Appendix 1 - Economic Impact Assessment of the CRC for Beef Genetic Technologies

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Introduction

Investing in the CRC for Beef Genetic Technologies was always both a long-term and an uncertain investment due to the fundamental nature of the science being undertaken. Some optimistic claims were made about projected outcomes, but claims that were well justified by the information available at the time the business case was written in June 2004. To quote from the prospectus documentation: *"The explosion in knowledge of genetics, best evidenced by completion of the Human Genome Project (HGP), probably the world's most ambitious and far-reaching biological experiment, started only in 1990 and completed 2 years ahead of schedule in April 2003. The technology developed by the HGP and subsequent genomics research can be applied directly to cattle. One huge outcome of this application of genomics to cattle will be the completion in December 2005 of the 'Bovine Genome Project'. By combining the publicly available bovine genomic sequence with Australian expertise in genomic technology and the CRC's unique genotypic and phenotypic databases, we will be able to understand the genes that control basic biological processes in cattle. The resulting technologies will be easier to apply to cattle than to humans because it is not unethical to control the breeding, growth and development of cattle. Australian beef research will not have another such opportunity this century"* (CRC for Cattle and Beef Quality 2004).

The reality is that while the optimism about the eventual outcome remains and is now beginning to be realised, the process has taken longer and was more incremental than initially anticipated. As well, when the bovine genome sequence was publicly released in 2006, it very quickly became apparent that hundreds of thousands of genes controlled most economically important traits in beef cattle, rather than the very small (5-10) number of genes with major effects that were hypothesised in 2004 to control the basic biological processes in cattle. The Beef CRC's annual reports since 2007 have documented the complex challenges that the CRC has overcome as a result of the very rapidly changing genomics technologies during a period that was arguably the most rapidly changing research environment in the history of biological science.

This report examines how the new information on these uncertain processes has impacted on the overall outcome of the CRC, as defined in the original business case.

The original business case (June 2004)

The original business case for funding of the CRC for Beef Genetic Technologies was documented in CRC for Cattle and Beef Quality (2004) and in Griffith *et al*. (2005). A brief summary is given here to provide a baseline for the alternative scenarios detailed below.

Overall approach: A "top-down" modelling approach was followed. Given the nature of the proposed scientific programs in the CRC (i.e. a lot of interlocking projects, resources applied across a number of projects and outputs from some projects becoming inputs into other projects), it was considered too difficult to allocate costs across individual project areas and to apportion benefits to individual project areas, as would be done in a more traditional “bottom-up” approach. Thus, the emphasis was on estimating the impact of the whole RD&E package, not the impacts of the individual project areas or programs. Overall rates of productivity improvement were examined and the role of technological change in generating this productivity growth was assessed. Expert opinion was used to disaggregate the shares of potential productivity growth due to the CRC across the various outcome areas, and the benefits from the expected shifts in these various outcomes were then estimated.

A critical requirement was to define appropriate "with-CRC" and "without-CRC" scenarios: i.e. to be able to estimate the marginal benefits from the investment by the Commonwealth. This is a critical but difficult requirement because evaluations of investments such as this are concerned with on-going, rather than completely new, research programs. For example, there had been significant past RD&E investments, and there were significant current investments, in the general areas covered in the proposed program of research. There have been, and will be in the future, productivity improvements that result from these earlier programs. These will arise because we are assessing RD&E investments in the beef cattle industry and there are very long biological lags involved in this industry. Second, the nature of the technology under investigation (genetics) means that the impacts of adopting such technologies are spread over a long time period and the impacts accumulate over time. Benefits flowing from past investments, even though they formed the building blocks of some of the new proposals, cannot be claimed to be benefits of the proposed CRC research. Other issues to consider were that there had been a long history of collaboration achieved by researchers and agencies through involvement in the predecessor CRCs, and that the research issues making up the renewed CRC program were the result of substantial consultation between industry and potential core partners.

Applying this broad approach in the context of the selected software package meant consideration of four key parameters.

