On farm

Evaluating the returns from beef cattle genetics R&D in Australia

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Final Report prepared for MLA by:

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GLOSSARY OF TERMS

ABARE	Australian Bureau of Agricultural and Resource Economics
ABRI	Agricultural Business Research Institute
ABS	Australian Bureau of Statistics
AGBU	Animal Genetics and Breeding Unit
ARCBA	Australian Registered Cattle Breeds Association
BCA	Benefit Cost Analysis. An economic approach to assessing the expected returns from an R&D investment where discounted benefits are compared with discounted costs. This can be either ex ante (looking forward at proposed investments) or ex post (looking backward at past investments).
BCR	Benefit Cost Ratio. The sum of discounted benefits divided by the sum of discounted costs. A value greater than 1.0 suggests a profitable investment.
Beef-N-omics	A decision support system developed by NSW Agriculture for southern beef production systems which combines herd dynamics, pasture availability and gross margin budgets.
CRC	Cooperative Research Centre for the Cattle and Beef Industry
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Demand elasticity	The proportional change in the quantity demanded for a given change in the relevant price. Usually negative. Eg, "an own-price beef demand elasticity" of -1.0 means that a 1% increase in the price of beef induces a 1% decrease in the demand for beef over the relevant period of adjustment. Values greater than –1 in absolute value are called “elastic” and imply high responsiveness to price; values less than –1 in absolute value are called “inelastic” and imply low responsiveness to price.
Discounting	The process of adjusting expected *future* costs and benefits to values at a common point in time (typically the present). The opposite is compounding, which is the process of adjusting *past* costs and benefits to values at a common point in time. These processes recognise that dollars at different points in time are not of the same value.
DM	Dry matter
DSE	Dry Sheep Equivalent
EBV	Estimated Breeding Value
EDM	Equilibrium Displacement Model. A synthetic approach to modelling changes in prices and quantities of beef, say from an R&D investment, where the model parameters are chosen from published results and theoretical considerations rather than being directly estimated from actual data.
FCE	Food conversion efficiency
FTE	Full-time equivalent
Gross margin budget	A gross margin is the gross income from an enterprise less the variable costs incurred in achieving it. It excludes fixed or overhead costs. A gross margin budget is the process followed in calculating a gross margin.
IRR	Internal Rate of Return. The interest rate where the sum of discounted benefits equals the sum of discounted costs. A value greater than the nominated discount rate suggests a profitable investment.
LSM	Livestock months
NPV	Net Present Value. The sum of discounted benefits minus the sum of discounted costs. A positive value suggests a profitable investment.
MLA	Meat and Livestock Australia
MSA	Meat Standards Australia
R&D	Research and Development (including advisory/extension)
Supply elasticity	The proportional change in the quantity supplied for a given change in the relevant price. Usually positive. Eg, an “own-price cattle supply elasticity” of +1.0 means that a 1% increase in the price of beef induces a 1% increase in the supply of cattle over the relevant period of adjustment. Values greater than +1 are called “elastic” and imply high responsiveness to price, or a flexible production system; values less than +1 are called “inelastic” and imply low

	responsiveness to price, or an inflexible production system.
UNE	University of New England
Whole farm budget	Accounts for the gross margins of each of the enterprises considered as well as the fixed or overhead costs of the farm (also called a profit and loss statement). Usually includes a statement of farm assets and liabilities (or a balance sheet).

1. EXECUTIVE SUMMARY

Meat and Livestock Australia (MLA) commissioned an economic evaluation of the returns from beef cattle genetics research and development (R&D) in Australia. For the purposes of this analysis, genetics R&D was defined to include all breed manipulation, including selection, crossbreeding and grading up or breed substitution. R&D within Australia was also defined to include the effects of imported genetics.

Evaluations of returns from three different types of gains have been included in this report. The first result is that investment in genetics and southern crossbreeding has shown healthy returns. These particular investments have realised a net present value (NPV) of $861 million, a benefit cost ratio (BCR) of 3.6 and an internal rate of return (IRR) of 19%. These are net social benefits expressed in 2001 dollars, and they apply to producers and others in the beef industry as well as to consumers of beef products. Second, an evaluation of the benefits from infusing Bos Indicus cattle into the northern Australian herd resulted in net benefits of $10.2 billion, and finally an evaluation of the changing herd breed composition in southern Australia (in terms of Angus cattle) showed a net benefit of $88 million. These last two figures are in addition to the first results. A 7% discount rate was used in this analysis.

1.1 Summary of total investment into beef cattle genetics R&D up to the present

1. The total cumulative present value (PV) of investments to 2001 by industry, government and other agencies into selection, crossbreeding and grading up since 1963 was estimated to be $310 million. The split between research and extension was not provided by a number of agencies, so that it was not possible to calculate separate returns to these activities. The cumulative PV of imported semen was estimated to be $27 million.

2. These investments were made by state government agencies (Departments of Agriculture) (46%), by MLA and its predecessors (23%), by beef breeders (13%),by CSIRO (6%), by Breed Societies and ABRI (2%,) and by UNE and the Beef Cooperative Research Centre (CRC) (2%). Beef semen imports contributed 8% of the total.

1.1.1 Cattle evaluations, indexes and genetic trends

3. Information on numbers of cattle evaluated within the BREEDPLAN program was difficult to document. Information on registrations was derived from the Australian Registered Cattle Breeders Association (ARCBA), but this is not the same as evaluations, and is likely to overestimate evaluations. Information on evaluations by sire and breed is presented for certain breeds based on the BREEDPLAN database.

4. Genetic trends were derived from BREEDPLAN Estimated Breeding Values (EBV) information for seedstock animals within breeds. The BreedObject software was used to translate these numbers into seedstock EBVs for commercial herd traits. Averages of these by year of birth of seedstock bull were used to measure genetic change (or trends). Genetic change was assumed to occur in the commercial sector at the same rate as in the seedstock sector, but lagged by 5 years for herds using BREEDPLAN bulls, and lagged by 10 years for those using non-BREEDPLAN bulls.

5. Genetic trends in index traits were calculated for sale liveweight (kg), dressing percentage (%), carcase meat percentage (%), fat depth (mm), cow weaning rate (%), marbling score, cow survival rate (%), cow liveweight (kg) and calving ease (%). The predicted trait trends at 5-year intervals from 1985 to 2005 for the main breed x market combinations were assessed. Significant genetic trends were only observed for progeny liveweight and cow weight. Other trait trends were either not statistically different from zero or not significant enough to include in farm-level budgets. No evidence of feed conversion efficiency was provided, and no improvements in feed conversion ratio to offset larger cattle sizes were included in the analysis.

1.1.2 Aggregation

6. Estimates were made of the proportions of the beef cattle population according to bull breed, cow type, market orientation (domestic or export) and market type (eg supermarket). Aggregate benefits were derived using these proportions to weight the benefits estimated from trait trends.

7. This detailed breed x market classification was represented by different cases, termed domestic high recording, domestic moderate recording, export high recording, export moderate recording, European and northern.

8. The genetic trends and herd x market case proportions were used to assess potential gains from selection and crossbreeding, however actual market capture may be less than predicted. Environmental and market factors are very important in determining technology capture or uptake by commercial industry.

9. Non-adopters also benefit from general breed improvement (through the general availability of better bulls), but later. This was included in the analysis.

1.1.3 Estimating economic returns

10. An Equilibrium Displacement Model (EDM) of the Australian beef industry was used for the evaluations. This has been developed to evaluate relative returns to beef producers, processors and consumers from on-farm versus off-farm R&D. The general approach is widely used by agricultural economists in evaluating economic returns from different types of investments (including promotion). The model has a horizontal and vertical representation of the industry sectors and markets. It incorporates prices and quantities, and supply and demand elasticities, so that any interactions within and between market sectors are represented. The model is based on actual data for the Australian beef industry.

11. This framework represents technological change as a percentage change in variable costs per unit of output, which is interpreted within the model as influencing the supply of beef product. The genetic trend impacts were incorporated into Gross Margin budgets for market x production system cases to calculate the relevant changes in variable costs. Extra feed costs associated with the larger animals were calculated using the BEEF-N-OMICS program together with estimates of improved pasture costs and stocking rates. Because no feed conversion efficiency gains were observed, the larger animals required more feed and the extra costs that accompanied it were included.

1.1.4 Results

12. If all of the R&D investments were applied only to selection and cross-breeding, the estimated returns to these investments were $1199 million. So these R&D activities show a healthy return to investment - an NPV of $861 million, a BCR of 3.6 and an IRR of 19%.

13. Previous results from this economic model showed that a 1% reduction in variable costs (shift in supply) at the farm level results in a $30 million change in economic surplus (to both consumers and producers), expressed in 2001-dollar terms. These analyses have also shown that about 33% of gains from on-farm technologies accrue to farmers (weaner producers, grass finishers and backgrounders), and domestic consumers receive 50% or more of the gains.

14. Applying these proportions to the 2001 NPV figure of $861 million, beef producers are likely to have benefited by up to $287 million and domestic consumers by $431 million or more in PV terms from past investments in beef cattle selection and crossbreeding R&D.

