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An Economic Evaluation of Two Beef Cattle Breeding Projects

R.J. Farquharson*

NSW Agriculture
Agricultural Research and Advisory Station
Private Mail Bag
Grafton NSW 2460

In this paper two broad objectives were addressed. The first was to review the processes of economic appraisal and evaluation in planning, conducting and monitoring public sector research and development projects. This objective has been achieved by canvassing a number of methodological issues and discussing aspects of the major techniques used in conducting economic assessments of projects.

The second objective was to document cost benefit analyses of the NSW Agriculture beef cattle projects on crossbreeding (at Grafton) and selection for growth rate (at Trangie). These are the major beef breeding projects that NSW Agriculture has conducted on research stations in the last two decades. The evaluations included research, advisory and administrative inputs, and encompassed the period from the beginning of each project to the year 2020 to account for future project impacts. The methods of measuring benefits and costs from the projects have been fully explained and documented, as have the underlying assumptions and information sources. A survey was conducted to gauge the impact of the projects on the uptake of the crossbreeding and genetic selection technologies. Financial performance measures were calculated for the projects.

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1. Introduction

The primary aim of this paper is to document a cost-benefit analysis (CBA) of two research projects undertaken by NSW Agriculture. The projects involved developing beef cattle crossbreeding systems better suited to the beef production environments in NSW and investigating the impact of within-breed selection for growth rate in beef cattle. In order to achieve this aim a review was first undertaken of the processes of economic appraisal and evaluation in planning, conducting and monitoring public sector research and development projects.

Some preliminary CBA results for the Grafton crossbreeding project were included in a paper by Barlow, Farquharson and Gaudron (1991). However, NSW Agriculture recently undertook a review of its beef cattle breeding research program and this assessment of its two main breeding research projects on research stations provided an input to the review team. Hence this paper more fully describes and extends the analysis of Barlow *et al.* (1991) and also includes an analysis of the Trangie selection project.

NSW Treasury (1990) emphasised the importance of improving public sector resource allocation through the use of economic appraisal and evaluation techniques. Because the NSW public sector is a major component of the state economy, the "efficiency with which it uses resources can have a significant impact on the overall performance of the state economy and the welfare of its residents" (NSW Treasury, 1990, p.i). Governments are increasingly emphasising the need for programs to be efficiently managed and accountable in the face of limited public sector resources (Department of Finance 1989). The CBA detailed in this paper is aimed at reviewing particular research projects as a guide to their potential public value and as an input to the Beef Cattle Breeding Research Review conducted by NSW Agriculture.

In the terminology of NSW Treasury (1990), economic <u>appraisals</u> are applied to all proposals for new capital works, asset management, program evaluation and regulation review. Such appraisals provide important information to decision makers on the various ways of meeting an objective. They are *ex ante* assessments undertaken during project planning.

In contrast, *ex post* <u>evaluations</u> are undertaken once the project is fully complete. Three important reasons for *ex post* evaluations are (NSW Treasury 1990):

(i) reassessment of the economic appraisal approach (providing feedback to fine tune future *ex ante* appraisal procedures);
(ii) control on *ex ante* appraisal thoroughness (to provide an extra discipline on the economic appraisal process); and
(iii) ongoing asset management (to review the utilisation of assets and of alternatives to ensure that resources are allocated in the most effective manner).

Carruthers and Clayton (1977) gave similar reasons for *ex post* evaluations of agricultural projects (i.e. to provide feedback on project performance and input to the planning process). They also identified the elements in the project cycle approach to planning and implementing agricultural projects. This sequential and irreversible process involves project identification, design and appraisal, construction, operation and maintenance, monitoring and evaluation. It is increasingly being used to plan and implement agricultural research and development (R&D) projects in Australia (e.g. Australian Meat and Livestock Research and Development Corporation 1989).

In the next section some issues in undertaking CBAs of publicly-funded projects are discussed. Following that, the crossbreeding and selection projects are described and in Section 4 the measurements of project benefits and costs are detailed. The final section includes discussion and implications for the research review.

2. Issues in cost-benefit analysis of public projects

2.1 Practical issues in evaluation

Carruthers and Clayton (1977) discussed a number of issues in conducting *ex post* evaluations. One reason for the lack of such evaluations is that agencies often may not want to reveal the truth about past project investments, "evaluation can be a real finger-pointing exercise" (p.311). They further pointed to the need for sufficient manpower and financial resources to be provided for the purpose. They suggested a figure of around one per cent of capital cost for a comprehensive review. For *ex ante* appraisals, the Australian Tax Office suggested that 30% of the time available should be used in planning projects (Department of Finance 1989).

Carruthers and Clayton (1977) also discussed the advantages and problems associated with in-house and independent evaluations. They considered that independent agencies should be used for critical evaluations or spot checks. In the Departmental Review Team for Beef Cattle Breeding Research all team members were Departmental officers. However, this author has not been involved in the conduct of any beef breeding projects although he has undertaken budgeting analysis for the advisory stages of the crossbreeding program (Barlow, Farquharson and Hearnshaw 1989).

The last point made by Carruthers and Clayton (1977) was of the dangers of "casual empiricism" in *ex post* evaluation studies. This paper is aimed at clearly stating the basis for measuring project benefits and costs and the methodology used in the present study.

2.2 Economic and financial analysis

The main strength of economic appraisal is that it allows ".. a systematic examination of all the advantages and disadvantages of each practicable alternative way of achieving an objective .." (NSW Treasury, 1990, p.3). CBA allows the quantification in money terms of all the major costs and benefits of a proposed project.