Potential rates of total factor productivity improvement: Based on documented measured rates of total factor productivity (TFP) improvement of 1.0-1.5 per cent pa (ABARE data) and low rates of adoption of new technologies by the beef industry in the order of 25 per cent (MLA, pers. com. 2004), it was estimated that the potential rate of productivity improvement available to the Australian beef industry at the time of the business case was in the order of 5 per cent pa. The adoption rate for genetic technologies was higher than 25 per cent, based on the proportion of the breeding herd mated to BREEDPLAN registered bulls (around 30 per cent; Farquharson *et al*. 2003), so the adoption of non-genetic technologies was less than 25 per cent.

We estimated the aggregate impact of the renewed CRC on the Australian cattle and beef industry to be an additional 4 per cent in the potential annual rate of productivity improvement (i.e. 9 per cent). This would occur after maximum adoption of the research outcomes of the CRC. Such a figure reflected the expectation that the majority of benefits would be related to improvements in genetic merit, and so there would be a strong relationship between the level of explanation of genetic variance and potential productivity gains. This expectation was supported by: i) recent estimates of the benefits of specific genetic technologies (e.g. Burrow *et al*., 2003,a,b; Farquharson *et al*., 2003; Griffith *et al*., 2004); ii) the strong expectations by the scientists involved that CRC funding would provide the resources necessary to repeat these types of successes in the future (in particular that 5-10 DNA markers could be discovered that would explain something like 50 per cent of the genetic variance in traits of interest); and iii) the estimates by Manson and Black (2004) that the great majority of the measured rates of productivity improvement in the Australian beef industry are attributable to RD&E investment. Although a 9 per cent rate of potential productivity improvement seems large, when this rate is multiplied by an expected adoption level of 35 per cent (reflecting the additional ambition of the CRC to increase the industry adoption rate from 25 per cent in 2004 to 35 per cent by 2012), it is noteworthy that the implied actual or measured rate of productivity improvement is only just over 3 per cent. The Australian grains industry exceeded 3 per cent annual productivity growth long ago and according to the ABARE data available at the time, the northern Australian beef industry was close to 3 per cent already.

Distribution of the overall rates of productivity improvement: The wide range of participants in the CRC application reached some consensus on the relative contributions of each of the seven major outcome areas to the success of the new CRC. We used these consensus estimates to allocate the selected overall potential rate of productivity improvement across different types of impacts and different regions, based on the RD&E activities in the various proposed programs of research. These shares are shown in Table 1. That is, 20 per cent of the total productivity impact from the beef quality improvement outcome, 10 per cent from the reduced feed cost outcome, etc. We took these overall allocations to relate to the whole Australian beef industry. Based on the material provided for each of the science programs in the Prospectus document (CRC for Cattle and Beef Quality, 2004), we allocated these impacts as cost-saving (C), yield-increasing (Y) or demand-enhancing (D), and as applying to either the Northern industry, the Southern industry, or to both.

Table 1. Original 'With-CRC' scenario components of growth

Program area	**Weighting**	**North C or Y**		**South C or Y**		**Demand D**	
Increased beef quality	0.20	C	0.90	C	0.90	D	0.90
Reduced feed cost	0.10	C	0.45	C	1.35		
Reduced parasite input cost	0.10	C	1.80	C	0.00		
Increased market access	0.10					D	0.90
Increased meat yield	0.10	Y	0.90	Y	0.90		
Increased reproductive rate	0.30	Y	2.70	Y	2.70		
Misc. enhanced management	0.10	C	0.90	C	0.90		

Thus, in the first data row of the table, 20 per cent of the 9 per cent overall potential productivity figure, or 1.8 per cent, was estimated to be due to increased beef quality (Program 1). Half of this 1.8 per cent was assumed to directly influence consumer demand in the domestic and major export markets; the other half was assumed to be reflected in reduced transaction costs throughout the marketing chain. These costs were further assumed to be split 50:50 between the northern and southern beef industries (since cattle numbers were assumed to be approximately 50:50 between the north and the south over the simulation period), so each region has the same cost saving of 0.9 per cent. Similar types of arguments were made to generate the other specific types of total factor productivity improvements that would be applied to each region.