15. Using a different method, the cumulative NPV of infusing Bos indicus genes in the northern herd since 1970 is estimated at $10.2 billion. It has been estimated as the extra revenue to the producer resulting from an increase in the Bos indicus proportion of the northern herd from 5% in 1970 to 85% in the 1990s, evaluated at an on-property benefit of $110/cow/year (2001 dollars). The estimated cow population over the period has also been incorporated.

16. Using a similar methodology, the benefits from changing breed composition in the southern herd during the 1990s has been estimated at $88 million. This is basically estimating a premium for Angus cattle. The percentage of southern slaughter that has been Angus-influenced has risen from 9.5% to 22% since 1990. The $88 million figure was derived using an assumed premium of $25 per slaughtered animal and beef population estimates.

17. While the initial benefit of these breed changes accrues to the producer, over time the benefit will be distributed across all sectors of the industry.

18. Longer term breed changes and benefits from other breeds (eg European breeds) have not been evaluated.

1.1.5 Conclusion

19. The estimated returns on investments in beef cattle genetics R&D have been healthy. In addition the cumulative nature of genetic gain means that the benefits will continue into the future, and are expected to grow.

2 INTRODUCTION

The cattle and beef industry is in most years the largest contributor to income received from Australia's primary industries. According to ABARE (Riley *et al.* 2001), in 2000, some 18,000 specialist beef enterprises and another 20,000 mixed grazing enterprises held about 24 million cattle and calves. The output of these enterprises at the farm gate was valued at over $5 billion. Almost two million tonnes of beef and veal was produced in carcase weight terms. Roughly two thirds of this output is exported, totalling some 900,000 tonnes shipped weight, valued at about $3.5 billion FOB. Major markets are the United States and Japan, which each take around 37% of exports. The remaining 25% of exports is spread over some 50 smaller markets (see Figure 1).

Figure 1: Summary statistics on the Australian beef industry

Item	1997	1998	1999	2000	2001
No. of cattle for meat (mill)	23.3	23.2	22.8	22.9	-
Cattle and calf slaughterings (mill)	8.4	9.3	9.1	8.6	8.7
Beef and veal production (Mt cw)	1.815	1.957	2.011	1.988	2.054
Beef and veal exports to all dest. (Kt sw)	730	821	884	852	959
Beef and veal exports to the US (Kt sw)	212	240	289	312	389
Beef and veal exports to Japan (Kt sw)	281	313	314	326	336

Sources: Riley *et al.* (2001), MLA (2001)

Previous reviews of R&D investment in beef cattle genetics have tended to be from the viewpoint of individual agencies investing in the R&D. An MLA review of genetic improvement programs in the beef and sheepmeat industries was conducted by Sillar Associates, Trurobe Pty Ltd and John James (1999). That review stopped short of a full economic analysis of investment returns but focused on MLA investment. A NSW Agriculture review of returns to the NSW beef industry from investments in selection and crossbreeding R&D was conducted in 1992 as part of an R&D program evaluation (Parnell, Cumming, Farquharson and Sundstrom 1992). That review estimated that the Grafton cross-breeding program would yield a NPV of benefits of approximately $170 million by 2020, a BCR of 8.5:1 and an IRR of 13.5%. Corresponding figures for the Trangie/Glen Innes program were $170 million, 3.2:1 and 13.5%. Graser and Barwick (2000) estimated a NPV of over $350 million and a BCR of over 9:1 for the genetic improvements from developing and using BREEDPLAN (1985-2005, 8% discount rate).

Nitter *et al*. (1994) estimated the return, cost and profit per cow in the relevant cow population from one round of genetic selection for growth to be $8.14, $1.34 and $6.81, respectively.

However, there has been no previous attempt to summarise all investments and to quantify total economic benefit.

3 REVIEW OBJECTIVES

The present review was commissioned by MLA with terms of reference as shown in Appendix 1. The objectives of the review were to:

- provide a comprehensive summary of total investment into beef cattle genetics R&D including delivery, and across state and national agencies for the period 1980 to present;
- estimate returns from genetics R&D; also here to provide information on numbers of cattle evaluated in Australia and overseas, through BREEDPLAN, and on genetic trends in individual production traits and indexes; and
- provide estimates of net present NPV, return on investment, BCR and IRR for investment in beef cattle genetics R&D on a national basis, and where possible on a per-agency basis.

4 APPROACH

4.1 Definitions

Beef cattle breeding and genetics R&D was defined to include all breed manipulation, including selection, crossbreeding and grading up or breed substitution. It was also defined to include all effects from the importation of genetics. Changes in breed composition were separately considered for northern and southern parts of the national herd. The breed composition change valued in the tropical (northern) herd was the increase in *Bos indicus* content that has occurred in response to the need for greater adaptability to tropical conditions. The breed change valued in the southern herd included that deriving from demand for marbling in certain markets.
Thus the definition includes all inputs into beef cattle genetic improvement, and the acronym R&D includes all associated extension and advisory activity.

4.2 Time period

Following discussion with MLA and with individual R&D agencies the time period over which investments were considered was varied to include those occurring prior to 1980. In NSW, a selection project commenced at Trangie in 1963 and crossbreeding R&D commenced at Grafton in 1972. Extension work in Queensland and South Australia has been active from 1970. Activities in WA and Tasmanian commenced in 1972. MLA and its predecessors funded beef cattle genetics research from 1971, and R&D funding information from AGBU was available from 1978.

Returns from beef cattle genetics R&D were assessed based on these investments. In the case of returns from selection within breeds, the genetic gains occurring were only able to be assessed through seedstock herd performance records available from the early 1970's. The genetic gains valued in commercial herds, as a consequence of within-breed selection, were consequently those occurring from 1980.

4.3 Economic framework

The economic framework used provided separate estimates of the investments into beef cattle breeding and genetics R&D inputs (the 'costs' of the process), and of the resulting outcomes (calculated as 'benefits'), allowing standard economic performance measures to be calculated.

Two approaches were used to estimate benefits. Benefits from selection and crossbreeding in temperate southern areas were estimated by assessing the economic surplus accruing to industry and the community. This approach values benefits that flow from impacts on costs of production. The economic surplus approach is best used to value production-type gains where impacts on cost of production can be quantified.

To value change in the *Bos indicus* content of the tropical northern herd, where impacts on costs of production were not well quantified, a simpler approach was used, involving calculation of the extra revenue derived per cow. This approach does not require detailed information on impacts on production costs, but it provides less information for policy analysis. The same approach was used to evaluate gains in the southern herd from the use of breeds with greater marbling propensity. Benefits from the increased use of these breeds take the form of a premium paid for the breed. This was most readily accounted for in an extra-revenue analysis.

More information on the relative advantages of these approaches is provided in Section 6.

5 INVESTMENT IN BEEF CATTLE GENETICS R&D

5.1 Methods

The R&D agencies traditionally and currently involved in beef cattle genetics improvement in Australia were contacted and asked to provide historical information on R&D inputs invested in the process. A copy of the letter sent is included in Appendix 2.

A number of agencies could not provide the necessary estimates either because accounting records were no longer available or they were not able to distinguish genetics R&D from other beef-related activities (eg nutrition research). Where this was so a compromise approach was followed to fill in the gaps. This involved experienced officers within each agency estimating the research, advisory and technical support staff full-time-equivalents (FTEs) spent on beef breeding and genetics work. These FTE numbers were then valued at a current representative cost and aggregated to provide an estimate of the current NPV of agency resources invested. Other information on costs (eg capital) was also provided where possible.

In the case of NSW Agriculture, the 2001 costs for representative FTEs were calculated as salary plus on-costs of 23%, plus management and other overheads. These amounts totalled $132 000 for a scientific research officer, $120 000 for an advisory officer and $105 000 for a technical officer. These figures were also applied to other agencies where agency-specific estimates were not provided.

5.2 Investment by agencies and industry groups

5.2.1 Meat and Livestock Australia and predecessors

Estimated levels of MLA investment in beef cattle genetics projects since 1972 are shown in TFigure 2. These amounts are in nominal (actual year) values. Levels of investment peaked in 1984-85. In the last decade investments initially increased and then declined since 1996-97.

Figure 2: Estimates of MLA investments in beef breeding/genetics: By year

Year	**$'000**	**Year**	**$'000**
1970-71	961.0	1986-87	3531.2
1971-72	175.9	1987-88	n.a.
1972-73	157.8	1988-89	1945.8
1973-74	178.2	1989-90	n.a.
1974-75	195.8	1990-91	753.4
1975-76	180.0	1991-92	688.1
1976-77	231.5	1992-93	943.6
1977-78	309.1	1993-94	1422.8
1978-79	270.8	1994-95	1502.7
1979-80	309.4	1995-96	1045.2
1980-81	370.9	1996-97	2591.2
1981-82	448.7	1997-98	2115.4
1982-83	603.1	1998-99	1348.8
1983-84	933.7	1999-00	1661.9
1984-85	4438.9	2000-01	1109.5
1985-86	3518.9		

5.2.2 NSW Agriculture

NSW Agriculture estimated inputs to breeding/genetics R&D were based on the following. Inputs made into research projects at Trangie, Glen Innes and Grafton Research Stations, as estimated in the review by Parnell *et al*. (1992), were re-used after updating figures from the base year for that review, 1990, to 2001 values. These estimates include advisory inputs. Subsequent staff inputs are included below.