Economic and financial analysis have much in common but there are some differences. Economic analysis is a framework within which all benefits and costs of a project proposal, whether monetary or non-monetary and whether they accrue to the project sponsor or to some other individual or group, are considered. However, a financial analysis takes the more narrow perspective of the project sponsoring entity - it does not account for impacts on other individuals or groups. Also a financial analysis uses actual costs rather than opportunity costs, even if the former are not a good measure of value in alternative uses. Financial analysis implies the maximising of a financial service over time, whereas an economic analysis involves maximising the economic "surplus" generated for the whole community (consumer surplus measures the extra amount consumers are willing to pay over and above the market price).

An economic evaluation does not include the payment of interest, but does include real resource flows which are discounted according to the time preference of the investor or sponsor. Also, capital expenditures are shown as resource costs in the particular period for economic evaluations, rather than being amortised over the project life for financial analysis. Economic evaluations are the main requirement in the public sector, but financial analyses are also necessary for determining cash flows (NSW Treasury (1990)).

2.3 Major appraisal techniques

CBA, the most comprehensive economic appraisal technique, quantifies in money terms all the significant project costs and benefits. For public projects it is best applied to projects or programs that either generate revenue or where the major benefits can be easily quantified (by actual or proxy values).

If a project output is not easily measurable in monetary terms, then an alternative approach, cost effectiveness analysis (CEA), is available. This approach compares the costs of different initial project options with the same output (NSW Treasury 1990, p.4). CEA cannot be used to directly compare projects with different objectives. This method still requires quantification of as many of the project benefits and costs as is possible.

The choice between these techniques depends on two criteria - the ease with which the benefits can be valued and the relative importance of the project. CBA will be used if the project is reasonably large and the benefits are easily quantifiable. CEA ought to be used where the benefits cannot be easily quantified and/or the project is not large.

Other appraisal techniques mentioned by NSW Treasury (1990) include incidence analysis (where the overall impact is disaggregated according to impact on individual community groups), regional impact analysis and multiple objective programming (where mathematical programming models are used to select projects based on a number of explicit objectives).

2.4 Steps in a full economic appraisal

The steps in preparing a full economic appraisal include:

(i) defining objectives - an investment proposal can only be evaluated in terms of its objective(s), which must be related to the performance of a particular function and which must be clear and unambiguous;

(ii) identifying options - the widest possible range of realistic options for achieving the objective must be canvassed;

(iii) identifying benefits - which may be avoided costs, savings in existing expenditure, incremental revenues, benefits to consumers not reflected in revenue flows, and benefits to the broader community (which may be valued by alternative means);

(iv) identifying costs - including all relevant incremental costs due to the project;

(v) identifying qualitative factors - which may need to be subjectively weighted;

(vi) assessing net benefits - all costs and benefits over the life of the program need to be expressed in present value terms for CBA (only costs need to be so expressed in CEA) and investment criteria calculated;

(vii) undertaking sensitivity testing - looking at projected outcomes under alternative scenarios; and

(viii) undertaking a post implementation review - to assist in the development and evaluation of future projects.

2.5 Identifying and valuing costs and benefits

For an economic analysis the analyst will sometimes have to estimate values where no direct price is charged and will have to consider a wider range of costs and benefits than occurs in a financial appraisal.

In project appraisal the costs and benefits are measured for the "state of the world" with and without the project in place. The differences between these scenarios can only be attributed to the project. The influences of the project included in the appraisal should be both the positive and negative impacts. These should include indirect effects of the project.

In valuing benefits and costs in economic appraisals two principles are important. In valuing inputs the opportunity cost of the resource in its most rewarding alternative use should be used. Often this value will be the market value or price of the input but if an input can be purchased for less, the opportunity cost (market price) should still be used. This is because in a social CBA the input resource should not be undervalued for the purposes of the particular project. The other principle relating to valuing benefits is that where the service provided by the project is not freely traded, more indirect methods of willingness-to-pay for the benefits need to be used. A variety of techniques are available to measure these values.

2.6 Time preference rate

In evaluating projects where cash inflows and outflows are generated over a number of years, there is a need to measure benefits and costs in common units. The common unit is generally a monetary value in a particular year. In bringing a cash flow over time to such a common unit there are two aspects that need to be considered. These are the effects of inflation and the characteristic of time preference.

Because of inflation a 1970 dollar is different from a 1990 dollar in terms of purchasing power. To make these amounts directly comparable they must be adjusted by a factor that accounts for the change in value of money over time. Usually the factor used is the Consumer Price Index (CPI) expressed as a ratio of the CPI in the relevant year (eg 1970) to the CPI in the base year (eg 1990). In this way the cash flows can all be expressed in common dollar values.

There remains the question of whether a 1990 dollar in 1970 is worth more or less than a 1990 dollar in 1990 or in 2010. Because the dollar in 1970 can be invested to accumulate interest, it will be worth more in 1990. Similarly a dollar in 1990 would be preferred to the same dollar in 2010 because it could be invested.

If project cash flows are expressed in actual (or nominal or current) dollar values they need to be adjusted by a factor that includes the effects of both inflation and time preference. If the cash flows are expressed in constant (or real or inflation-adjusted) terms they need to be adjusted only by a time preference factor. If the evaluation is of a cash flow that extends both before and after the base year, then the earlier values need to be compounded forward and the later values discounted back to determine the base year values.