Adoption rates and levels: Because of their biology, cattle genetic technologies have small initial impacts that slowly accumulate in the population over time. Thus we would normally expect the adoption process to be spread over many years. However, here we allowed planned CRC commercialisation and adoption strategies to also contribute to the adoption of existing pipeline stocks of technologies produced from previous CRCs or elsewhere. There was an explicit focus on accelerated adoption methodologies and industry take-up of the outcomes generated (in particular, a continuous improvement and innovation cycle), and the RD&E itself was planned to be more coordinated and intense. Thus it was expected there would be some measurable change in adoption of new technologies, attributable to CRC activity, in the short to medium term, that is, shorter lags in achieving results and in industry adopting them, and an overall higher level of industry adoption, than would otherwise be the case. This would be driven by higher accuracies for EBVs which would induce greater use of BREEDPLAN registered bulls, and a significant improvement in the adoption of the non-genetic technologies generated by the CRC. Thus, we assumed a 5-year R&D lag, a maximum adoption level of 35 per cent and a 2-year lag till that level was reached. That is, the maximum annual benefit is expected to be achieved in 2012/2013. This was in contrast to the business-as-usual case of a 7-year R&D lag, a maximum adoption level of 25 per cent and a 5-year lag till that level was reached (in 2017/2018).

Risk of failure: With the provision of more specific resources for equipment etc., we also assumed that the overall quality of the R&D would be slightly enhanced when the CRC was funded, with higher probabilities of successful outputs. The overall probability of success was assumed to be 80 per cent, instead of 70 per cent in the business-as-usual case.

Results

These key assumptions were used as inputs into separate scenarios for each of the demand and supply shifts using the DREAM modelling framework (Griffith *et al.,* 2005). A consistent set of price and quantity data for a representative year (2001/2002) and a consistent set of producer and consumer responsiveness parameters were used to calibrate the model. Various scenarios were run over a 25-year time horizon and the return on investment criteria calculated using a 4 per cent real discount rate. The main results are shown in Table 2.

The total benefits from the demand-enhancing components of the portfolio had a present value of about $593 million when summed over the 25-year simulation period. More than half the benefits accrued to consumers in export markets because of the greater size of these markets and the higher prices that consumers in these markets are willing to pay for higher quality, compared to Australian consumers. Producers in our export markets, and in competing supply regions, also gained from this investment since the overall demand for beef is increased and they are large suppliers to these markets. Domestic producers and consumers gained about $125 million from these impact areas. The annual benefit of this set of impacts was around $55 million after reaching maximum adoption levels, with about $12 million accruing in Australia.

The total benefits from the cost-reducing and yield-increasing components of the portfolio had a present value of about $1.337 billion when summed over the 25-year simulation period. The great majority of these benefits accrued to cattle producers in Australia because they have direct access to the new technologies. Consumers in our export markets were also beneficiaries as they have access to more beef at lower prices. However, producers in competing supply regions lose from the research program since they suffer the consequence of an overall fall in prices but do not have the cost savings from the technologies to compensate. The annual benefit of this set of impacts is about $124 million after reaching maximum adoption levels, with almost all of this accruing in Australia.

Total estimated benefits from the with-CRC scenarios therefore were around $1.930 billion. With the full costs of the CRC program (nominally expected to be $110m) having a present value of around $98 million when discounted at the same rate as the benefits, this results in a Net Present Value of $1.831 billion ($1.930 billion - $98 million) and a Benefit Cost Ratio of 19.65:1 ($1.930 billion/$98 million). Thus, under the set of assumptions made in 2004, the proposed research portfolio of the CRC for Beef Genetic Technologies was expected to return around $20 to the Australian beef industry for every $1 invested from all sources.

Table 2. Original Results for the With-CRC Scenarios, 2006-2030

Shift	**Region**	**Producer Benefits**	**Consumer Benefits**	**Total Benefits**	**Total Cost**	**NPV**	**BCR**
Demand	Northern Australia	5	21	26			
	Southern Australia	5	95	100			
	Export markets	152	315	467			
	All markets	162	431	593			
Supply	Northern Australia	691	1	692			
	Southern Australia	628	5	633			
	Export markets	-299	311	12			
	All markets	1020	317	1337			
TOTAL		**1182**	**748**	**1930**	**98**	**1832**	**20**

$ million Present Value over 25 years discounted at 4 per cent real.

