Economic Evaluations of Production Technologies in the Australian Sheep Industry[1]

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Abstract

The Australian Sheep Industry Cooperative Research Centre (Sheep CRC) commenced operations in February 2002 and will receive federal funding of $19.8 million over its seven-year grant period. As well, the sheep industry is expected to invest over $10 million in Sheep CRC activities over this period, while core and supporting parties will make in-kind contributions totalling about $60 million. The main objective of the Sheep CRC is to develop new technologies that will increase the productivity and profitability of sheep meat and wool production and provide the skills and knowledge needed to fully utilise the available technologies. The Sheep CRC will be considered to have been successful if its outcomes have delivered measurable economic benefits to the sheep industry and to the rural communities. Accordingly, the Sheep CRC has placed a high priority on the rigorous economic evaluation of its research activities. With a focus on the production technology programs, that requirement has included the preliminary economic evaluation of a large number of individual projects. The more comprehensive evaluation of groups of projects is now being attempted. This paper describes the procedures that have been adopted in making those evaluations and presents some preliminary results.

1. Introduction

The main objective of agricultural research processes that develop new production technologies is to generate economic benefits to the rural industries. Most of these processes involve the investment of limited resources to produce new knowledge that leads to future productivity improvements and the satisfaction of economic and social objectives (Alston *et al.* 1995). Their outputs typically include better management practices, higher quality inputs and resource improvements. Such outputs offer opportunities for improving production efficiencies where their adoption and diffusion throughout an industry results in increased productivity and product quality relative to the gains that are achievable using

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existing technologies (Marshall and Brennan 2001). For a production-based technology, productivity gains result where adoption increases the output-input ratio of a production process and reduces unit production costs. When a new production technology is widely adopted throughout an agricultural industry, benefits also accrue to the consumers of agricultural commodities (Griffith *et al.* 1995).

New technology development in Australian agriculture is publically funded to a higher level than in many other countries on the rationale that there are inadequate incentives for the private sector to promote a socially-desirable level of this activity (Brennan and Mullen 2002). In the mid-1990's, 90% of Australian rural research was undertaken by government agencies with a 50%-26%-14% split between state governments, federal government and higher education institutions (Lack 1996). This high level of public funding highlights the continued need for research agencies that operate under reducing budgets to be able to demonstrate the potential returns to all stakeholders from this level of investment. In response to this demand, Pannell (1999) has observed an unprecedented interest in the formal economic evaluation of new agricultural technologies. That demand has been motivated by research administrators seeking such information to support external submissions to maintain existing funding commitments and to assist in research priority setting that identifies both low and high return areas for guiding funding allocations.

Mullen (2003) considered that public investment in research programs such as the Sheep CRC had an opportunity cost that was equivalent to the public benefit that could have been derived had those resources been directed to other areas such as health and education. It was therefore important for the recipient organisations to demonstrate that these resources were used in ways that enhanced public welfare. Some of the purposes of this process are to satisfy external accountability requirements, to assist in allocating resources to research areas that are likely to have high payoffs and to assist in designing research and extension projects that have clearly defined objectives consistent with the role of public research institutions. Working through a formal economic evaluation methodology (eg., benefit-cost analysis) gives the participants a greater appreciation of the paths by which, and the extent to which, R&D activities are likely to have an impact, particularly at the farm level, and so lead to better projects. A component of this process is a greater understanding of trends in the industry and of the extent to which the ‘market’ fails to deliver outcomes sought by the industry or by the public (Mullen 2003).

The Australian Sheep Industry Cooperative Research Centre (Sheep CRC) is such an institution that has a requirement for the formal economic evaluation of its research activities. The Sheep CRC is a typical agriculturally-based agency that comprises universities, government and private industry in a long-term collaborative arrangement that supports research, development and education activities that achieve outcomes of economic and social significance to the sheep industry and the Australian public. This CRC commenced operations in early 2002 and will receive federal funding totalling $19.8 million over its seven-year grant period. In addition, the sheep industry will invest over $10 million in the Sheep CRC over this period, while core and supporting parties will make in-kind contributions with an approximate value of $60 million.