Therefore an important issue in undertaking CBAs of publicly-funded projects is choosing the appropriate discount rate to use (Dasgupta and Pearce 1978, Pearce and Nash 1981). The conduct of publicly-funded projects is aimed at generating benefits for the general public or groups in society using public funds. Thus the project results are characterised as social benefits and the project evaluation is a social CBA. This is in contrast with a private (individual or company) project in which private investment funds are used and the results are appropriated by the investors to the exclusion of others. Because of these characteristics of public projects there are important questions about what discount rates to use in evaluating private versus public projects.

Two approaches to the choice of discount rate in CBAs have been distinguished. The first is the social time preference (STP) approach which allows the comparison of different (real) cash flows at different points in time. This approach is based on the premise that individuals prefer consumption now rather than in the future. The second approach is to use the social opportunity cost (SOC) which is a method of achieving a proper balance between investment in the private and public sectors. If total investment funds are limited, investment in the public sector competes with investment in the private sector. For the economy to gain the highest potential return, the same discount rate should be used in the private and public sector. Therefore public sector investments are valued at the opportunity cost of those funds.

The question of what actual rates to use for each approach is more difficult. In a perfect world the STP rate equals the market rate of interest on risk-free long term bonds. Bird and Mitchell (1980) in discussing appraisal of animal breeding projects set the STP rate at about 3 per cent a year. The SOC rate in theory should be the rate used in practice to appraise risk-free private sector investment. Bird and Mitchell (1980) indicated that a proxy for this rate is the average rate of return achieved *ex post* in the private sector (measured at 5% in the UK in 1978). This suggests that the SOC rate is higher than that usually taken to reflect STP.

Three questions can be asked in appraising animal breeding projects (Bird and Mitchell 1980):

1. How much do these projects divert funds from private sector investment projects;

2. What values should be assumed for the STP rate and for the rate of return required in the private sector; and

3. On who do the costs and benefits of animal breeding projects fall and how does this affect the determination of risk?

Bird and Mitchell (1980) discussed the effect of uncertainty or risk on the discount rate. They indicated that uncertainty can be allowed for by increasing the discount rate for risky projects. They argued that for animal breeding projects costs are depletable (ie one extra person's participation in the financing of a project reduces the share held by others) while benefits are not and so a risk premium should be included when valuing benefits.

However, Anderson (1983) affirmed Arrow and Lind's (1970) argument that explicitly accounting for risk in pure public projects was generally unnecessary. The only exceptions to this were the 'large project' case and the 'correlated project' case. Neither of these special cases applies to these beef breeding projects, hence a common discount rate is used for both project benefits and costs in this analysis.

NSW Treasury (1990) estimated that STP rates are around 2-4 per cent, while SOC rates are 7-10 per cent. They recommended that a standard set of discount rates be used in public project appraisal - 7 per cent being the central rate with sensitivity tests on 4 and 10 per cent. Proposed public sector projects should be considered if they generate returns greater than these test discount rates. The Victorian Government has directed that a 4 per cent (real) rate of return be used for all its projects (Department of Conservation, Forests and Lands 1989). In this evaluation cash flows will be discounted at 4, 7 and 10 per cent.

2.7 Decision criteria

NSW Treasury (1990) set out the alternative decision rules used in investment decision-making. These are the Net Present Value (NPV), Benefit-Cost Ratio (BCR) and Internal Rate of Return (IRR). The net present value per dollar of capital required (NPVI) is also used. The preferred measures are NPV and NPVI, with BCR and IRR also being useful.

2.8 Methods of assessing risk

Anderson, Dillon and Hardaker (1977, p. 3) stated that '.. when a person is uncertain about the consequences of his decision, we can say he faces a risky choice'. Decision analysis involves making risky choices. Anderson (1988) discussed risk in livestock improvement programs and argued that risk was close to being synonymous with uncertainty.

Anderson, Dillon and Hardaker (1977) included the elicitation of prior beliefs and probabilities in the process of decision analysis. They argued that subjective probability was the only operational concept of probability in making real-world decisions (provided that these subjective probabilities were consistent with the axioms, rules and calculus of probabilities, and that they were consistent with the degree of belief really held) (Anderson, Dillon and Hardaker 1977, p. 18). If subjective probabilities can always be estimated then there is no difference between risk and uncertainty - risk (ie outcome effects) are the result of uncertainty.

Traditionally in the public sector risk in projects has been ignored on the basis that there are many public projects and the risks are pooled (NSW Treasury 1990). Investment proposals in this case are judged on the basis of their expected values with no account of the likely dispersion of outcomes around these levels. If the probabilities of different outcomes are unknown then sensitivity analysis (which shows how changes in certain key variables affect the outcome) and scenario planning (looking at the results for various possible future outcomes), can be used to assess the impact of uncertainty.

NSW Treasury (1990) discussed two decision criteria for the situation where probabilities cannot be attached to different outcomes and where the expected net present value is not feasible. The Maximin Pay-Off Criterion maximises the return when the most adverse conditions are encountered. The strategy with the highest minimum NPV is chosen. The Minimax Regret Criterion minimises the maximum loss which could result from selecting a particular option. However, these measures are irrelevant if subjective probabilities are always estimable (Anderson, Dillon and Hardaker 1977, p. 204).

Where risk can be quantified the expected NPV can be augmented by a probability density function (PDF) of NPV and by measures of range (difference between the biggest and smallest outcomes), variance (or standard deviation (SD)) and the coefficient of variation (the standard deviation divided by the expected value) (NSW Treasury 1990). In Figure 1 a PDF is shown as a distribution of a random variable. This PDF can also be expressed as a (less than) cumulative distribution function (CDF). The vertical axis measures the probability that the random variable will turn out to be less than any given value. For instance in Figure 1, there is a 20% probability that the random variable will be less than 96 (point A) and an 80% probability that it will be less than 104.