Re-assessing the original business case in May 2012

Given the modelling philosophy adopted and the specific software chosen for the analysis, any changes made to the initial assumptions have to be couched in terms of changes to one of the four parameter values.

The major recognised uncertainty from the original ‘With-CRC’ model relates to the expected timeline and outputs stemming from the ‘DNA markers’ research program and their consequent use by the seedstock sector and commercial beef producers to generate industry benefits. Issues documented in successive CRC annual reports related to the CRC’s difficulty of achieving independent validation of DNA markers, the greatly increased numbers of DNA markers that were associated with each economically important trait, the lower levels of explanation of genetic variance for each set of DNA markers and changes in the genomic technology that required significantly increased numbers of animal records than originally anticipated to validate results.

As shown in Table 3, there are expected positive relationships between the biophysical measures of level of genetic variance explained and EBV accuracy and the economic measure of level of potential total factor productivity. So a decline in accuracy will lead to a lower expected productivity gain following maximum adoption of research outcomes. Ten per cent of explained variance would imply 6 per cent potential productivity growth, 15 per cent would imply 6.5 per cent potential productivity growth, and so on.

Some of the initial assumptions made were changed for the mid-term review of the CRC in 2009/10. In particular, as the difficulty of the gene discovery task became clearer, expectations about the level of genetic variance that could reasonably be explained by gene markers were reduced from 50 per cent to at least 15 per cent, the sum of the R&D lag and adoption lag was lengthened from 7 years to at least 10 years, and the maximum level of industry adoption was reduced from 35 per cent to 30 per cent. Based on the relationships shown in Table 3, the implied potential TFP generated from the CRCs R&D portfolio was wound back from 9 per cent to around 7 per cent. The components of potential productivity (meat quality, feed savings, reproduction, etc) were also changed a little from those reported in Table 2 to reflect results to date in the various project areas.

Table 3. Level of genetic variance explained and overall rate of potential productivity improvement

Level of genetic variance explained	**Implied level of EBV accuracy**	**Overall rate of potential productivity improvement**
WITH CRC CASE		
50 per cent	70 per cent	9 per cent
30 per cent	55 per cent	8 per cent
20 per cent	45 per cent	7 per cent
10 per cent	30 per cent	6 per cent
WITHOUT CRC CASE		
5 per cent	20 per cent	5 per cent

Until recently, the genetics and non-genetics components of the portfolio have been lumped together and the same rates of productivity improvement and the same adoption lags and levels have been applied to both areas. However there is now recognition of the substantial differences between the genetic and non-genetic components of the portfolio in terms of these key parameters. To properly specify DREAM for the exit analysis we have to go back and separate out the initial assumptions into genetics and non-genetics components.

So for the baseline in the initial bid analysis, we assume the 5 per cent potential TFP annual gain was composed equally of genetic and non-genetic technologies i.e. 2.5 per cent genetics and 2.5 per cent non-genetics. Further assume that the growth to 9 per cent potential TFP due to the CRC investment was all due to genetic progress i.e. genetics 2.5 per cent to 6.5 per cent, non-genetics stays at 2.5 per cent. Thus for the changes foreshadowed during the mid-term review, growth in genetics was wound back from 6.5 per cent to 4.5 per cent, while non-genetics stays at 2.5 per cent. This gives an aggregate potential TFP of 7 per cent.

We know that adoption of genetic technologies is around 30 per cent (proportion of cows mated to BREEDPLAN registered bulls), so if MLA assumes that average adoption over all technologies is 25 per cent and genetics and non-genetics technologies are equally weighted, then adoption of non-genetics technologies is 20 per cent.