NSW Agriculture staff input to the Animal Genetics and Breeding Unit (AGBU), a joint unit of NSW Agriculture and the University of New England (UNE), included the position of Director until 1992, and salary contribution to the Director position to Principal Research Scientist level since that time. In addition, included was one research officer FTE for the period 1978-1989 and two research positions since that time. These two positions have addressed beef issues almost exclusively but have also had input to the Beef CRC. Input to AGBU also included an extension officer FTE from 1978-1994.

In addition to advisory officers directly associated with initiatives mentioned, other advisory officers have provided beef breeding advice. The number of FTEs involved in this, assuming 30% of advisory officer time is spent on breeding advice, was estimated to be:

- 1970 – 1980 7.3 FTE
- 1981 – 1988 6.7 FTE
- 1989 – 1998 6.3 FTE
- 1999 – 2001 5.9 FTE.

5.2.2 University of New England (UNE)

UNE input was mainly through co-ownership of AGBU jointly with NSW Agriculture. UNE contributions, from 1977, included overhead costs associated with staff and managing research grants, provision of the building and administrative support staff. Additionally since 1994, UNE has contributed approximately $300 000 annually to AGBU. Of the UNE contribution, 50% is estimated to be allowable to beef cattle genetics. More general University education is not specifically evaluated here, although it is acknowledged that this has had an effect on R&D generally and in this particular circumstance.

5.2.3 Animal Genetics and Breeding Unit (AGBU)

AGBU provides R&D services in breeding and genetics across livestock species and to other agricultural industries. Included are training schools for service providers and other contributions to education. Funding is from a variety of sources. Here it was assumed AGBU input to beef cattle genetics R&D is encompassed in the investments in beef cattle genetics R&D already specified for NSW Agriculture and UNE, as owners of AGBU, and by that specified for MLA.

5.2.4 Victorian Department of Natural Resources and Environment (DNRE)

DNRE expenditure on beef cattle genetics research for the last five years was estimated to be:

- 1997-98 $111 089
- 1998-99 $111 877
- 1999-00 $194 016
- 2000-01 $140 888
- 2001-02 $332 538.

Unfortunately, no data were provided on research expenditures prior to 1997/98, although it is known that there was considerable expenditure. In addition, beef cattle genetics extension inputs were estimated to be 2 FTEs per annum from 1980 to 2001, although again it is known that there were beef cattle extension officers employed from 1970. These figures were valued at the NSW Agriculture rate specified above and aggregated to 2001.

5.2.5 Queensland Department of Primary Industries (QDPI)

Estimates of QDPI investments in beef cattle genetics R&D were based on the following:
(1) Involvement of an extension officer working almost exclusively in beef cattle genetics from 1970 until about 1985 (a total of 15 FTE's);
(2) Conduct of crossbreeding trials on research stations and co-operators' properties from the early 1970s until the early 1990s. These trials, involving use of *Bos indicus* infused cattle, are estimated to have involved 50% of a research officer and 20% of 15 extension officers and numerous support staff over 20 years. This commitment was estimated to be 5.5 FTEs per year over 20 years, or a total of 110 FTEs;
(3) Conduct of the Beef Genetic Improvement Project (BGIP), an extension project conducted from approximately 1989 onwards to promote objectively-based recording and selection. BGIP is also the vehicle for technology transfer in Queensland of the genetics results from the Beef Quality CRC. The number of FTEs involved in BGIP since 1989 has varied between 6.27 and the current 3.65. The total input to BGIP activities since 1989 was estimated to be 79 FTEs.

In summary, a total of 204 FTEs were estimated to have been involved in beef cattle genetics R&D since 1970. The 2001 dollar value of each FTE was put at $80,000, allowing for salaries, on-costs and operating.

5.2.6 Tasmanian Department of Agriculture

This agency provided estimates of expenditure from 1972 to 2001 in terms of current (2001) dollars. These expenditures were simply aggregated to provide the current PV.

5.2.7 SA Department of Agriculture

This agency also provided estimates in terms of annual expenditure expressed in current (2001) dollar terms. A long term (from 1970) beef cattle breeding trial has been conducted with substantial levels of inputs.

5.2.8 CSIRO

Estimates of FTEs involved in R&D were provided and then valued using the NSW Agriculture costs. The numbers provided from 1980 to 1993 were non-Beef CRC personnel and from 1994 to 2001 these were a portion of the in-kind contributions to the Beef CRC.

5.2.9 Beef cattle breeders

An important contributor to genetic gain in the beef industry has been the performance recording carried out by breeders, especially as required for the genetic evaluation system BREEDPLAN. An estimate of $20/cow on an inventory basis was used as a measure of recording costs contributed by breeders and registration costs. Most performance recording is by the breeder, except scanning for carcass traits, the costs for which are paid to accredited contractors.

The breeder costs associated with recording were applied to annual BREEDPLAN registration figures and aggregated to 2001 values.

5.2.10 Breed Societies

Breed Societies have played a major part in the herd registration and performance recording required for participation in BREEDPLAN. The Breed Societies, jointly with ABRI, provide services to seedstock breeders to promote and facilitate data recording, and to facilitate use of EBVs in breeding programs. Estimated FTEs for advisory services associated with BREEDPLAN (since 1985) collectively provided by Breed Societies and ABRI were estimated to be valued at $100 000 per annum each.

4.2.12 Beef Cooperative Research Centre (CRC)

Estimates of direct CRC expenditure apportioned to beef cattle genetics R&D were derived from the financial controller (direct investments since 1994), converted into 2001 values and aggregated. Care was taken to avoid double counting of partner institution costs.

4.2.13 Beef semen imports

Information on beef semen imports was difficult to obtain. Australian Bureau of Statistics (ABS) data show the volume (doses) and value of “bovine” semen imports to Australia since 1974.

After consultation with industry experts, bovine semen imports were judged to consist of 90% dairy and 10% beef semen. On this basis the value of semen imports since 1974 was estimated, converted to 2001 dollars and summed. The cumulative PV of beef semen imports to 2001 was estimated to be $27 million.

5.3 Summary of investments

The cumulative PV of investments in beef cattle genetics R&D, in 2001 dollars, was estimated to be $310 million.. The value of beef semen imports was estimated to be a further $27 million. A summary of the investments is shown in Figure 3.

Figure 3: Summary of Investments in beef cattle genetics R&D

Agency	PV of investments 2001 $mill.	Percent
5.3.1.1 MLA	79.03	23.4
NSW Agriculture	70.73	21.0
SA Department of Agric	52.94	15.7
Beef breeders	42.14	12.5
Semen imports	27.00	8.0
CSIRO	20.64	6.1
Qld DPI	16.31	4.8
WA Dept Agriculture	8.16	2.4
Breed Societies/ABRI	7.06	2.1
Vic DNRE	6.11	1.8
Beef CRC	5.00	1.5
UNE	1.54	0.1
Tasmanian Dept Agric	0.72	0.0
Total	337.38	100

6 TYPES OF IMPROVEMENT DUE TO BEEF CATTLE GENETICS R&D

Consideration was given to the types of improvements which can arise from R&D and how these can be evaluated economically. The gains from R&D can be experienced by the production, processing, marketing and consumption sectors. Investments in R&D have been made by both the beef industry (beef producers and processors) and by governments on behalf of society (principally consumers).

Ideally the evaluation of returns from R&D should account for returns to all these groups, and the main economic evaluation incorporates the interests of all these groups. However, there are other types of gains which are more difficult to evaluate in this framework and for these gains a simpler approach of estimating extra revenue at the farm level was used. Each of these approaches to valuing the improvement due to beef cattle genetics R&D are described in this chapter.

6.1 Returns from within-breed selection

To value returns from within-breed selection, genetic change within breeds was first assessed from genetic trends in EBVs for animals evaluated in BREEDPLAN. This was done for representative breeds with different levels of performance recording. Estimates of the proportions of the national herd in various production system-market niches were used to define the proportion of the national herd to which each estimate of gain applied. Breed Societies were asked for access to their EBV data for use in assessing genetic trends. The EBV data used were those computed with BREEDPLAN V4.1 and available in October 2001.