2.9 *Ex post* evaluations

NSW Treasury (1990) indicated that about 1 in 10 major projects need to be the subject of a full *ex post* evaluation, however projects of size greater than $10 million should be evaluated. These evaluations should be undertaken about 2 years after the project has started operating. The *ex post* evaluation should not be undertaken by the same personnel responsible for the initial economic appraisal.

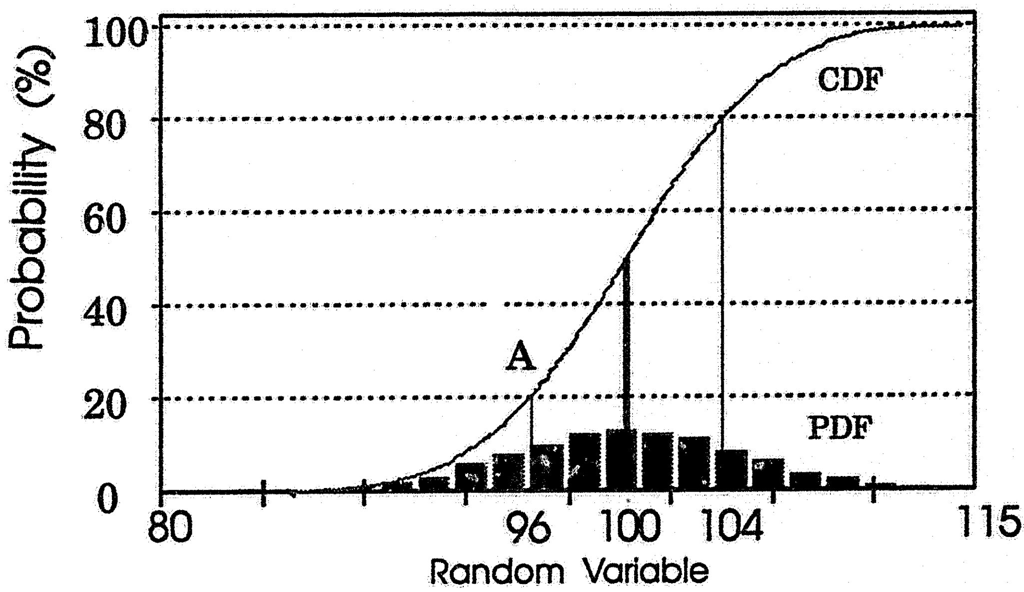
100
80
60
40
20
0
Probability (%)
CDF
A
PDF
80
96
100
104
115
Random Variable

Figure 1.

3. Research projects evaluated

3.1 The Grafton crossbreeding project

The NSW Agriculture beef crossbreeding project centred at Grafton was conducted from 1972 to 1990. At the outset the research objectives were more explicit than the development objectives. The former were to identify the most suitable beef genotypes and quantify the benefits of crossbreeding with Hereford females over the range of pasture/nutrition levels likely to be confronted in NSW. While the brief was wider than solving North Coast region problems, it was anticipated that the scope for improvement would be largest in that region. Implicitly the development objective was to use the research results to improve the profitability of NSW beef producers by encouraging them to adopt appropriate crossbreeding programs where applicable.

Development activities included assisting the development of promotional groups, study tours, use of early adopters as demonstration herds, carcass competitions, research station field days, growing research steers to slaughter on private cooperators' properties throughout NSW and inviting agents and buyers to evaluate research station cattle each year.

In the latter stages of the project increasing emphasis was placed on the relative profitability of crossbreeding and straightbreeding systems. At the final field day the presentation of Barlow *et al.* (1989) was based on estimated profitabilities of alternative breeding systems with the biological results being used to back up the main financial comparisons.

3.2 The Trangie selection project

The Trangie project involved selecting Angus breeding stock for high and low levels of progeny growth to yearling (400 days). These two divergent lines (being continually selected for high and low growth) were compared to a control line (no selection) and measures of productive performance and efficiency within each group were made. The project commenced in 1963 and its research component terminated in 1991. A field day was held in September 1990 at which results of the project were presented (Parnell, Herd, Perry and Bootle 1990).

4. Measuring project benefits and costs

4.1 The Grafton crossbreeding project

In assessing the Grafton crossbreeding project it is difficult to separate the effects of research and advisory activities in getting the message to beef producers. The project, for this review, is therefore treated as an R&D project rather than just a research project which was the way that the project was conducted.

This evaluation of project benefits and costs is for the period 1972 to 1990 and for a further 30 years to 2020. The measured impact was within NSW only. Thus, while total project costs for the period are included, the benefits don't include project impacts either beyond 2020 or in other Australian states. Project benefits are only estimated for calves up to weaning (ie post-weaning gains are excluded) and for potential impacts on medium quality pastures (see section 4.1.3 below). Therefore the evaluation of this project is conservative in estimating benefits

4.1.1 Uptake of crossbreeding

One of the major problems in evaluating R&D projects is assessing project impact. In determining the impact of new technology an objective measure of uptake is needed. In the case of beef cattle crossbreeding the Australian Bureau of Statistics (ABS) has collected information on the number of beef cattle by breed type in 1982 and 1987 (see ABS (1987)). Over that period the total percentage of crossbred cattle in NSW increased from 18 to 33 per cent. In the NSW North Coast region the increase was from 31 to 47 per cent. More recent estimates of the proportions of crossbred calves and cows have been produced by Wilson Rural Marketing (unpublished) in Victoria and NSW, indicating that the percentage of crossbred calves and cows has increased substantially since 1987 in both states.