Now, average accuracies of BREEDPLAN traits have been confirmed at around 30 per cent from the genomics prediction equations, which implies explanation of variance of around 10 per cent which implies aggregate potential TFP of 6 per cent based on the analysis for the mid-term review. An additional 5 per cent accuracy is assumed to arise from the extra collection and analysis of phenotypic data from several of the CRC projects and from ongoing analysis of past CRC databases (Appendix 10). This would mean growth in genetics should be wound back further to 4.0 per cent, giving gives an aggregate potential TFP of 6.5 per cent.

However, based on the results from the Impact Tool, we can now show that the value of the CRCs non-genetics technologies have at least partially compensated for the reduced accuracies in the genomic selection component of the portfolio. Growth in the non-genetics components are assumed to increase from 2.5 per cent to 4.5 per cent. Non-genetics includes both on-farm productivity and improved market access through improvements in meat quality and animal welfare attributes, so the total 4.5 per cent is split into supply side and demand side impacts. At the increased level of non-genetics growth, the aggregate potential TFP is 8.5 per cent.

As part of this unpacking of genetics from non-genetics, the original components of growth were divided into genetics and non-genetics and then re-weighted so the weighted average matched the overall potential TFP figures. With slight differences in the impact of some of the components across the north and the south, this gives slightly different productivity shifts for different states.

The final option involves varying levels of adoption lag (years) and adoption uptake (percentage). In the 2004 analysis there was an explicit focus on accelerated adoption methodologies and industry take-up of the outcomes generated (in particular, a continuous improvement and innovation cycle) and the RD&E itself was planned to deliver earlier (marker-by-marker from 2007 rather than prediction equations based on all markers in 2012). Thus it was expected there would be some measurable change in adoption of new technologies, attributable to CRC activity, in the short to medium term i.e. shorter lags in achieving results and in industry adopting them and an overall higher level of industry adoption than would otherwise be the case.

In reality, the accelerated adoption project (Griffith 2008) took longer to design and implement than originally anticipated and consequently, while the project is now progressing very well, actual evidence of the accelerated adoption of new genetic technologies has not been as strong as expected (Parnell *et al*. 2008). As well, the delayed discovery of DNA markers associated with economically important traits has delayed reaching those levels of variance required to induce rapid and/or widespread adoption.

The time sequences for the various individual products spelt out in the Impact Tool were then used to define average R&D lags, average adoption lags and average adoption levels across the genetics and non-genetics areas, separately. These are shown in Table 4.

No changes were made to the figure of 80 per cent for the overall probability of successful outputs from the whole CRC portfolio. Of the 19 separate identified products, only that related to gene expression for female reproduction was not delivered as planned, and there were a number of additional products that were delivered due to additional funding received.

Before deciding on the new parameters for input into DREAM, one more major change needed to be made. Working through the detailed “bottom-up” analyses reported in the Impact Tool, and in particular using a gene flow spreadsheet to accurately track the rate of genetic gain from the now more accurate EBVs, shows that in the DREAM analyses to date the underlying rate of genetic progress already in train from past R&D investments was not properly netted out, including in the original 2004 analyses. Even though it was explicitly stated "*Benefits flowing from past investments, even though they formed the building blocks of some of the new proposals, cannot be claimed to be benefits of the proposed CRC research*", that was inadvertently overlooked for the case of the underlying rate of genetic gain. The with-CRC case summarised in Table 2 is therefore overstated to the extent that the assumed "with" potential TFP (9 per cent) already accounts for the base rate of TFP in the business as usual case (assumed as above to be 2.5 per cent). Hence all the simulations were re-run to recreate the "with-CRC" scenario using the net rate of potential TFP for the genetics component. Thus the productivity improvement parameters in the supply side scenarios were all reduced by 2.5 per cent. These new "with-CRC" results are shown in Table 5.

