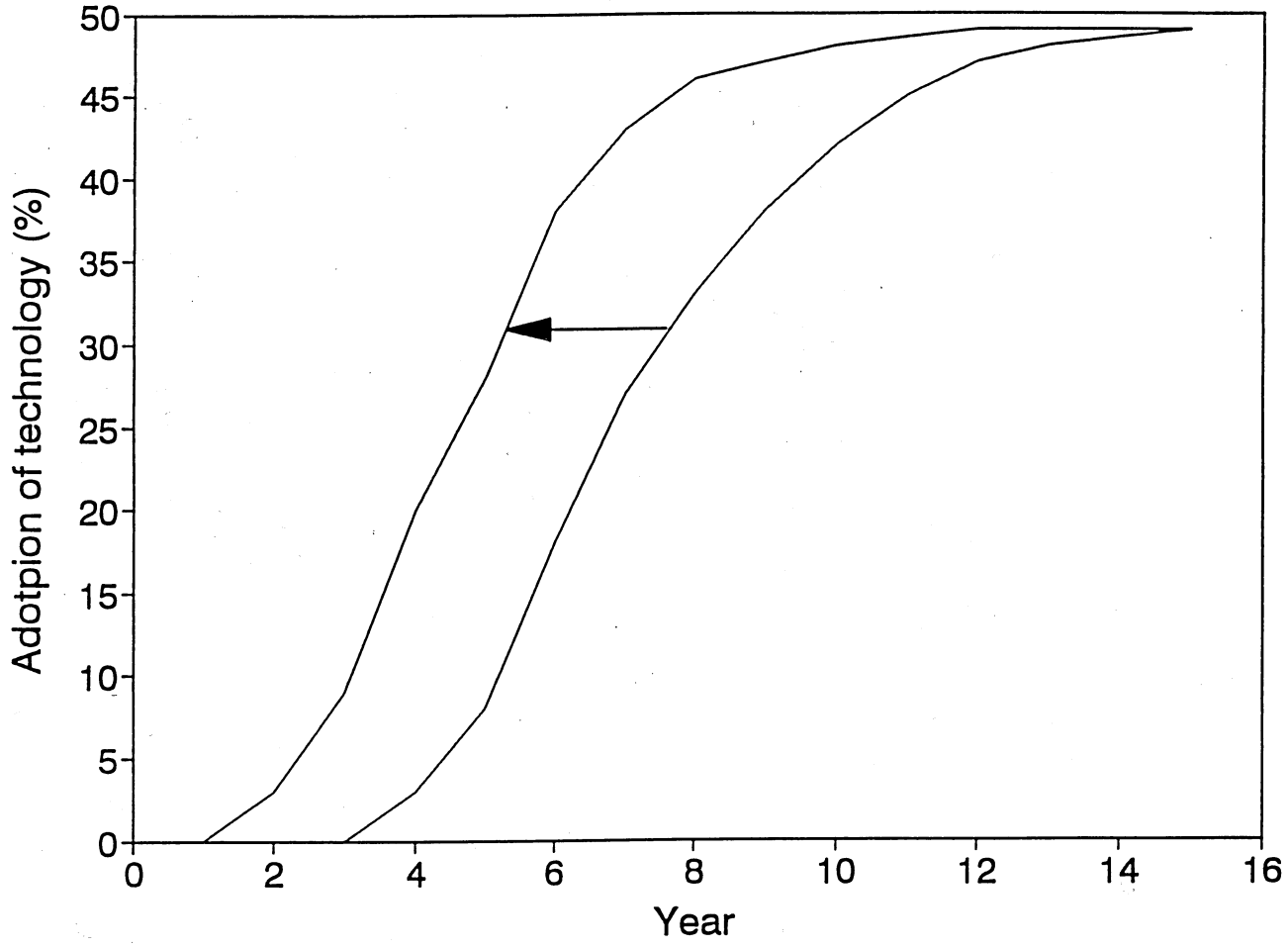
Figure 1. Wheat supply curves (Source: MIDAS model version EWM 91-4)

Figure 2. Lupin supply curves (Source: MIDAS model version EWM 91-4)

Figure 3. Acceleration of adoption


180
160
140
120
100
80
60
40
20
Price ($/tonne at farm gate)
Without
Lupins
With
Lupins
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Wheat production (tonne/farm)


200
180
160
140
120
100
80
60
Lupin price ($/tonne at farm gate)
No interactions
Interactions
included
0
50
100
150
200
250
300
350
400
Lupin supply (tonne/farm)


Adotpion of technology (%)
50
45
40
35
30
25
20
15
10
5
0
0
2
4
6
8
10
12
14
16
Year

Footnotes

[1]A simple example may help clarify this point. Suppose a farmer grows only product A, with profit = π_0 and producer surplus $\approx \pi_0$. Scientists develop a new product B which has no biological interaction with A but which substitutes for A with the same use of resources and happens to give a profit of exactly π_0 for this farmer. Assume demand for each product is perfectly elastic. Now recall that producer surplus approximates the opportunity cost of not producing a product. Because the two products are perfect substitutes with the same profit, the opportunity cost (and thus the producer surplus) of not producing either one of them is zero. In the case of B, the producer surplus of zero reflects that the development of the product results in no benefit to the farmer. In the case of A, the change in producer surplus of $-\pi_0$ does not reflect any reduction in farm profit (which is obviously unchanged, whichever product the farmer produces) but rather a change in the opportunity cost of not producing A. This is not a helpful value when calculating the benefits of having developed the new product.

[2]This assumes that the spin-off arises in the production of the researched product. It would not apply if research into product A had a spin-off effect on product B which occurred whether or not product A was produced by the farmer.