The Sheep CRC will be considered to have been successful if the outcomes of its research have delivered quantifiable economic benefits to the industry and to the general public. Accordingly, the Sheep CRC has placed a high priority on the economic evaluation of its research, particularly in relation to its production technology programs. The requirements of the economic evaluation component of the overall research program are to develop and apply best-practice economic methods to provide information on the expected returns from investments in new technologies to management and to all participants in the sheep meat and wool industries. To date, that has included the preliminary economic evaluation of individual projects, and is now involving the more comprehensive evaluation of groups of projects. This paper describes the procedures that have been adopted in making those evaluations and presents some preliminary results.

2. Evaluation methods

The Sheep CRC is organised around a suite of production research programs and other non-production orientated programs that include communication, extension support, technology evaluation and knowledge management. The production programs cover most aspects of Australian sheep production; genetic technologies, wool science, meat science, parasite management, strategic nutrition and precision sheep management based on electronic identification. The Sheep CRC's Strategic Plan states that its major objectives are to develop a range of technologies, practices and delivery mechanisms that will provide measurable gains in sheep industry productivity and profitability, and to meet community and stakeholder expectations regarding animal welfare, resource use and product safety. That continues to involve the development of new technologies, management practices and marketing strategies that will make the sheep industry more profitable and sheep products more highly valued by consumers.

The potential benefits from the Sheep CRC's research projects can be defined in three categories: (i) the benefits from new research that has not been previously undertaken and would not have been undertaken without the involvement of the Sheep CRC; (ii), the benefits from improved research outputs that are likely to have a greater impact on the target industries than those benefits that result from other research programs that may be undertaken by the same agencies without the Sheep CRC's investment; and (iii), the benefits that result from the extension of improved information to the target industries that can be legitimately attributed to the work of the Sheep CRC. On the surface, the benefits to the Sheep CRC's research appear less likely to fall into the first category because there has been some past level of research in most of the project areas given the long history of research by many institutions in the Australian sheep industry. Hence, it is likely that there will be future productivity improvements in Australian sheep production that can be attributed to improved technologies from research other than that undertaken by the Sheep CRC. The benefits are more likely to fall into either categories (ii) or (iii) or both, where the Sheep CRC's investment intensifies the level of research in the sheep industry by providing additional research funding.

The technology/project evaluations described in the remainder of this paper are based on the proposition that the principal effect of the Sheep CRC's research investment is moreso to expedite the delivery of new production technologies to the industries rather than to generate completely new technologies. This outcome results from the provision of additional research funding and by reinforcing the long experience of collaboration between researchers and agencies that is well recognised and valued by the Australian sheep industry. It follows that for a given project, the main task of the evaluation becomes one of measuring the marginal or incremental benefits that can be attributed to that project where such benefits are net of the ongoing benefits from past research and net of any expected benefits that could come from other non-Sheep CRC research programs (Griffith *et al.* 2004).

2.1 Evaluation scenarios

The first requirement of the evaluation process was to establish realistic scenarios that recognised the effects of past research on the potential benefits from a particular project. This distinction enabled the economic benefits to be estimated as the difference in the benefits with the project (the with-Sheep CRC project scenario) and those that would have resulted from other related but independent research (the without-Sheep CRC project scenario). Alston *et al.* (1995) noted that defining relevant scenarios is a most useful component of the research evaluation process but it is also often difficult because many evaluations are concerned with on-going rather than new programs. They further noted that in this process, the with-project scenario usually implies a baseline that presumes an indefinite continuation of the research program, whereas the without-project scenario implies that none of the baseline research has been undertaken. For that reason, the with-project scenario seems to have limited relevance to many agricultural research programs since there has usually been some past research investment that helps to establish the baseline, eg. improved plant varieties usually incorporate improvements that resulted from earlier programs.

Another scenario was proposed that embodied different assumptions about the baseline and this was considered to be more relevant in this sheep technology evaluation context. That was that the with-Sheep CRC project scenario represented a continuation of a research investment while the without-Sheep CRC project scenario represents a funding reduction. The latter scenario recognises the investment in sheep research prior to the advent of the Sheep CRC that has been made by Australian state and federal governments over many years. Thus the activities of the Sheep CRC enabled the development and extension of new technology to be expedited and to produce research outputs that capitalised on the findings of the past research. The with-Sheep CRC project scenario was defined as covering the research in a particular area that was undertaken during the CRC's period. The alternate without-Sheep CRC project scenario was assumed to have a research budget that was reduced by the amount of the Sheep CRC's project funding.