The situation as at 30 April 2012 was used to define the worst case scenario (Table 4). This uses the average estimated EBV accuracies through the addition of genomics information released on that date, and discussions with project leaders and program managers responsible for the various CRC products. On the supply side, potential TFP values are as described above (4.0 per cent gross for genetics minus 2.5 per cent underlying growth, and 4.5 per cent for non-genetics split up as 3.5 per cent for supply effects and 1.0 per cent for demand effects); a 7 year R&D lag for genetics (accuracies released recently, enhanced EBVs will be used in 2012/13) and a 5 year R&D lag for non-genetics (many of the products have already been released and are being used); a 5 year adoption lag for genetics (1 generation interval) and slightly shorter for non-genetics; and adoption levels no better than the base case (35 per cent for genetics and 20 per cent for non-genetics). On the demand side, the R&D lag is the same as the supply side; the adoption lag is shorter as the two big drivers, meat quality programs and animal welfare, are already well entrenched in industry policies; and the adoption level is set at 5 per cent of the three major quality markets (Japan, Korea and the US) to reflect Australia's limited ability to influence many consumers in those markets.

The current/worst case scenario was modelled over a 15 year time horizon and a 5 per cent discount rate to try and match as closely as possible the results from the Impact Tool. The models have quite different philosophies and different parameter inputs, but some small adjustments to the DREAM parameters were made to produce a similar balance in component areas as the 15 year scenario as the Impact Tool.

The most likely scenario (Table 4) reflects an improvement in the level of EBV accuracy to the targeted 40 per cent based on current R&D and a consequent improvement in the accuracies of EBVs and an improvement in the speed with which non-genetic technologies are adopted by industry.

The best case scenario (Table 4) reflects possible further improvements in potential TFP from both the genetics and non-genetics portfolios and associated improvements in adoption levels over the next few months.

Results from re-assessing the original business case in May 2012

The results of these simulation runs are shown in Table 5, by scenario, source of impact and market segment.

Table 4. Assumptions for the DREAM Analysis (based on 2012 information)

Scenario and Component	Potential Total Factor Productivity	R&D Lag	Adoption lag	Maximum Adoption Level
Worst case Genetic Supply	4.0-2.5=1.5 (South=1.59; North=1.40)	7	5	35
Non-genetic Supply	3.50 (South=4.0; North=3.0)	5	4	20
Non-genetic Demand	1.00	5	2	5
Most Likely Genetic Supply	4.5-2.5=2.0 (South=2.12; North=1.88)	7	5	35
Non-genetic Supply	3.75 (South=4.28; North=3.24)	5	2	20
Non-genetic Demand	1.25	5	2	5
Best case Genetic Supply	4.5-2.5=2.0 (South=2.12; North=1.88)	7	5	40
Non-genetic Supply	4.00 (South=4.57; North=3.43)	5	2	25
Non-genetic Demand	1.50	5	2	5

Table 5. Results from the DREAM Analysis (given 2012 information based on 2001 model version), by scenario, type of impact and market segment

Scenario and Component	Producer Benefit	Consumer Benefit	Total Benefit	Total Cost	NPV	BCR
Without-CRC analysis from the initial bid	316	200	516	58	458	8.9
Worst case Genetic Supply	140	44	184			
Non-genetic Supply	266	84	350			
Non-genetic Demand	136	114	250			
Total	542	242	784	111	673	7.1
Most Likely Genetic Supply	218	68	287			
Non-genetic Supply	308	97	405			
Non-genetic Demand	170	143	313			
Total	696	308	1004	111	893	9.0
Best case Genetic Supply	250	78	328			
Non-genetic Supply	410	129	537			
Non-genetic Demand	204	171	375			
Total	864	378	1242	111	1131	11.2
With-CRC analysis from the initial bid	(new) 817 (original) 1182	635 748	1453 1930	98 98	1355 1832	14.8 20.0

$ million Present Value over 25 years discounted at 4 per cent real

Although there are a wide range of potential outcomes, all scenarios offered an improved level of benefit to the beef and cattle industry over the ‘Without-CRC’ scenario in the original business case. The worst case scenario provides net benefits to the beef industry almost 50 per cent greater than the estimated business as usual case, the most likely case provides close to double the base case, and the optimistic best case generates over $670m more than the base case. However even the best case falls short of the (revised) 2004 estimate for net benefits by some $225m. This is the net effect of the difficulties and time delays associated with the DNA marker discovery projects, which could not be recovered by the subsequent adaptations to work plans and readjustment towards the non-genetics components of the portfolio. The most likely and best case scenarios also generate greater returns per $ spent on R&D than the business as usual case.