Estimates were also required of the percentage of crossbred cattle at the start of the project period. Barlow *et al.* (1991) estimated that the level of crossbreeding in 1972 was 10 per cent in NSW and 16 per cent in the North Coast region. Table 1 contains estimates of the proportions of crossbred cattle in NSW over the period 1972 to 1990. The figures for 1982 and 1987 are from ABS. The figures for 1972 are estimates from research and advisory personnel in NSW Agriculture and the figures for 1990 have been derived from Wilson Rural Marketing survey results (unpublished). The interpolated figures have been derived as gradual increases from 1978 to 1982 and equal annual percentage point increases since 1982. Table 1 also contains estimates of meat cow numbers over this period.

The important focus for this analysis is on the increased proportion of crossbred cows since the mid 1970s. How much of that increase has been due to the research and advisory activities of NSW Agriculture? Barlow *et al.* (1991) only estimated benefits and costs of the Grafton project up to 1990. For this analysis the benefits and costs have been extended to account for future impacts. This approach is expected to provide a more realistic evaluation although further assumptions are necessary about future cash flows. It was assumed for this analysis that the NSW meat cow population is 2.5 million per year for the next 30 years and (conservatively) that the percentage of crossbred cows remains at the same level as in 1990.

From Table 1 there was a certain amount of crossbreeding being undertaken already in 1972. Whether this was a result of deliberately-planned programs or poor management is open to speculation. It is also likely that some increase in crossbreeding would have occurred regardless of the Grafton project. So the question from the figures in Table 1 is to what extent the increase in crossbred numbers was influenced by the Grafton project.

A survey of beef advisory officers and beef breed society technical officers was conducted to determine estimates of the minimum, most likely and maximum level of project influence on the uptake of the crossbreeding and selection technologies in the NSW beef cattle industry. Each response was weighted by the numbers of beef cattle in the advisory district. The range of estimates of project influence from this group was 30% for the minimum, 49% for the most likely and 68% for the maximum level for the crossbreeding project. The overall expected level of influence was 49% from this survey.

4.1.2 Measuring project costs

Annual project labour costs (including overhead costs and expressed in 1990 dollar terms) were estimated to be $100 000 for each research scientist, $100 000 for each advisory officer and $50 000 for each support staff member. The numbers of staff involved in the project are shown in Table 2, including estimates for future work by research and advisory staff.

The capital cost of a 40 megalitre dam and associated irrigation costs which was constructed for the project in 1978 (estimated as $[illegible] 000 in 1990 values) was included in the analysis. Cattle sales were assumed to cover all non-staff operating costs attached to running the Grafton

Table 1
Estimated time pattern of growth in crossbred cattle in NSW

Year	Estimated % of Crossbred Beef Cattle in NSW	NSW Meat Cows (a)
	%	'000
1972	10	422
1973	10	3666
1974	10	4042
1975	10	4439
1976	10	4455
1977	10	3985
1978	11	3477
1979	12	3111
1980	14	3023
1981	16	2741
1982	18	2729
1983	21	2447
1984	24	2547
1985	27	2610
1986	30	2322
1987	33	2324
1988	36	2362
1989	39	2524
1990	42	

(a) Cows and heifers (1 year and older) mainly used for meat
Source : ABS

Table 2
Benefits and Costs of Grafton Crossbreeding Project

Year	Costs: Staff resources: Research	Costs: Staff resources: Support	Costs: Staff resources: Advisory	Costs: Total Capital Costs (a)	Costs: Present Value of Costs (b)	Benefits: Annual Present Value of Benefits (c)	Benefits: Cumulative Present Value of Benefits (c)	Cumulative Present Value of Benefits less Costs
	No	No.	No.	1990 $	1990 $MILL	1990 $MILL	1990 $MILL	1990 $MILL
1972	1.0	2.0	0.5	0	0.845	0.0	0.0	-0.845
1973	1.0	2.0	0.5	0	0.790	0.0	0.0	-1.635
1974	1.0	2.0	0.5	0	0.738	0.0	0.0	-2.373
1975	1.0	2.0	1.0	0	0.828	0.0	0.0	-3.200
1976	2.0	5.0	1.0	0	1.418	0.0	0.0	-4.619
1977	2.0	6.0	1.5	0	1.566	0.0	0.0	-6.185
1978	2.0	6.0	1.5	95000	1.678	0.940	0.940	-6.923
1979	1.0	6.0	1.5	0	1.158	1.572	2.511	-6.509
1980	1.0	6.0	1.5	0	1.082	2.854	5.366	-4.737
1981	1.0	7.0	1.5	0	1.103	3.628	8.994	-2.212
1982	2.0	7.0	1.5	0	1.203	4.501	13.495	1.087
1983	2.5	7.0	1.5	0	1.204	5.187	18.682	5.069
1984	2.5	7.0	1.5	0	1.126	6.422	25.104	10.365
1985	2.5	7.0	1.5	0	1.052	7.468	32.571	16.781
1986	2.5	7.0	1.5	0	0.983	7.305	39.876	23.103
1987	2.5	7.0	1.5	0	0.919	7.858	47.734	30.042
1988	2.5	7.0	1.5	0	0.859	8.437	56.171	37.620
1989	2.5	7.0	1.5	0	0.803	9.398	65.570	46.216
1990	2.5	6.0	1.5	0	0.700	9.600	75.170	55.116
1991	1.5	3.5	1.5	0	0.444	8.972	84.141	63.644
1992	1.5	3.5	1.5	0	0.415	8.385	92.526	71.615
1993	1.5	3.5	1.5	0	0.388	7.836	100.363	79.063
1994	1.0	2.5	1.5	0	0.286	7.324	107.687	86.101
1995	0.5	0.5	1.5	0	0.160	6.845	114.531	92.785
1996	0.5	0.5	1.5	0	0.150	6.397	120.928	99.032
1997	0.5	0.5	1.5	0	0.140	5.978	126.907	104.870
1998	0.0	0.0	1.5	0	0.087	5.587	132.494	110.370
.	.	.	.	.	.	.	.	.
2020	0.0	0.0	1.5	0	0.020	1.261	194.3	171.2
Total Present Value					23.1	194.3		