2.2 Models used in evaluations

Approximately 80% of the Sheep CRC's budget is allocated to the production research programs. The potential impact of that research is the main focus of the economic evaluations. Economic evaluations of new production technologies determine whether adopting a new technology is likely to be profitable to producers and their industries. Because estimates of the likely benefits of new technologies are required at separate levels, the economic models that are used for this purpose need to have components that represent the production and market industry levels of an industry.

The methods adopted for the Sheep CRC production research evaluations follow the partial equilibrium measures of economic surplus or welfare change that result from the adoption of a production increasing technology in an industry that has flow-on market demand and price effects. This approach is considered to be most appropriate for evaluating production level gains where differences in production costs from the adoption of research outcomes can be determined (Alston *et al.* 1995). The benefits from this adoption process are measured in value terms that can be converted to economic welfare changes with values for various parameters. Benefits include the possible gains to producers from adopting the technology through reducing unit production costs, and the gains to consumers from reduced market prices. These benefits are distributed between producers and consumers according to the relative values of the supply and demand elasticities.

The application of the standard economic surplus model in this context of evaluating a production-increasing or cost-reducing technology assumes a parallel shift of the industry supply curve that implies that the cost reductions are the same across the industry. However, this implication is considered to be unrealistic if the technology has a regional rather than an industry-wide relevance and so production costs are likely to vary between regions. Lindner and Jarrett (1978) held that because many agricultural technologies were location specific, it was necessary to apply the economic surplus model at a disaggregated level. Differences in the production environments between regions which resulted from variations in resources and climates, such as typify Australia's sheep producing environments, meant that the cost structures of producers and the effects of cost-reducing technologies were similarly variable.

This situation is illustrated in Figure 1 (after Davis 1994) in which three production regions are considered to vary sufficiently to generate different cost structures. The cost variations are indicated by the different slopes of the supply curves which are then aggregated to form the national supply function. Price is the same in each region but the production levels vary; the latter are indicated by the different sloping segments of the national supply curve. Separate regional demands are not considered to be relevant and the national demand determines the prices P_0 and P_1. The main points that this figure shows are that the regions have different cost conditions and so their supply curves have different slopes, that technology adoption in region 3 increases that region's production and reduces its price, that this price becomes the national price and that production in regions 1 and 2 decreases because of the price reduction. In this model, technology adoption in region 3 increases production in that region but not in the other two regions. The main effect of region 3's supply shift is to reduce price to P_1 in each region because all regions face the same national demand). Producers in regions 1 and 2 actually lose economic surplus as production falls in response to $P_{1,}$ i.e., producers in regions 1 and 2 are unable to adopt the technology and the lower price forces a shift down the supply functions to quantities $QR1_1$ and $QR2_1$ at higher average production costs. This effect differs from region 3 where technology adoption lowers average costs and shifts production out to $QR3_1$. The national effect of the technology is the sum of the regional effects which in this instance, is to increase production to QN_1. The national increase in economic surplus is less than that in region 3 because of the losses to producers in the regions where the technology cannot be adopted. Because production technologies such as those generated under the Sheep CRC's research are more applicable regionally than nationally, producers in the non-adopting regions are likely to suffer price effects from the adopting regions.

The main features of this model are that price is the same in each region and the regional variations in production result in different production costs that are indicated by the different sloping segments of the national supply curve. This disaggregated form of the economic surplus model was used to calculate the annual benefits that could result from the Sheep CRC's projects using the formulae provided by Alston *et al.* (1995, p. 407). The elasticity and other parameter values used in making these calculations are given in Table 1. At present, only two regions were defined for the evaluations: Australia and the rest-of-the World because Australia's dominant status in the international sheep and wool markets indicates the likelihood of price spillovers to other sheep-producing countries from technology adoption in Australia. It is intended to define separate Australian regions to reflect the regional relevance of the specific technologies when more comprehensive evaluations of the projects are undertaken.

Table 1. Elasticity values and prices used in economic surplus change calculations

	Supply	Demand
Australia wool	1.15	-0.8
Australia lamb	1.4	-4.54
Rest-of-World wool	1.5	-2.0
Rest-of-World lamb	2.0	-2.0
Wool price - 750 c/kg		
Lamb price - 350 c/kg		

Elasticity sources: Griffith *et al.*(2001).