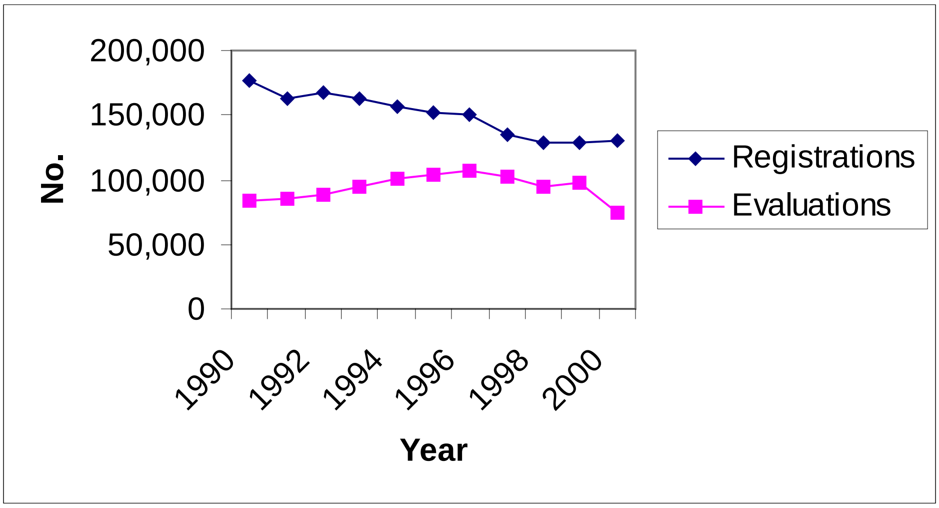
A usual difficulty in valuing genetic change in a trait is in knowing whether the change has also been accompanied by change in other traits. This difficulty was overcome here using BreedObject software. This software accounts for genetic associations among traits. It also is able to use BREEDPLAN EBVs to target EBVs for economic traits of commercial herds producing for different production system-market niches. The use of BreedObject consequently allowed assessment of genetic trends in EBVs for economic traits of commercial herds producing for different production system-market niches.

Gross Margin (GM) budgets were used to translate the assessed genetic gains into cost of production savings. The budgets used corresponded to the production system/market niches for which the genetic gains were estimated. The identified savings in cost of production were the inputs to an Equilibrium Displacement Model (EDM) used to assess returns from within-breed selection (detailed in Section 7). The results are presented in Section 11.

6.1.1 Numbers of cattle evaluated through BREEDPLAN

Assessment of within-breed genetic gain was limited to that which could be identified from BREEDPLAN EBV data. Information on beef cattle registrations, obtained from statistics published by the Australian Registered Cattle Breed Association (ARCBA) show numbers of cattle registered with breed societies have fallen over the period 1990 to 2000. Information from breed databases in BREEDPLAN, by contrast, show numbers of seedstock evaluated through BREEDPLAN has increased. These are summarised in Figure 4. Data on cattle evaluated through BREEDPLAN were based on numbers of animals in the major breed databases that had EBVs based on own or progeny performance records.

Figure 4: Numbers of beef cattle registered with Breed Societies and evaluated through BREEDPLAN



6.1.2 Rate of adoption and the time to realisation of benefits

Breeds vary both in the amount of performance recording undertaken and in the timing of this for particular BREEDPLAN performance measures. This aspect of rate of adoption contributes to differences between breeds in the rate of genetic change in commercial traits. The genetic changes observed in each breed, obtained from the averages of EBVs for a trait, by year of birth (genetic trend), were assumed to occur in the commercial sector of industry at the same rate as in the seedstock sector, though at a later time. For commercial herds using BREEDPLAN-evaluated bulls, the genetic change was assumed to lag by 5 years relative to that occurring in the seedstock sector. No additional assumption was made about adoption or understanding of BREEDPLAN in the commercial sector. Other increases in genetic gain that might be achieved through informed use of EBVs in bull selection in commercial herds were consequently not considered.

The extent to which the identified genetic gains benefit the commercial sector depends on the level of use of BREEDPLAN-evaluated bulls in that sector. Estimates were obtained of the proportions of commercial herd bulls that have BREEDPLAN EBVs. Commercial herds using non-BREEDPLAN bulls were assumed to still benefit from the technology but after a longer lag period. A lag of 10 years was assumed for genetic gain in the seedstock sector to be expressed in commercial herds using non-BREEDPLAN bulls. This reflects the tendency for well-proven bulls to also influence bulls bred in non-BREEDPLAN herds.

In addition to the lags of 5 and 10 years for gains in seedstock herds to be expressed in commercial herds using BREEDPLAN evaluated and non-BREEDPLAN evaluated bulls, a sensitivity analysis was conducted with lags of 8 and 13 years respectively. Expression of gains in maternal traits, such as maternal genetic effects on growth, also occur a further generation (5 years) later and only after animals reach maternal age. The analysis of returns from within-breed selection consequently took account of the often long time lag between the observation of genetic gain in seedstock and the expression of this in commercial herds. The analysis also took account of the permanence of the gains arising from selection, benefits being accumulated over time.

6.2 Returns from crossbreeding

The returns from increases in the use of crossbreeding in the southern (temperate) herd were also estimated using the same economic methodology as for within-breed selection. As explained in Section 7 these gains were estimated based on a change in cost of production which translates into a shift in supply. Results from farm-level budgeting in Barlow, Farquharson and Hearnshaw (1989) as well as estimates of cow numbers in southern herds and current percentages of herds using crossbreeding were utilised.

On medium quality pastures, Barlow et al. (1989) found the highest GM crossbred-cow combination was Brahman x Hereford cow mated to a Hereford bull, and this was compared to a straightbred Hereford production budget. Budget estimation established that the crossbred system had a variable cost/kg dressed weight (DW) of $0.81, compared to the straightbred cost of $0.84/kg DW. This once only cost advantage, due in part to hybrid vigour, is realised immediately. These differences in cost of production were input to the EDM and used to assess returns from crossbreeding.

6.3 Returns from breed changes

For a number of reasons the returns from changes in breed composition of the Australian beef herd associated with beef cattle genetics R&D were difficult to evaluate in the main economic framework. These included the difficulty of measuring changes in costs of production in northern (extensive) beef regions and the issue of price premiums associated with particular breed types. Both these issues are more difficult to include in a supply shift (cost of production) framework and could not be accommodated within the timeframes and resources available. A simpler approach of estimating extra net returns at the production level was used to obtain an idea of the magnitude of these gains. The limitations of this approach are noted in Section 7.

The returns from increased use of *Bos indicus* genes in the northern herd were estimated from the extra revenue associated with *Bos indicus* infused cattle at the property level, and from estimates of the change in *Bos indicus* usage. Industry estimates (Dr Heather Burrow, pers com) suggested improved profit per cow for *Bos indicus* infused cattle of $110/cow (in 2001-dollars) as a result of cattle tick and drought tolerance. The proportion of *Bos indicus* cattle in the northern herd increased from 5% in 1970 to around 85% in the 1990s. The cumulative aggregate benefits to the industry were then assessed assuming a northern cow population of 5 million (Riley *et al*. 2001).

A similar calculation was made to value the change in breed composition arising from use of breeds with greater marbling propensity in the southern (temperate) herd. The benefits to producers were based on an assumed premium of $25/slaughtered animal (in 2001-dollars) in these breeds (Dr Peter Parnell, pers com). The change in breed use was based on the proportion of southern slaughter cattle with marbling propensity, from 9.5% to 22% since 1990, and data on the southern cow population from Riley *et al.* (2001).

7 ECONOMIC METHODOLOGIES FOR EVALUATING TECHNOLOGY CHANGE IN THE BEEF INDUSTRY

7.1 Assessment of industry and community economic surplus

This approach to estimating benefits utilises an Equilibrium Displacement Model (EDM) of the Australian beef industry. Xhao, Mullen, Griffith, Griffiths and Piggott (2000) developed this model specifically for conducting detailed evaluations of the returns to sectors of the beef industry from technological changes or other policy (eg expenditure on promotion, changes in market access) measures. The model characterises changes in technology, such as the effects of beef cattle breeding and genetics R&D, as impacting the supply of beef products by the industry over a medium term, assumed to be 5 years. The change in supply is represented by a percentage change in the minimum average variable costs of production per unit of output. This is in accordance with economic theory of supply representing marginal costs of production.

In the present case, the process of transforming estimated changes in trait values (or trends over time) into proportional variations in production costs was achieved through an enterprise-level GM budgeting analysis. First, a categorisation of the Australian beef herd was made according to breed and market characteristics. An estimate was made of the proportions of cattle within each breed x market niche (as described in Section 8). Then trends in trait values were generated and the budgeting process for different market x breed combinations was conducted. Representative beef enterprise budgets were used to estimate impacts in the important breed x market cases. An aggregation procedure was used to transform the representative farm enterprise-level cost impacts into relevant industry-level responses. This was achieved using the estimated proportion of the beef cattle population within the breed x market niches as weights on the farm-level impacts that were applied to the EDM. Finally, the time pattern of costs and benefits was used to estimate standard financial analysis measures (NPV, BCR and IRR).

7.2 An Equilibrium Displacement Model (EDM) of the beef industry

The approach involves estimating changes in economic surplus from productivity gains across the industry. With this approach, the equilibrium of the industry is represented by a system of demand and supply relationships for each sector of the industry. The impacts of new technologies, promotional campaigns and government policies, are modelled as shifts in demand or supply curves in the relevant markets. Comparative static analysis is used to linearly approximate changes in prices and quantities of all outputs and inputs from specified % reductions in production or processing costs or from specified % increases in demand in the case of promotion. The consequent changes in producer and consumer surpluses are then estimated as changes in economic surplus to various industry groups. A review of the equilibrium displacement modeling approach can be found in Alston, Norton and Pardey (1995).

The Australian beef industry involves multiple markets and multiple production and marketing stages. In order to study the returns from various types of on-farm and off-farm research investments and the distribution of benefits among different industry sectors, a model disaggregated along both vertical and horizontal directions is required. Horizontally, both grass-finished and grain-finished product needs to be included. Vertically, production of retail beef products involves breeding, backgrounding, grain or grass finishing, processing, and domestic or export marketing.