Although not reported here, as expected, the calculated benefits increase with increasing potential productivity, increasing maximum adoption level and decreasing adoption lag. The lowest NPV is $673m for the lowest aggregate potential productivity growth (8.5 per cent), the lowest set of maximum adoption levels (35, 20 per cent) and the longest set of adoption lag (5, 4 years). The highest NPV is $1131m for the highest aggregate potential productivity growth (10 per cent), highest set of maximum adoption levels (40, 25 per cent) and shortest set of adoption lags (5, 2 years). The results are most sensitive to potential productivity gain and adoption level and less sensitive to adoption lag given the low discount rate used.

In terms of which source contributes and which segment benefits, the non-genetic supply component contributes over 40 per cent of the benefits across all scenarios. This is consistent with the results from the Impact Tool where in the first 15 years of the benefits stream the non-genetics components heavily outweighed the genetics components. Improved market access provides a little over 30 per cent, and genetics improvements in aggregate a little under 30 per cent, across all scenarios. In aggregate, both beef producers and beef consumers gain, with producers taking about 70 per cent of the aggregate benefits across all scenarios. Here beef “consumers” are defined as all participants in the value chain post farm gate.

Another way of looking at the results is given in Table 6. Here, only for the most likely scenario, the aggregate gross benefit of approximately $1 billion is broken down by source of impact, market segment and region.

In aggregate, southern Australian beef producers gain about 55 per cent of the returns from genetics supply and non-genetics supply impacts, with northern Australian beef producers picking up about 45 per cent. Australian consumers gain almost no benefit, and consumers in our major markets gain, but at the expense of beef producers in those markets. This is a typical pattern for a cost-reducing type of technology, where producers who cannot or do not adopt the technology suffer the consequences of the inevitable price decline but do not have the savings from the technology to offset it.

The increased willingness to pay in our major markets from the market access scenario leads to price rises in all markets. Foreign consumers gain because their increased willingness to pay is greater than the price rise, and foreign beef producers gain as it is now more profitable to supply beef. Australian producers benefit just a little, as price changes are not transmitted perfectly around the world, but Australian consumers are harmed as prices rise but their willingness to pay is not greater (in this scenario).

Table 6. Results from the DREAM Analysis, most likely case (given 2012 information based on 2001 model version), by type of impact, market segment and region

Component	**Region**	**Producer Benefit**	**Consumer Benefit**	**Total Benefit**
Genetic Supply	Southern Australia	152	1	153
	Northern Australia	131	0	131
	Export markets	-64	67	3
	All markets	218	68	287
Non-genetic Supply	Southern Australia	230	2	232
	Northern Australia	169	0	169
	Export markets	-91	95	4
	All markets	308	97	405
Non-genetic Demand	Southern Australia	5	-3	2
	Northern Australia	5	-1	5
	Export markets	160	146	306
	All markets	170	143	313
All Sources		696	308	1004

$ million Present Value over 25 years discounted at 4 per cent real.

Conclusion

In re-assessing the original estimates of economic benefit from the CRC, the most prominent issues to consider were the potential total productivity growth occurring in the beef and cattle industries as a result of CRC technologies, how each research program contributes to the overall productivity gain, the level of adoption of the technologies by industry and the time lag of these technologies.

This paper has reviewed the impact of adjusting these four variables on the total economic benefit of the CRC to the beef and cattle industry, given information available as at May 2012. A reduction in productivity gains has the largest impact on benefit to industry, followed by a reduction in the expected maximum level of adoption. Research program components of growth, R&D rates and adoption lags have more marginal impacts.

Whilst the estimated economic benefits of the Beef CRC to industry varies substantially according to the mix of assumptions used relating to the key parameters, it is important to note that even with the most adverse scenario the Beef CRC is still expected to generate a superior total benefit to the industry ($784m) over the ‘Without-CRC’ scenario ($516m). The most likely scenario as assessed at this point in time, delivers an expected industry benefit of $1004m, almost twice that of the “Without-CRC” scenario. This would provide a return on investment of around $9 for every $1 invested into the Beef CRC.

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