Project benefits that were estimated in terms of annual economic surplus changes were simulated in a stochastic benefit-cost process to calculate the net present values (NPVs) and benefit-cost ratios (BCRs) for each project that was evaluated. The main factors that influence project benefits are the effect of the technology on production costs (the supply shift), the level of adoption of the research outcomes and commodity prices. Since production technology is the main focus of the Sheep CRC projects, the supply shifts (or K values) were measured in terms of the impact of the project's technology on the variable unit costs of production for the with-Sheep CRC and without-Sheep CRC project systems, and expressed as a proportion of the initial equilibrium commodity price P_0. A common supply shift of 1% was assumed to apply to the three example projects because to date, there has been insufficient data from the projects to enable the production cost differences to be accurately determined. The more precise definition of these shifts is a current focus of the project evaluation process. Here, sheep production systems models are being developed to enable the differences in the costs and returns between existing sheep production systems and those that incorporate the new technologies that are being developed within the projects.

The benefit-cost analysis also required some parameter values that could not be accurately defined because the incomplete nature of the projects. These values mainly concern the expected levels and rates of adoption for the projects' technologies. When combined with seasonal variations these factors are the main sources of benefit uncertainty associated with a project. Expected adoption values for the outcomes of the projects were elicited from the project leaders, including the adoption ceiling or maximum anticipated level of adoption for the project's outcomes by the relevant industry, and the adoption lag or the number of years expected to be taken to attain the adoption ceiling. Because these values were subjectively derived, they were specified as random variables in the benefit-cost analysis with value ranges that were simulated within triangular probability distributions using a stochastic (Monte Carlo) model. The supply shifts and commodity prices were also treated as random variables. By enabling the NPVs and BCRs to be calculated in terms of probability distributions, this approach overcame the problem of using single values for variables that were likely to be uncertain because of the *ex ante* nature of the assessments. It provided the advantage of being able to generate a full range of benefit-cost results in a single run in which the values of main variables are sensitised between the expected minimums, medians (or most likely) and maximums. A further output from this simulation approach was the cumulative distribution functions (CDFs) for each project’s range of possible benefit-cost outcomes. These CDFs indicated the likelihood of obtaining a particular benefit-cost outcome by determining the probabilities of the project generating a NPV or a BCR of a given value. Ignoring the 100^{th} and zero percentiles, the maximum, median and minimum values of the benefit-cost criteria were represented by the 95^{th}, 50^{th} and 5^{th} percentiles of the probability distributions, respectively. The start or base year for the benefit-cost analysis was 2002-03 which was the most recent year for which the project cost data was available, and projected to 2017. All values were discounted at a 5% real discount rate. Table 2 contains the values of the probability distributions for the randomly-specified variables.

Evaluation results are reported for three of the 35 individual projects that were the subject of preliminary economic evaluations during 2004. These projects are core components of three of the Sheep CRC’s sheep major production programs. The first project (total project cost $2.037 million) ‘Genetic analysis of sheep production traits’ is in Sub-program 1.1 Genetics. Its objective is ‘..to provide the Australian sheep industry with accurate genetic parameters and genetic evaluation models for a comprehensive range of traits for wool and meat production, product quality and resistance to parasites for use in the genetic evaluation and optimization of commercial breeding programs and the accurate prediction of their outcomes’. The second project (total project cost $0.96 million) ‘On-farm detection of parasite eggs in faeces' is in Sub-program 1.4 Parasite Management. The objective of that project is '..to develop a rapid on-farm method for quantification and identification of nematode eggs in sheep faeces samples'. These two projects were evaluated in terms of their potential impacts on the wool industry. The third project (total project cost $0.43 million) 'Evaluating individual animal (electronic) management strategies' is in Sub-program 2.0 Improving Profitability in the Sheep Industry and has the objective of '..evaluating the feasibility, costs and profitability of new management and production strategies based on individual animal management'. A further objective is to develop resource material that identifies the profitability of precision sheep production and provide the means of implementing such strategies on farm. This project was evaluated in terms of its potential impact on the lamb industry.