Thus the EDM includes four end products – domestic grass- and grain- fed beef and export grass- and grain-fed beef. These four products have different market specifications at all production and marketing stages and each comprises a significant share of the industry. This disaggregated specification enables the analysis of productivity changes in individual sectors and promotion in different markets. It also enables the identification of benefits to individual industry sectors. A technical account of the EDM specification and assumptions made is given in Zhao, Mullen, Griffith, Griffiths and Piggott (2000).

Three types of information are required for operating the EDM: (1) initial price and quantity values for all inputs and outputs, which define the equilibrium status of the system before the introduction of new technology or promotion; (2) market elasticities, which describe the market responsiveness of quantity variables to price changes; and (3) the values of all the variables which quantify the effects of new technologies and promotions.

The initial equilibrium values are specified as the average prices and quantities for a representative year. Significant effort has been invested to compile a set of equilibrium prices and quantities for all sectors and product types at the required level of disaggregation. This includes prices and quantities of weaners, backgrounded cattle, grass/grain finished cattle, processed beef carcass, and final products as free-on- board export boxes and domestic retail cuts. Details about the data sources, the assumptions made and the derivation of prices and quantities of all sectors for various years are given in Zhao *et al* (2000).

Various market elasticities are required to solve the displacement model. These include supply elasticities of factor inputs, demand elasticities of final products, and input substitution and output transformation elasticities among inputs and outputs of all sectors. Values for these elasticities are specified based on economic theory, reviews of existing empirical estimates and subjective judgement. Full details of the selected specification of the base market elasticities are given in Zhao *et al* (2000).
Where published estimates are limited, subjective judgement is required in order to choose a set of 'most likely' elasticity values. A stochastic approach to sensitivity analysis was used in Zhao *et al* (2000) to systematically study the robustness of results to uncertainty in market elasticities.

New technologies are modelled as reducing the costs of production or processing, thereby generating shifts in supply. Promotion is modelled as a shift in demand. This allows for the simulation and comparison of the impacts of cost reductions in various production and processing sectors and increases in consumer's 'willingness to pay' in the end product or retail markets.

7.3 Results from previous R&D investment analyses using the EDM

As an illustration of the uses of this modelling approach, some previous results are summarised briefly in this section. Total economic surplus changes and their distributions among various industry groups were calculated, resulting from 1% cost reductions in 7 R&D scenarios of the 12 possible technology and promotion scenarios able to be run using the EDM (see Zhao, Griffith and Mullen 2001). These scenarios covered R&D in various farm sectors (weaner production, cattle backgrounding and grass-finishing) and off-farm sectors (feedlotting, processing, and domestic and export marketing). The results are consistent with previous studies in showing that farmers will receive higher shares of total benefits from all types of farm research than research in the feedlotting, processing and *domestic* marketing sectors.

For the same percentage exogenous shift in the relevant markets, domestic beef marketing technology (Scenario 7) and weaner production research (Scenario 1) resulted in the largest total returns: $23.88 million and $19.60 million, respectively. The total benefits from cost reductions in the backgrounding, feedlot, processing (Scenario 6) and export marketing sectors were much smaller (mainly less than $2 million) due to the small value added to the cattle/beef products in these sectors.

Figure 5: Summary statistics for welfare benefits (in $ million and shares of the total benefits (in%) for various industry groups

Industry Group	Scenario 1 **(weaner production research)** **$m**	**%**	Scenario 6 **(processing research)** **$m**	**%**	Scenario 7 **(domestic marketing research)** **$m**	**%**
Farmers total: Base	6.61	33.7	1.21	25.9	4.72	18.7
Processors: base	0.19	1.0	0.14	3.0	0.19	0.8
Domestic Consumers: Base	9.97	50.8	2.60	55.4	15.66	65.6
Total benefits: Base	19.6	100	4.69	100	23.88	100

1. Figures on the left of each cell are the monetary benefits and figures on the right are the percentage shares of total benefits, for individual groups.

For all 7 R&D scenarios, the majority of the total benefits accrued to domestic consumers and cattle farmers. Domestic consumers gained the largest share of total benefits (48.3% to 65.6%) in all seven cases. This is because domestic retail beef comprises the bulk of total industry value at retail and because domestic beef demand is assumed far from perfectly elastic. Farmers, including weaner producers, grass-finishers and backgrounders, received between 18.7% to 33.7% of total benefits for the seven scenarios. Some of these results are reported in Figure 5.

7.4 Change in farm-level revenue

The approach involved calculating the extra farm-level revenue associated with a technology change, on a per unit (cow or beast slaughtered) basis. The per unit net revenue impacts were then multiplied by the relevant number of units and aggregated over time periods. This type of benefit takes no account of possible industry production or market price responses due to the improved technology.

While the initial benefit of these breed changes accrues to the producer, over time the benefit will be distributed across all sectors of the industry as producers respond to the incentive to supply more of the preferred breeds and the market adjusts to the new set of prices and quantities. So this extra revenue to producers is really an industry benefit, and would be distributed in *broadly* the same way as shown in the EDM. However, we cannot make *precise* statements about associated returns to other sectors of the beef industry because these impacts occur in particular parts of the industry whereas the EDM analysis discussed above is calibrated and tested on aggregate, Australia-wide data.

8 INDUSTRY REPRESENTATION AND AGGREGATION

8.1 Industry breed x market production systems

To assess benefits across different segments of the commercial beef industry, a breakdown of the industry by breed and market production system was required. Gains were valued and accumulated across the whole industry. Estimates were made of the following:

- the size (number of cows joined) of the national beef herd;
- the proportion of industry cows that are *Bos taurus* and *Bos indicus/adapted composites*;
- the proportion of *Bos taurus* and *Bos indicus/adapted composite* cows that are put to *Bos taurus* and *Bos indicus/adapted composite* bulls;
- the proportion of young finished animals that go to domestic and export markets;
- the proportion of *Bos taurus* cows that are put to different bull breeds; and
- the proportion of *Bos indicus/adapted composite* cows that are put to different bull breeds.

Based on these estimates the beef industry cow herd was apportioned into 28 breed x market groups. Additionally, within a number of breed x cow joining and market types, an estimate was made of the proportion to which different market niches were considered to apply. Taking these additional market niches into account apportioned the industry into 35 breed x production system-market niches. The resulting segmentation of the beef industry cow herd is shown in Figure 6.

Figure 6: Estimated proportions in breed x market production system niches

Proportion	Bull breed	Cow type	Market	Niche (#)
.07	Angus	Bos taurus	Domestic	(1) Supermarket
.02	Angus	Bos taurus	Domestic	(2) CAAB
.09	Angus	Bos taurus	Export	(3) 220d fed/B3
.03	Angus	Bos indicus/comp.	Export	(4) Terminal
.05	Heref/Poll H.	Bos taurus	Domestic	(5) Supermarket
.01	Heref/Poll H.	Bos taurus	Domestic	(6) Heref. Prime
.06	Heref/Poll H.	Bos taurus	Export	(7) Short-fed
.01	Heref/Poll H.	Bos taurus	Export	(8) Long-fed
.005	Limousin	Bos taurus	Domestic	(9) Terminal
.001	Limousin	Bos taurus	Domestic	(10) Straightbred
.005	Limousin	Bos taurus	Export	(11) Terminal
.001	Limousin	Bos taurus	Export	(12) Straightbred
.003	Simmental	Bos taurus	Domestic	(13) Terminal
.001	Simmental	Bos taurus	Domestic	(14) Straightbred
.003	Simmental	Bos taurus	Export	(15) Terminal
.001	Simmental	Bos taurus	Export	(16) Straightbred
.24	Brahman	Bos indicus	Export	(17)
.10	Brahman	Bos indicus	Domestic	(18)
.01	Brahman	Bos taurus	Domestic	(19)
.01	Santa, Others	Bos taurus	Domestic	(20)
.01	Brahman	Bos taurus	Export	(21)
.01	Santa, Others	Bos taurus	Export	(22)
.01	Charolais	Bos taurus	Domestic	(23)
.01	Charolais	Bos taurus	Export	(24)
.01	Murray Grey	Bos taurus	Domestic	(25)
.01	Murray Grey	Bos taurus	Export	(26)
.01	Shorthorn	Bos taurus	Domestic	(27)
.01	Shorthorn	Bos taurus	Export	(28)
.01	Other Bos taur.	Bos taurus	Domestic	(29)
.01	Other Bos taur.	Bos taurus	Export	(30)
.03	Other Bos taur.	Bos indicus/comp	Export	(31)
.03	Santa G, Others	Bos indicus/comp	Domestic	(32)
.07	Santa G, Others	Bos indicus/comp	Export	(33)
.02	Composites	Bos indicus/comp	Domestic	(34)
.03	Composites	Bos indicus/comp	Export	(35)
1.00				

8.2 Choice of representative groups

Six measures of genetic gains were obtained, based on genetic trends in BREEDPLAN EBVs. Gains were assessed for four breed groups chosen to represent breeds with different levels of performance recording. The gains occurring in the Angus and Hereford breeds were taken as representative of breeds with high and moderate amounts of performance recording, respectively. Gains in the Limousin breed were considered representative of that occurring in European breeds. Gains in the Brahman breed were considered representative of breed types used in northern herd production systems.