Net Present Value $171.2 MILLION
Benefit Cost Ratio 8.4

(a) Irrigation dam and associated equipment.
(b) Using 1990 values of $100 000 per research and per advisory officer and $50 000 per support staff at a discount rate of 7% per annum.
(c) Using $12 per cow per year for the total annual crossbred meat cow numbers in excess of the 1972 percentage (ie assumes all extra crossbreeding since 1972 is due to the project) at a discount rate of 7% per annum.

program. Cattle progeny at weaning and cast-for-age cows were sold at commercial rates. The costs covered include the opportunity costs of land and buildings used for the project and the costs of special measurements and other studies (e.g. of efficiency, carcass measurements, etc.) undertaken in conjunction with the project.

Annual project costs were estimated as shown in Table 2. The Present Value (PV) of costs was $29 million, $23 million and $20 million at time preference rates of 10, 7 and 4 per cent respectively. The project cost for the period 1972 to 1990 was $20 million at 7% discount rate.

4.1.3 Measuring project benefits

Measuring the increased profitability at the farm level from use of crossbreeding programs is the second major unknown factor in this analysis. Estimates of the potential increased financial returns to beef producers from crossbreeding were budgeted by Barlow *et al.* (1989). Their figures were based on the biological research results from the Grafton project.

Barlow *et al.* (1989) estimated that the potential financial advantages of the best crossbreeding options (terminal sires mated to first-cross cows), compared to straight-bred British cattle, where $80, $36 and $55 per cow area up to weaning on pastures of high, medium and low quality respectively. This was based on the same price per kg at weaning for all breeds and crosses. With the same assumptions, first-cross calves reared on straight-bred cows yielded up to $20 per cow area more than straight-bred calves on pastures of medium quality. Barlow *et al.* (1991) used $24 per cow area as the maximum on-farm benefit for their analysis. This figure was a combination of $36 for crossbred cows and $20 for straightbred cows producing first-cross calves on medium pasture.

Davidson and Martin (1965) investigated the relationship between yields on farms and in experiments. For animal product relationships they estimated (linear) regression coefficients for the proportion of experimental yield increases that are likely to be gained on-farm. They estimated on-farm proportions of 48% for meat production per acre and 38% for lambing percentage.

The question is whether all of the potential increased profitability identified by Barlow *et al.* (1989) should be counted as a project benefit in the light of Davidson and Martin's (1965) results. The cattle involved in the crossbreeding project at the Agricultural Research Station were managed as a commercial herd except that extra weighings were undertaken. In the Grafton research project around 450 breeding cows were run over 18 years, so the results reflect the full range of seasonal conditions for a large group of animals. Because of this it is probably not necessary to discount the $24 per cow for experimental station bias. However, in this analysis the project was assessed using $24 per cow with a sensitivity test of $12 per cow. It can be noted that the $24 per cow on medium pastures was much less than the $80 and $55 per cow improvement on the high and low quality pastures respectively.

In Table 2 the potential annual benefits (column 7) are shown as total annual crossbred cow numbers in excess of the 1972 percentage multiplied by $12 per cow. That is, potentially all of the increase in crossbred cow numbers is due to the project. The next column shows the annual potential benefits accumulated in 1990 dollars. At the foot of that column the total Present Value of benefits is shown as $194 million in 1990 terms. The last column shows the benefits minus costs expressed in 1990 dollars. Also shown in Table 2 is the NPV and BCR. Under the assumptions of a $12 per cow benefit and a 100% project influence the NPV was $171 million and the BCR was 8.4.

Table 3 contains the full set of results estimated in the crossbreeding CBA. At $24 per cow benefit the results for 49% influence are NPVs of $143 million (10% time preference), $167

Table 3: Summary of Crossbreeding Cost-Benefit Analysis 1972 to 2020

Farm Level Benefit $ per cow per year	Project Influence (Percent)	Net Present Value 1990 $M	Benefit Cost Ratio	Internal Rate of Return (Percent)
NSW Beef Industry				
4% time preference				
24	49	209	11.8	-
7% time preference				
	30	35	2.5	-
12	49	72	4.1	-
	68	109	5.7	-
	30	93	5.0	-
24	49	167	8.2	-
	68	241	11.4	-
10% time preference				
24	49	143	6.0	-
	30	-	-	17
12	49	-	-	20
	68	-	-	28
	30	-	-	26
24	49	-	-	30
	68	-	-	39

million (7% time preference) and $209 million (4% time preference). The respective BCRs are 6.0, 8.2 and 11.8 and the IRR is 30%.

At $24 per cow for 7% time preference the NPVs (and BCRs) for influence levels of 30% and 68% are $93 million (5.0) and $241 million (11.4) respectively. If the benefit is only $12 per cow (Davidson and Martin (1965)), then at 7% the NPVs are $35 million, $72 million and $109 million and the BCRs are 2.5, 4.1 and 5.7 for influence levels of 30%, 49% and 68% respectively. The relevant IRRs are 17%, 20% and 28% respectively.