Table 2. Triangular probability distribution values for adoption variables

	Maximum	**Median**	**Minimum**
Adoption ceilings (%)			
Genetics project	30	20	10
Parasite management project	25	15	5
Electronic sheep management project	40	25	10
Total research and adoption lag (years)			
Genetics project	5	3	1
Parasite management project	10	5	3
Electronic sheep management project	8	5	3

3. Results

Estimates of the potential annual economic surplus changes from the adoption of the technologies generated by the three Sheep CRC projects are given in Table 3. These changes are equal to the total annual benefits from each project, and are similar for the genetics and parasite management projects because the (1%) supply shift assumption and the equilibrium wool industry price-quantity data were common to both evaluations. The median value of this total annual benefit was about $64.5 million, while the electronic sheep management project generated an annual benefit with a median value of $14.2

million. These estimates of total economic surplus change comprise the gains to Australian wool and lamb producers who adopt the cost-reducing technologies, losses to producers in other countries who cannot adopt the technologies and benefit from the cost savings, and gains to all wool and lamb consumers.

Table 3. Potential annual economic surplus changes for three Sheep CRC projects

	Value of annual economic surplus change ($A millions)		
	Maximum	**Median**	**Minimum**
Genetics project			
Australian wool producers	47.1	23.4	8.4
Rest-of-World wool producers	-41.6	-115.8	-232.9
Australian wool consumers	2.3	1.2	0.42
Rest-of-World wool consumers	314.2	155.9	56.1
Total change	133.2	64.7	21.1
Parasite management project			
Australian wool producers	46.6	23.3	8.4
Rest-of-World wool producers	-41.2	-115.2	-230.1
Australian wool consumers	2.3	1.2	0.4
Rest-of-World wool consumers	310.4	155.3	55.5
Total change	131.7	64.5	22.1
Electronic sheep management project			
Australian lamb producers	12.3	5.5	1.5
Rest-of-World lamb producers	-12.4	-44.1	-99.1
Australian lamb consumers	7.9	3.6	1.54
Rest-of-World lamb consumers	102.4	45.6	12.8
Total change	31.8	14.2	4.5

Table 4 contains the results of the 15-year stochastic benefit-cost analysis for the three projects. Over the range of expectations concerning the adoption of their technologies, the NPV and BCR estimates indicate the potential for the three projects to deliver significant levels of benefits to the Australian sheep industries relative to the project costs. These benefit-cost outcomes are the simulated differences or the incremental benefit between the with- and without-Sheep CRC project scenarios, and result from the differences in the adoption assumptions regarding ceilings and lags. The rationale for these differences is that the main impact of the research investments made by the Sheep CRC has been to expedite the development of improved sheep production technologies and their adoption by sheep producers. Benefits are larger under the with-Sheep CRC project scenario because the shorter adoption lags enable them to occur earlier in the period of the benefit-cost analysis and are therefore less reduced by the discounting.

The genetics project generated potential incremental benefits with a 15-year NPV and BCR of $55 million and 14.7:1 (median values), while the equivalent estimates for the parasite management project were a median NPV of $23.8 million and a median BCR of 8.9:1. These results indicate the effects of the adoption assumptions on benefit levels wherein the higher adoption ceiling and shorter adoption lag for the genetics project resulted in a NPV with a median value that was approximately double that of the parasite management project. The simulated median values for the incremental benefits to the electronic sheep management project were an NPV of $5.9 million and a BCR of 3.1:1.

Table 4. Stochastic 15-year benefit-cost results for three Sheep CRC projects

	Maximum	Median	Minimum
Genetics project			
Net present value ($millions)	106.1	55.0	25.6
Benefit-cost ratio ($:1)	27.4	14.7	7.4
Parasite management project			
Net present value ($millions)	48.9	23.8	9.9
Benefit-cost ratio ($:1)	17.4	8.9	4.3
Electronic sheep management project			
Net present value ($millions)	16.8	5.9	0.9
Benefit-cost ratio ($:1)	6.6	3.1	1.3

Calculations based on the total annual economic surplus changes (Table 3) discounted at 5% real over 15 years.

The CDFs for the median values of the NPVs and BCRs for the three projects are given in Table 5. These estimates indicate the probabilities of obtaining a particular benefit-cost outcome for each of the three projects. In each project, the minimum NPV, as represented by the 5th percentile, was positive and the minimum BCR was greater than unity. The probability that each of the projects would return benefit-cost outcomes equivalent to four to five times the total cost of the project was 80%, as represented by the 50th percentile values for the NPVs and BCRs. The median NPV values that indicate the most likely benefit-cost outcomes for the projects are represented by the 50th percentiles and were $55 million for the genetics project, $23.8 million for the parasite management project and $5.9 million for the electronic sheep management project. The corresponding median BCR values were 14.7:1, 8.3:1 and 3:1.