The genetic trends assessed were for commercial herd traits. These were assessed from BREEDPLAN EBVs using BreedObject software. The commercial herd traits were defined for either domestic or export markets, and notionally for particular production systems within each of these. As a consequence, six measures of genetic gains were obtained. In summary, the six breed x market production systems used to assess genetic trends, the notional production system involved and the cases they represented, were as shown in Figure 7.

Figure 7: The six representative breed x market production systems used to assess genetic trends

Measure of genetic gains	Breed x market	Production system	Cases represented
1	Angus-Domestic	Pasture grown & finished steers, 420kg at 17m, for Supermarket trade (herd 'self-replacing')	high recording-domestic
2	Angus-Export	Pasture grown, 220d long-fed steers, 650kg at 25m, for Japanese B3 market (herd 'self-replacing')	high recording-export
3	Hereford & Poll Hereford -Domestic	Pasture grown & finished steers, 475kg at 17m, for Supermarket trade (herd 'self-replacing')	moderate recording - domestic
4	Hereford & Poll Hereford-Export	Pasture grown, 100-150d fed steers, 640-700kg at 20-22m, for Export markets (herd 'self-replacing')	moderate recording export
5	Limousin-Export (terminal role)	Pasture grown & finished steers from British breed cows, 575kg at 25m, for Export markets	European breeds
6	Brahman-Export	Pasture grown & finished steers/bullocks, 650kg at 30-36m, for Export markets (herd 'self-replacing')	northern breeds

8.3 Aggregation of systems for estimating returns from genetic change

For aggregation of benefits across the whole industry, genetic gain assessments based on Angus-Domestic and Angus-Export measures were applied to the above niches 1 and 2 and niches 3 and 4 respectively. Genetic gain assessments from Hereford/Poll Hereford-Domestic and Hereford/Poll Hereford-Export were taken to apply to niches 5, 6, 25, 27, 29 and 7, 8, 26, 28 respectively. Genetic gain assessments for Limousin-Export (Terminal) were applied to niches 9-12, 13-16, 23, 24 and 31. Genetic gains in the remaining niches were represented by that assessed for Brahman-Export.

Informed estimates were obtained of the percentages of BREEDPLAN-evaluated and non-BREEDPLAN-evaluated bulls used in commercial herds by breed. These were then pooled over niches represented. The type of bull use affects the lag assumed for the time to expression of genetic gains in commercial herds. A lag of 5 years was assumed for commercial herds using BREEDPLAN-evaluated bulls and a lag of 10 years was assumed for commercial herds using non-BREEDPLAN-evaluated bulls. Taken together with the above aggregated market niche proportions, the percentages concerning bull use further define the proportions of the national cow herd to which each measure of gain was applied. In summary, this was as shown in Figure 8. A sensitivity analysis was also performed on the assumed lag lengths where lags of 8 and 13 years were imposed instead of lags of 5 and 10 years.

Figure 8: Proportions of the cow herd to which different measures of genetic gain and different lag periods were applied

Measure of genetic gains	Aggregated niche %	% BREEDPLAN bulls used	% non-BREEDPLAN bulls used	Cow herd %
		(lag 5 years)	(lag 10 years)	
1. Angus-Domestic	.09	.64		5.76
	.09		.36	3.24
2. Angus-Export	.12	.64		7.68
	.12		.36	4.32
3. Her./PHer.-Domestic	.09	.54		4.86
	.09		.46	4.14
4. Her./PHer.-Export	.09	.54		4.86
	.09		.46	4.14
5. Lim.-Export (Term.)	.07	.38		2.66
	.07		.62	4.34
6. Brahman-Export	.54	.10		5.40
	.54		.90	48.6
Total	1.00			100

9 ASSESSMENT OF TRAIT GENETIC CHANGES IN REPRESENTATIVE INDUSTRY GROUPS

9.1 Methods

Genetic trends in BREEDPLAN EBVs were translated into genetic trends in economic traits of commercial herds, using BreedObject software (Sundstrom and Barwick undated), for each of the breed groups examined. The commercial herd traits were defined for either domestic or export markets and according to particular production systems as described in Section 8.2. The commercial herd traits considered are shown in Figure 9. These traits are also the breeding objective traits that underlie industry $Indexes constructed with BreedObject. Note that efficiency of feed use is not a separately specified trait in Figure 9. Other approaches are used to cost feed in the construction of $Indexes for industry. Separate attention was consequently given here to costing additional feed associated with genetic gains.

Trends in these traits were assessed over the period 1985 to 2000, using as inputs the BREEDPLAN EBVs of animals born over this period. Trait changes were assessed at 5-year intervals, as required for use in subsequent analysis using the EDM.

Figure 9: Traits of commercial herds originally examined for genetic trend

Trait	Unit
Sale liveweight	kg
Sale liveweight-maternal	kg
Dressing percentage	%
Carcase meat percentage	%
Fat depth	mm
Cow weaning rate	%
Marbling score	score units
Cow survival rate	%
Cow liveweight	kg
Calving ease	%
Calving ease-maternal	%

The substantial measured trait changes were in progeny liveweight and cow weight in each breed x market group in which gains were assessed. Changes in other traits of Figure 9 were not considered large enough to warrant assessment of associated cost of production or demand effects. The absence of appreciable change in traits other than growth, at least as expressed in commercial herds, is due to the relatively recent introduction to BREEDPLAN of EBVs addressing these traits (breeds using BREEDPLAN are reported to have progressively adopted EBVs for carcass and fertility traits during the 1990s). Importantly, the absence of appreciable genetic changes in other traits also suggests that the changes in growth have been able to be achieved without antagonistic genetic change in other traits. Examples of genetic trends observed in all traits are shown in Appendix 3.

9.2 Results

Trait changes are shown in Figure 10 for gains occurring in seedstock and expressed 5 years later in commercial herds. These are the gains expected in herds using BREEDPLAN-evaluated bulls. Similar gains are expected in herds using non-BREEDPLAN bulls after a further 5 years. Trait trends in the table are projected to 2005 to account for the first occurrence of genetic gains in commercial herds arising from gains in BREEDPLAN evaluated seedstock in the period up to 2000. Projections are made to 2010 for those gains from non-BREEDPLAN-evaluated bulls.

Figure 10: Genetic changes in traits of commercial herds. Calculations are from measures of genetic trend in seedstock, deviated from 1980 levels and lagged by 5 years for expression of the gains in commercial herds

Measure of gain	1985	1990	1995	2000	2005
		Progeny liveweight (kg)			
1. Angus-Domestic	0	4	12	22	37
2. Angus-Export	0	5	15	28	48
3. Her/PH-Domestic	0	3	10	19	31
4. Her/PH-Export	0	3	10	19	31
5. Limousin-Export (T)	0	1	7	11	21
6. Brahman-Export	0	10	15	23	33
		Cow liveweight (kg)			
1. Angus-Domestic	0	4	13	23	36
2. Angus-Export	0	4	13	23	37
3. Her/PH-Domestic	0	3	9	18	29
4. Her/PH-Export	0	3	9	18	29
5. Limousin-Export (T)	not applicable				
6. Brahman-Export	0	6	7	12	18

10 ASSESSMENT OF THE IMPACTS OF TRAIT CHANGE ON COST OF PRODUCTION

10.1 Representing gains from breeding and genetics technology

The EDM analysis requires gains at the farm level to be expressed as percentage changes in the minimum average variable cost per unit output. The estimation of these percentage changes was accomplished using representative beef enterprise budgets for each of the breed x market cases listed in Figure 7.

The trends in significant genetic traits (progeny and cow liveweight) over each 5-year period were valued by an analysis of the costs associated with such changes. Of particular importance were the feed costs associated with growing larger animals. As stated previously, no change in FCE was included in the analysis, so those larger animals required proportionately more feed.

The BEEF-N-OMICS program (NSW Agriculture and Meat Research Corporation 1991) was used to estimate the feed requirements of the herds in each production system. BEEF-N-OMICS is a GM budgeting tool, which includes a herd model that calculates the numbers, types, ages and weights of all cattle within the herd according to user-supplied inputs or parameters. The monthly feed requirements (expressed in LSMs) are calculated according to the number, live weight, weight gain and pregnancy/lactation status of herd members.

In the analysis, the estimated feed requirements were converted to total DSEs for the year and these were converted to feed requirements expressed in terms of hectares of improved pasture. The basis for these calculations is presented in the next section.

10.2 Feed requirements from improved pasture

Details of assumptions underlying the estimation of improved pasture areas are shown in Appendix 4.

Key assumptions were for medium-high rainfall (>625 mm average annual), pasture species of improved pastures (eg phalaris, fescue, rye, cocksfoot) and legumes (sub/white clover), a pasture lifespan of 5 years and input costs of $250/ha establishment and $50/ha annual maintenance ($90/ha/year average). Pasture production was 12 000kg dry matter (DM)/ha/year with 50% grazing utilisation.