All these results indicate that the crossbreeding project has been successful in providing value to the NSW beef industry. Even the pessimistic scenario of $12 per cow benefit and 30% influence provides a NPV of $35 million, a BCR of 2.5 and an IRR of 17%.

There are also likely to be other intangible benefits from this project. These would include benefits from the database set up to look at research and on-farm management questions. Issues that can be addressed from the database include estimating lean meat yield and deriving equations for industry prediction, the value of skins and hides, the impact of bruising and the question of longevity in beef cows.

In measuring project benefits it was assumed that there were no price reduction effects (supply response) resulting from any increase in beef production due to crossbreeding.

4.2 The Trangie selection project

A number of issues need to be borne in mind when considering the Trangie selection project. First the project was physically located in an area of low beef cattle population. While this did not affect the efficiency of conducting the research project, it did mean that there was not a large group of beef producers nearby who could identify with the research. The second point is that the Trangie results have been used in support of BREEDPLAN, as a basis for measuring genetic gain from selection. Hence the uptake of BREEDPLAN can perhaps be in part attributed to the Trangie work. Finally, in contrast to the crossbreeding technology, where improvements can be observed very quickly, the process of selection for genetic gain involves smaller but cumulative increments over longer periods of time. These factors have been incorporated into the evaluation of the Trangie project.

The assessment of benefits and costs for this project commenced in 1963 and is extended to 2020 to account for future impacts. Costs associated with the Glen Innes component of the project have been included. The same concepts of compounding and discounting have been used, but in this case capital expenditures in some early years were measured in nominal values so they have been adjusted for inflation. Because this project was funded by industry, AMRC and AMLRDC contributions have been debited in measuring project costs. Cash flows have again been expressed in 1990 dollars.

4.2.1 Uptake of Trangie results

The impact of the Trangie project is being felt in the level of genetic improvement in growth rates within the NSW beef industry. Technically, selection for growth rate can be measured using an estimated breeding value (EBV) for the yearling weight trait. A bull selected for this trait might have an EBV of +10 kg, which means that his progeny will on average weigh 10 kg more at yearling than the progeny of bulls not selected for this trait. The net value of each 1 kg increase in yearling weight EL, has been estimated as $1.38 (Parnell *et al.* 1990).

The uptake of the Trangie research results by commercial beef producers is via stud herds selecting for increased growth rate. There will be a lag between the improvement in seedstock herds and the improvement in commercial herds. All of these factors are accounted for in developing the cash flows for the project evaluation. The level of influence of this project on industry practice was estimated by beef advisory officers and Breed Society technical officers to be 17% (minimum), 26% (most likely) and 39% (maximum). The expected level of influence from this triangular distribution is 27%.

4.2.2 Measuring project costs

Annual numbers of research, support and advisory staff over the period of the project were valued at the same dollar values as in Section 4.1.2. Additional capital costs of $100 000 in 1983 and in 1984 were included and expressed in 1990 dollar values. The costs of 0.5 advisory officers per year from 1992 to 2020 were also included. The total project costs were estimated at $21 million at 7% discount rate ($15 million and $31 million at 4% and 10% respectively).

4.2.3 Measuring project benefits

From beef sire summaries the levels of genetic trends over time can be observed. On average the annual genetic improvement in stud herds selecting for growth rate (or EBV) was 0.3 kg on yearling liveweight per bull from 1970 to 1979. From 1980 to 1985 the estimated improvement was 0.5 kg. In 1985 BREEDPLAN commenced and the yearling weight EBV increased from 0.5 to 1.0 kg from 1985 to 1990. For this evaluation the EBV was assumed to remain at 1 kg from 1990 to 2020, but this is also a very conservative assumption.

The proportion of commercial bulls obtained from stud herds also needs to be determined. This proportion was estimated to rise from 5% in 1970 to 28% in 1989 (Dr P. Parnell, NSW Agriculture, personal communication). The unpublished survey of Wilson Rural Marketing in 1990 estimated that 30% of bulls used in NSW commercial beef herds came from BREEDPLAN herds. While some of those stud herds might not be using BREEDPLAN for selection purposes, there are likely to be some stud herds not in BREEDPLAN that are selecting for growth and size, implicitly using the Trangie results.

In 1990 it is assumed that 30% of stud herds were achieving increases in yearling weight EBV of 1 kg. However, a lag period of one generation probably exists between availability in seedstock herds and commercial uptake. This period for the improved genes to disseminate was assumed to be 5 years. Therefore by 1990, although the annual genetic improvement in studs was 1 kg EBV, the genetic improvement in commercial herds was 0.5 kg (stud levels of improvement in 1985) multiplied by 30% of commercial bulls from stud herds, or 0.15 kg.

The PV of benefits from selection for growth rate was therefore estimated as the value of 1 kg EBV ($1.38) multiplied by the genetic gain factor, multiplied by the NSW population of beef cows and multiplied by the influence levels mentioned above. If it is assumed that 27% of the stud herds selecting for growth rate were doing so because of the Trangie results, then the total NPV of the Trangie project (ie benefits less costs) was estimated to be $55 million at 7% discount rate ($90 million and $30 million at 4% and 10% respectively). The BCRs in Table 4 are 7.0, 3.6 and 1.9 at 4%, 7% and 10% respectively.