4. Summary and Discussion

This paper discusses the economic approaches that are being adopted to undertake a series of economic evaluations of research projects that are currently being funded by the Australian Sheep Industry CRC. Some preliminary evaluation results for three projects are presented. In 2003, the Sheep CRC board requested that all projects within its research program undergo a preliminary economic evaluation. In response to that request, it was recognised that although *ex ante* project evaluation is useful in principle, it was difficult to undertake in the absence of reliable project data. Given the very early stage of most of the Sheep CRCs projects, it was considered that providing economic evaluations that were not firmly based on good project data and the valid economic interpretation of that data was likely to generate information that was of little value for decision making. The decision to proceed with the evaluations recognised these concerns.

The Sheep CRC has a requirement for this type of economic information for several reasons. One is that the Sheep CRC's research has a strong production system orientation. Economic evaluations of improved sheep production technologies are seen as being essential in promoting the value of those systems to producers and in assisting them to make better management decisions in accordance with their resources and objectives. Another reason follows the recognition that the widespread adoption of a new sheep production technology is likely to result in productivity gains in the form of increased outputs. Should that occur, the

Table 5. Cumulative distribution functions for benefit-cost results

	Genetics project	Parasite management project	Electronic sheep management project
Net present value (NPV $ millions)			
5%	25.6	9.9	0.9
10%	30.4	12.1	1.7
15%	33.8	13.9	2.3
20%	36.9	15.4	2.8
25%	40.0	16.9	3.4
30%	43.0	18.2	3.9
35%	45.8	19.5	4.3
40%	48.8	20.9	4.8
45%	51.7	22.3	5.4
50%	55.0	23.8	5.9
55%	58.2	25.3	6.6
60%	61.6	26.9	7.1
65%	65.5	28.7	7.9
70%	69.7	30.7	8.6
75%	74.3	32.9	9.5
80%	79.1	35.5	10.6
85%	85.1	38.7	11.9
90%	93.5	42.7	13.8
95%	106.1	48.9	16.8
Benefit-cost ratio (BCR $:1)			
5%	7.4	4.3	1.3
10%	8.6	5.0	1.6
15%	9.4	5.7	1.8
20%	10.2	6.2	1.9
25%	11.0	6.6	2.1
30%	11.7	7.2	2.3
35%	12.4	7.5	2.5
40%	13.2	8.0	2.6
45%	13.9	8.4	2.8
50%	14.7	8.9	3.0
55%	15.5	9.5	3.2
60%	16.3	10.0	3.4
65%	17.3	10.6	3.6
70%	18.3	11.3	3.9
75%	19.5	12.0	4.2
80%	20.7	12.9	4.5
85%	22.2	13.9	4.9
90%	24.3	15.3	5.6
95%	27.4	17.4	6.6

competitive nature of Australia's sheep industry suggests that market prices will be lower than those prior to the introduction of the technology, and so there is a need to evaluate the full industry-level effects of such changes on the producers and consumers of sheep products. A third reason is that because the Sheep CRC has a significant public funding component, it is also desirable to estimate the potential social returns to that investment. Each level of evaluation addresses the major accountability issue of the Sheep CRC being able to ultimately determine the full range of potential benefits from the adoption of improved technologies resulting from its research in the sheep industry. This information will assist in assessing the extent to which the Sheep CRC has achieved its objectives.

To date, a large number of projects have been subjected to a preliminary economic evaluation based on the methods described in Section 2. This process has yielded mixed results with some evaluations having considerably more rigour than others because of differences in the quality of the input data that have been derived from the projects. As with most *ex ante* project evaluations, the main task remains to derive credible data from the project leaders prior to the project's completion. Some projects are more advanced than others and are better placed to provide reasonable estimates about their likely outcomes and expected adoption profiles. The Sheep CRC has recognised the need for the project leaders to be able to supply credible input data for use in the economic evaluations and is in the process of introducing means to enable the project teams to formally consider the nature of the farm and industry benefits of their technologies and the anticipated level of technology adoption by the industries. A requirement is that this information be subjected to external validation by industry experts to ensure its credibility.