With available DM of 6000 kg ha/year and ruminant livestock requirements of 500 kg DM/DSE/year, the estimated carrying capacity was 12 DSE/ha. Average annual cost per unit of pasture production was calculated to be $15/1000 kg DM, and the annual cost per DSE was $7.50/DSE.

In the livestock budgets the total annual feed requirement per DSE calculated from the BEEF-N-OMICS analysis was divided by 12 to estimate the area of improved pasture required to carry the herd through the year. This area was multiplied by $90/ha to derive the average appropriate pasture feed cost.

10.3 Animal inputs from genetic trends

The genetic trends from Figure 10 were converted into appropriate liveweights for cattle (cows and progeny at different turnoff targets). Taking year 2000 beef cattle GM budget information as a base, the weights for each year from 1985 to 2005 were estimated and used as inputs to the BEEF-N-OMICS and GM budgets. These figures are shown in Appendix 5.

10.4 Gross margin budgets

GM budgets for the enterprises listed in Figure 7 were based on those of NSW Agriculture (2001). Consultations with extension specialists allowed adaptation of the BEEF-N-OMICS program and other inputs to the GM budgets to appropriate representations of current industry status. The progeny liveweights, the estimated improved pasture feed costs and other relevant parameters were all incorporated into the budgets.

Total variable costs included replacement bulls, replacement heifers (where appropriate), livestock and veterinary costs, ear tags, pasture establishment and maintenance costs, interest and livestock selling costs. Other costs (eg labour) which did not vary were not included. Feed costs for grain-fed steers were calculated at 2.8% of liveweight and $152/tonne ration cost. Examples of the GM budgets are shown in Appendix 6.

The total weight of beef sold in units of kg DW was estimated using dressing percentages of 55% and 53% for males and females respectively. The figure for total variable costs per kg DW was derived and percentage changes over the 5-year periods were input to the EDM model.

10.5 Changes in variable costs

The estimates of variable costs/kg DW for each 5-year point for each budget are shown in Figure 11

Figure 11: Variable costs per unit output results – based on genetic trait trends

Breed x market	1985	1990	1995	2000	2005
Angus supermarket	1.22	1.21	1.19	1.18	1.16
Angus B3	1.94	1.94	1.93	1.93	1.92
Hereford/Poll H supermarket	1.13	1.13	1.12	1.11	1.10
Hereford/Poll H short-fed exp	1.68	1.67	1.67	1.67	1.67
Limousin Terminal export	1.56	1.56	1.55	1.55	1.53
Brahman Jap Ox	1.18	1.18	1.17	1.16	1.15

The results in Figure 11 are interesting for several reasons. First the base cow weights used influence total variable cost levels. Hereford cows were assumed to be heavier (500 kg) than Angus cows (450 kg), therefore Hereford herd costs per kg of beef are likely to be lower, other things being equal. Also, the budgets associated with grain feeding had higher costs because the budgets included the breeding and backgrounding components, meaning higher aggregate cost levels. The budgets also had a regional aspect, so this impacts on variable costs to some extent.

The costs associated with grain feeding were based on feed requirements being a fixed proportion of liveweight. However, in the pasture-based budgets changes in cow weights are buffered by the maintenance component, which is likely to change by a lesser amount. Therefore the costs associated with the grain-fed cases are likely to change by less, since there is no evidence of FCE varying to influence the cost side of the analysis. This trend is observed in the results.

The Limousin terminal export budget required buying in replacement females. The cost of these, especially if bought as pregnancy tested in calf, was difficult to determine.

The results for crossbreeding in the temperate (southern) regions were based on results from Barlow, Farquharson and Hearnshaw (1989). For medium quality pastures, the best crossbred-cow combination (Brahman x Hereford cow mated to a Hereford bull) had a variable cost/kg DW of $0.81, compared to the straightbred Hereford herd cost of $0.84/kg DW. This cost advantage due in part to hybrid vigour is realised in each drop of crossbred calves but is not accumulated from year to year as are the cost advantages from selection.

10.6 Inputs to the EDM analysis

The results in Figure 11 were converted into percentage change figures for input to the EDM analysis. In this conversion, the gains from selection are cumulative. These and the crossbred results are presented in Figure 12. They are presented here as representing types of markets and according to the degree of herd measurement and recording undertaken in developing the EBV information used as a basis for the genetic trait trends.

Figure 12: Cumulative annual percentage point reductions in per unit variable costs

5-year period to	1985	1990	1995	2000	2005
Domestic high recording	0	0.5	1.7	2.9	4.8
Export high recording	0	0	0	0.6	1.2
Domestic moderate recording	0	0	0.8	1.6	2.6
Export moderate recording	0	0	0.6	0.6	0.6
European	0	0	0.9	0.9	2.1
Northern	0	0	1.1	1.6	2.3
Crossbreeding (south)	3.0	3.0	3.0	3.0	3.0

11 RESULTS: RETURNS FROM BEEF CATTLE GENETICS R&D

As mentioned previously, two methods of estimating economic benefits were used in this analysis. These are the EDM approach, which provides estimates of change in total economic surplus due to technology adoption, and an extra-farm-revenue approach which provides estimates of change in net revenue, initially at the farm level. The relative advantages and disadvantages of these approaches have been discussed in Section 7. The results from both methods are presented in this chapter.

11.1 Returns from within-breed selection and crossbreeding

Previous results (Zhao, Griffith and Mullen 2001) from the EDM showed that a 1% reduction in variable costs of beef production resulted in a $30 million change in economic surplus in 2001 dollars. They also showed that up to 33% of gains from technologies accrued to farmers (weaner producers, grass finishers and backgrounders) and domestic consumers received 50% or more of the gains. Figure 13 contains the estimates from the current analysis of gains in total economic surplus from selection and crossbreeding. It is apparent that the longer the lags in adopting selection improvements in seedstock herds into commercial herds, the lower the NPV.

Figure 13: Gains in economic surplus from selection and crossbreeding

	Selection	Crossbreeding	Total
	2001 $mill.	2001 $mill.	2001 $mill.
Benefits @ 7% - 5/10 year lag	943.9	254.8	1198.7
Benefits @ 7% - 8/13 year lag	720.6	254.8	975.4

11.2 Returns from breed change

The gains from infusing *Bos indicus* genes in the northern herd were estimated as extra revenue initially at the property level. The proportion of *Bos indicus* cattle in the northern herd has risen from 5% in 1970 to around 85% in the 1990s. Improved profit per cow due to cattle tick and drought tolerance of these cattle has resulted in an estimated present value benefit of $110/cow (H. Burrow, pers com). Using a cow population of around 5 million (higher recently), the cumulative aggregate benefits were calculated to be in the order of $10.2 billion in present value terms.

A similar calculation was made for the change in breed percentage in the southern (temperate) herd towards breeds with a greater propensity to marble. The benefits at the property level are based on a premium for such cattle, and were calculated (possibly conservatively) at $25/slaughtered animal (P. Parnell, pers com). Given that the percentage of southern slaughter that is of this type has risen from 9.5% to 22% since 1990, the benefit of this changing breed composition is estimated at $88 million in 2001 dollar terms.

As stated previously, while the initial benefit of these two breed changes accrues to the producer, over time the benefit will be distributed across all sectors of the industry as producers respond to the incentive to supply more of the preferred breeds and the market adjusts to the new set of prices and quantities. So this extra revenue to producers is really an industry benefit, and it would be expected to be distributed in *broadly* the same way as shown in the EDM.

We have not attempted to evaluate longer-term changes, nor the influence of other breeds eg European. However, these analyses have given indicative results for two of the major influences of breed changes in the last 30 years.

12 RESULTS: NET VALUE OF INVESTMENT AND RATES OF INVESTMENT RETURN

A summary of the results of these analyses is shown in Figure 14

Figure 14: Summary of investment returns

		Present Value in $2001		
		Total	**Producers**	**Consumers**
Investments (Industry/Govt)		310 mill.		
Value of semen imports		27 mill.		
Benefits (EDM analysis)		1199 mill.		
NPV (at 7%)		861 mill.	287 mill.	431 mill.
BCR	3.6			
IRR	19%			
Benefits (revenue analysis)				
B i infusion in North		10200 mill.		
Herd mix in South		88 mill.		

12.1 Whole-industry benefit

The investments in genetic improvement totalled $337 million in 2001 dollar terms. This figure is an aggregation of investments by beef producers, government and research agencies and Breed Societies, some dating back to 1963, and includes an estimate of the value of beef semen imports.

If it is assumed that these investments were applied only to selection and cross-breeding, the estimated returns to these investments were $1199 million. So these R&D activities show a healthy return to investment - an NPV of $861 million (at a 7% discount rate), a BCR of 3.6 and an IRR of 19%. If the benefits from selection to BREEDPLAN and non-BREEDPLAN producers are deferred by a further 3 years to 8 and 13 years respectively, the relevant figures are an NPV of $638 million, a BCR of 2.9 and an IRR of 16%.

An acceptable level of return can be gauged from the NSW Government guidelines for economic appraisal (NSW Treasury 1997). The recommended discount rate for public sector projects being economically appraised is 7%, with sensitivity analysis of 4% and 10%. This implies that estimated returns greater than 7% are acceptable in a state government agency context. Even at the higher rate of 10%, the above returns are healthy.