If the farm level benefit is less than the experimental level (Davidson and Martin 1965) the results for $0.69 per kg EBV in Table 4 provide alternative estimates of project worth. For project influence ranging from 17% to 39% the NPV varies from $3 million (BCR of 1.1) to $34 million (BCR of 2.6).

Table 4: Summary of Selection Cost-Benefit Analysis 1963 to 2020

Farm Level Benefit $ per kg EBV		Project Influence (Percent)	Net Present Value 1990 $M	Benefit Cost Ratio	Internal Rate of Return (Percent)
	NSW Beef Industry				
	4% time preference				
1.38		27	90	7.0	-
	7% time preference				
		17	3	1.1	-
0.69		26	15	1.7	-
		27	17	1.8	-
		39	34	2.6	
					-
		17	26	2.2	-
1.38		26	52	3.4	-
		27	55	3.6	
		39	88	5.1	
	10% time preference				
1.38		27	30	1.9	-
		17	-	-	8
0.69		26	-	-	10
		27	-	-	10
		39	-	-	12
		17	-	-	11
1.38		26	-	-	13
		27	-	-	14
		39	-	-	16

In the lower part of Table 4 the levels of IRR for different levels of project influence and farm level benefit are shown. At $1.38 per kg EBV and 39% influence the IRR is 16% and at $0.69 per kg EBV and 17% influence it is 8%. Even the pessimistic scenario shows an IRR greater than the 7% time preference rate.

4.3 Accounting for uncertainty in project evaluation

Two particular parameters have been shown to be important and difficult to estimate in this analysis - project influence on technology uptake and dollar benefits at the farm or herd level. In this part of the analysis the effect on NPV of varying both these parameters will be assessed.

This analysis was undertaken with the @RISK program (Palisade Corporation 1988). That program allows spreadsheet locations (or input variables) to be specified as a distribution rather than a single value. It allows a number of different probability distributions to be used. The output variable is also specified in the program and a simulation conducted by sampling within the parameters of the input distribution(s). The distribution of the resulting output variable is then estimated and plotted.

In this analysis the input variables were project influence and farm-level benefit. The triangular distributions (minimum, most likely and maximum) from the survey were used for project influence and a uniform distribution (assumes the quantity varies uniformly between two values) was used for farm-level benefits. The distributions used were TRIANG(30%,49%,68%) and UNIFORM($12,$24) for the crossbreeding project and TRIANG(17%,26%,39%) and UNIFORM($0.69,$1.38)for the selection project respectively.

No correlation between the variables was included in the models. The CDFs for the distributions of NPV are shown in Figure 2. It can be seen that the NPV distribution for the crossbreeding project lies to the right of that for the selection project, implying that the former project was expected to show a higher rate of return. The expected values of these distributions were $119 million for crossbreeding and $36 million for selection.

5. Discussion and implications

The results presented in this paper allow some interesting observations of the value of these projects. The total staff and oncosts for each project totalled well in excess of the $10 million mentioned in Section 2.9, whatever the time preference rate used.

For the crossbreeding R&D project the main scenario assessed was for an average $24 benefit per cow on farm and a project influence on crossbreeding technology uptake by the NSW beef industry of 49%. Using a time preference rate of 7%, the NPV of this project was $167 million and the BCR was 8.2. The IRR of the project for this scenario was 30%. This figure is much greater than the discount rate (7%) and so the project has performed well. At a $12 per cow on farm benefit the NPV was $72 million, the BCR was 4.1 and IRR was 20%.

The growth rate selection project was assessed in the same fashion. At $1.38 per kg EBV and using a 7% time preference rate and 27% influence factor the NPV was estimated at $55 million, the BCR was 3.6 and the IRR was 14%. Again this is above the discount rate. At $0.69 per kg EBV the relevant figures were $17 million, 1.8 and 10%.

This economic evaluation has been undertaken conservatively in estimating benefits. The assumptions underlying the analysis have been spelt out in this paper and it is for the reader to make judgements about how reasonable they are. However, given these conservative assumptions, it still appears that the financial return measures calculated using figures on benefit per cow and influence on uptake have been reasonable. Overall, the positive net benefits from these projects appear to be substantial in terms of impact on the target industry.

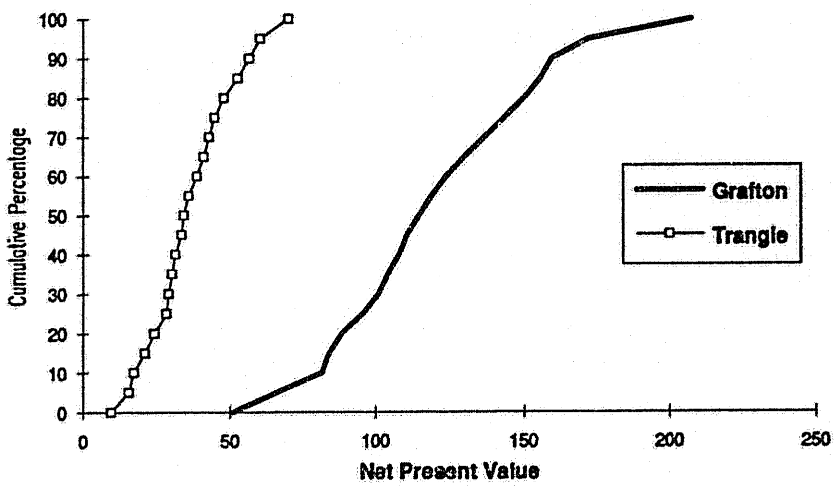

Figure 2

Cumulative Distribution Functions of Project NPVs

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