The potential economic benefits to the Sheep CRC's projects were considered in terms of the project's likely impact on either the wool, lamb or mutton industries. Benefits were measured in terms of the changes in the economic welfare of the industry that could result from the adoption of the project's outcomes. Welfare changes were estimated using stochastic economic surplus analysis in which probability distributions were specified for the uncertain values of the major variables, the supply shift, the adoption ceiling and lag and the commodity price. These estimates of welfare change were held to be the potential annual benefit from a particular project and matched against the project costs in a 15-year benefit-cost analysis. The results of the preliminary evaluations that have been undertaken using incomplete project information have indicated the potential for the research investment by the Sheep CRC to deliver significant benefits to the sheep industries.

The intention is to undertake more comprehensive evaluations of Sheep CRC projects that can be grouped under a common theme within the main research programs. For example, the three research areas represented in the preliminary evaluations reported in this paper comprise six projects in the Genetics sub-program, nine projects in the Parasite Management sub-program, and three sub-programs comprising seven projects in the Improving Profitability in the Sheep Industry sub-program. These areas represent different economic problems to the industry and have different implications for economic evaluation ie, long-term productivity improvements (genetics), short-term management with long term implications (parasites), and new innovation in flock management (individual electronic sheep management).

However, the need for input data that are seen to be credible by industry remains. To address that problem, a data elicitation process is being developed that is similar to one that was successfully used in the economic evaluation of research projects in the recently-completed CRC for Cattle and Beef Quality (Beef CRC) (Griffith *et al.* 2004). This process is based on a 'top-down' approach in which overall rates of productivity improvement are examined and the role of technological change in generating this productivity growth is assessed. The two major items of input data are the underlying rate of productivity improvement in the Australian sheep industry and the expected rate of productivity improvement that can be attributed to the Sheep CRC's research. Expert opinion will be used to disaggregate the shares of potential productivity growth due to the Sheep CRC across the various outcome areas, and the benefits from the expected shifts in these various outcomes are then estimated. In applying this process to the Beef CRC, it was estimated that the aggregate impact of that CRC on the Australian beef industries was an additional 4% in the potential annual rate of productivity improvement, and that would occur after maximum adoption of the research outcomes of the CRC. This estimate was obtained at a workshop attended by the scientists and core industry people where consensus of opinion was achieved. The estimates were adjusted by the Beef CRC's economists following a review of relevant literature and past project outcomes. Such an approach appears to have considerable potential in overcoming the data deficiencies that have been encountered in undertaking the Sheep CRC project evaluations.

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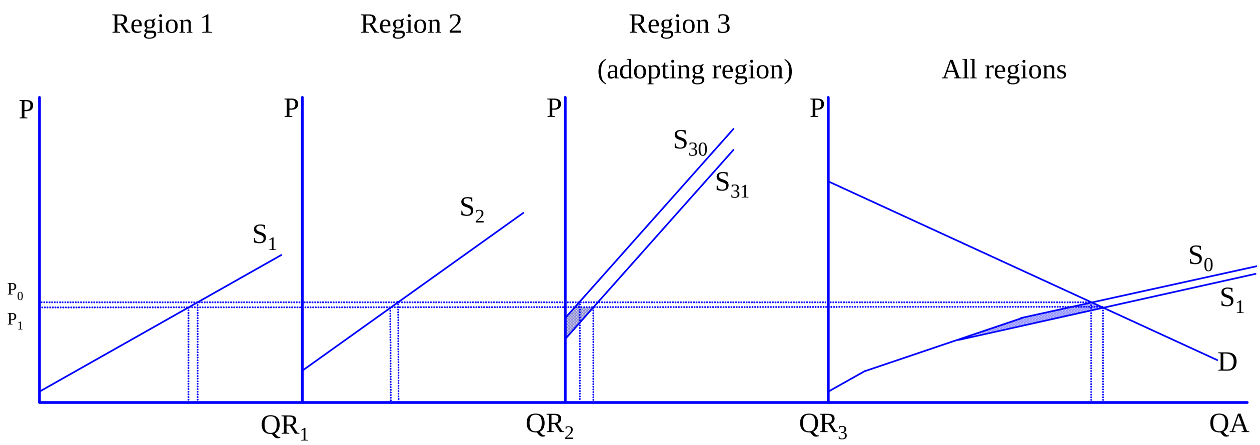

Figure 1: Regionally disaggregated model for a evaluating a production-increasing technology (after Davis 1994)