In addition, the industry-revenue benefits from *Bos indicus* infusion in the northern herd were estimated to be $10.2 billion, and the value of premium associated with a change in beef breed mix in the southern herd of $88 million. The benefits from this revenue analysis are over and above the investment return figures in the top part of the table estimated from the EDM analysis. If it is assumed that the R&D inputs were applied to all types of genetic gain measured here, the NPV is increased to something more than $11.1 billion and the BCR is increased to a very healthy 35.1.

12.2 Benefits to producers and consumers

The EDM model structure allows returns to be ascribed to different groups in the industry. Based on previous assessments of the gains to the whole industry from R&D-induced changes at the farm level, the NPV figure of $861 million for selection and crossbreeding can be divided between domestic consumers ($431 million), cattle producers ($287 million) and other sectors of the industry ($145 million). The interaction of supply and demand impacting on quantities produced and consumer willingness to pay has generated substantial benefits to consumers.

A similar precise ascription cannot be made for the other industry-level returns since these benefits were not estimated in the same framework. However it is reasonable to assume that these benefits would be distributed in *broadly* the same way as shown in the EDM. Thus of the $11.5 billion total benefits from beef cattle genetics R&D investment over the past 30 years or so, consumers would have gained about $5.75 billion and producers would have gained about $3.8 billion.

12.3 Attribution of benefits by type and source of investment

It would be potentially very useful to be able to attribute industry returns to particular investments by the various agencies or groups identified as contributing to the R&D process.

A review of the investment groups in Figure 3 shows that there are a number of groups whose impact cannot be divided into a state-base or even a north-south split. The investments by MLA, beef breeders themselves, CSIRO and AGBU (via UNE) would need to be apportioned to state beef industries and an implicit assumption made that impacts were similar on a per animal basis.

It was considered that making such assumptions would be so conjectural that any resulting rate of return estimates would have been subject to an unacceptable error potential. Therefore no such estimates were attempted.

12.4 Relationship to previous research

Alston *et al*. (2000) have recently reviewed almost 300 studies of R&D in agriculture which provided more than 1800 estimates of rates of return. The data period covered 1958 to 1998 and the studies came from a range of universities, government departments and international institutions across both the developed and developing worlds. The rate of return across all studies (some outliers excluded) ranged from -100 to +910. The average was 65. The rate of return for livestock-only studies was not significantly different from this average, but that for research and extension together (47) was significantly less than for research-only studies. When only the benefits to selection and cross-breeding are included, the rate of return calculated in this study is less than the average of the studies included in the Alston *et al.* report. However, the rate of return would be much larger than the average if the changing breed composition in the Northern and Southern herds were also included.

Parnell, Cumming, Farquharson and Sundstrom (1992) estimated that the NSW Agriculture Grafton beef cattle cross-breeding program would yield a NPV of benefits of approximately $170 million by 2020, a BCR of 8.5:1 and an IRR of 13.5%. Corresponding figures for the Trangie/Glen Innes program were $170 million, 3.2:1 and 13.5%. While the aggregate benefits are of course much smaller, the rates of return match those found for selection and crossbreeding in the current study.

In South Africa, Mokoena, Townsend and Kirsten (1999) recently estimated the return on investments in beef cattle performance testing. They found IRRs between 29-44%, compared to IRRs between 19-22% for all animal improvement schemes. Again, these estimates are similar to those found in this study.

In other industries, during 1991/92 the Grains Research and Development Corporation commissioned an independent economic analysis of 16 selected grains R&D projects undertaken over the previous 15 years (GRDC 1992). Using a 10% discount rate, the benefit cost ratios ranged from 3:1 to 297:1, the rates of return ranged from 34% to 561%, and the aggregate present values of the benefits exceeded the aggregate present values of the costs by just over $1 billion. The results from the present study are of similar orders of magnitude.

In a different type of analysis, Nitter *et al*. (1994) estimated the return, cost and profit per cow in the relevant cow population from one round of genetic selection for growth to be $8.14, $1.34 and $6.81, respectively.

13 LIMITATIONS OF THE ANALYSIS

The present study is an economic analysis of returns on all investments made in beef cattle genetics R&D. This was achieved within certain limitations, as described throughout this report. Here, limitations of the analysis are further discussed.

13.1 Definition of genetics investments by agencies

Some agencies had difficulty in providing estimates of genetics R&D costs or in ascribing costs to particular areas of R&D investment. Approximations were used in some cases. The estimated costs provided by CSIRO were incomplete and so may underestimate the real situation. The estimates provided by agencies included extension officer costs that often were not closely linked to defined genetics projects. Such less-targeted efforts may have social or environmental benefits that were not able to be included in the analysis.

The attribution issue comes up against the question of whether the inputs and R&D quality is consistent across agencies, and whether the extension component that encourages industry uptake of technology is consistent across agencies. These aspects can also be influenced by particular industry characteristics, by regional market and production characteristics, and by timing of historical events. These factors make the attribution process less useful.

13.2 Potential for other areas of benefit

The analyses described above are based mainly on higher growth rates, hybrid vigour and greater adaptability to a tropical environment. Other areas of industry potential benefit from genetics R&D that were not included in the analysis are:

- reductions in processor, wholesaler and retailer costs per kg carcase and per kg meat that might be generated by the production of heavier carcases for similar markets;

- demand benefits from the greater eating quality associated with faster growth to slaughter weights. Growth rate is a primary predictor of MSA eating quality score. The changing breed composition in the Southern herd would pick some of this up;
- price benefits and cost of production savings from the greater predictability of performance for animals by genetically well-described sires (eg. from increased market compliance);
- demand benefits to seedstock breeders, semen distributors and service providers from supplying genetically well-described bulls and semen and other services; and
- a full treatment of the increased use of European breeds. Some of this impact is picked up in the measurement of the benefits from selection (see Figures 6 and 7) and some was valued as part of the change in the level of crossbreeding, but there are probably other impacts that have not been measured.

All of these aspects would be worthy of further analysis.

Intellectual property benefits accruing to R&D providers were not valued in the analysis as these are not benefits accruing to industry at large. Such benefits can also be important where they help sustain R&D efforts and technology delivery systems that may be necessary for larger benefits to accrue to industry.

13.3 Attributing benefits to sources of investment

For reasons already raised (see 13.1) very limited capacity existed to attribute benefits to investments by different agencies or to investments in different areas of R&D. Some investments no doubt were more effective than others. Care should consequently be taken in interpreting benefits as applying equivalently across all investment.

It is also possible to attribute effects to different parts of the adoption process. Three areas can be identified here – the industry lag in adoption of breeding technologies, the rate of gain within industry segments, and the uptake (impact) of the technologies at the farm level. Sensitivity analysis was conducted for varying the lag in adoption. As discussed in section 12.1, increasing the lag in adoption from 5/10 years to 8/13 years reduced the IRR from 19 to 16%. This is still a very satisfactory figure compared to the NSW Treasury implied target rate of 7%.

13.4 Retrospective nature of the analysis

The analysis conducted was essentially of how effective investment in genetics R&D has been in the past. Benefits assessed were those from genetic changes occurring by 2000. However some changes, such as the shift to using better-adapted breeds in Northern Australia, are once-only changes. Their effectiveness in the past is useful information to future decisions but the same benefit will not occur again. The permanence and cumulativeness of genetic gains arising from selection, on the other hand, means that benefits from these gains will continue into the future. Discussion with industry representatives suggested that the balance in which breed substitution, crossbreeding and selection within breeds will contribute to future benefits is changing. It appears likely that judicious combining of breed and within breed differences through selection will be the avenue which will best capitalise on investments made to date and yield continuing benefits into the future.

The present analysis is a snapshot of the effectiveness to date of investment in genetics R&D. It should be appreciated that for some areas, such as for genetic gains occurring from selection, measures will change as data become available on animals born in more recent years. Some evidence was provided to the panel that genetic gains are indeed increasing and increasing for traits for which measures have only more recently been introduced to BREEDPLAN (see BREEDPLAN News, Issue 12, April 2002, p.14). Regular reviews of these data might be required to properly reflect changes in traits not covered in the current analysis.

The present analysis did not set out to evaluate the future benefits likely from investment in different areas of genetics R&D. Future investment planning would clearly benefit from such an analysis. Some general principles only were able to be drawn from the present analysis. These are described in the following section.

14 FUTURE R&D INVESTMENT

- Some additional general comments that may be relevant:
  returns on investment are likely to be greater for more closely targeted genetics R&D investments;
- individual agencies investing in genetics R&D will differ in their aims in the extent to which environmental, social and economic benefits are emphasised;
- consideration should be given to ways in which beef cattle genetics R&D can assist environmental sustainability;
- there may be benefit in closer integration between industry decision-support models and the EDM approach; and
- overall R&D investment planning would benefit from a fuller examination of the likely future benefits from genetics compared to other R&D investments.

15 SUMMARY AND CONCLUSION

In summary, the returns to investment in beef cattle genetic improvement within Australia over the last 30 to 40 years have been shown to be very positive. In addition many of these gains are likely to continue into the future, and are likely to grow because of the cumulative nature of the technology.

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