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Development of supply chain objective measurement (OM) strategy & value proposition to stakeholders

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Abstract

The red meat industry does not currently have all the measurement technologies and systems available and/or adopted that might assist to optimise red meat value within the supply chain. However, advances in objective measurement on the live animal, carcase or cuts have the potential to assist the red meat industry by improving efficiency and underpinning a new value-based transaction model.

All sectors of industry recognise that value is being lost through inaccurate measurement or appraisal systems and that this could be improved by addressing the current objective measurement-related limitations. There is also recognition across the industry of the need for change.

By modelling the potential impact of a small number of 'benefit scenarios' associated with greater use of objective measurement, associated pricing signals and resultant on-farm management changes across the red meat value-chain, this report estimates that around $420 million of potential gross benefit per annum exists by 2030. Less than $75 million of this is likely to be realised by 2020 while around $250 million could be realised by 2030. The difference between potential benefit and likely benefit is the gap between opportunity and the level of adoption.

These benefits were estimated to be split equally between producer and off-farm sectors of the supply chain over time in most of the scenarios modelled.

Executive summary

The Australian red meat industry does not currently have all the measurement systems available and/or adopted that might further improve red meat value within the supply chain. However, advances in objective measurement (OM) have the potential to assist the red meat industry by improving efficiency and underpinning a new value-based transaction model.

All sectors of industry recognise that value is being lost through inaccurate measurement or appraisal systems and that this could be improved by addressing the current objective measurement-related limitations. There is willingness across the industry for change and the delivery of the benefit scenarios in this report provides an indication of the value potentially available from doing so. Figure 1 provides a summary of the potential value opportunity for the red-meat industry by 2020 and 2030 from modelling a small number of benefit scenarios as summarised in Table 1.

While objective measurement opportunities lay at both the live animal and carcase level, for the purposes of this study only carcase measurement is modelled.

This report identifies that around $420 million per annum of potential gross benefit exists from the adoption of further objective measurements, associated pricing signals and resultant on-farm management changes by 2030. Less than $75 million of this is likely to be realised by 2020 while around $250 million is potentially realisable by 2030. The difference between potential benefit and likely benefit is the gap between opportunity and the level of industry adoption. These benefits were estimated to be split equally between producer and off-farm sectors of the supply chain in most of the scenarios modelled.

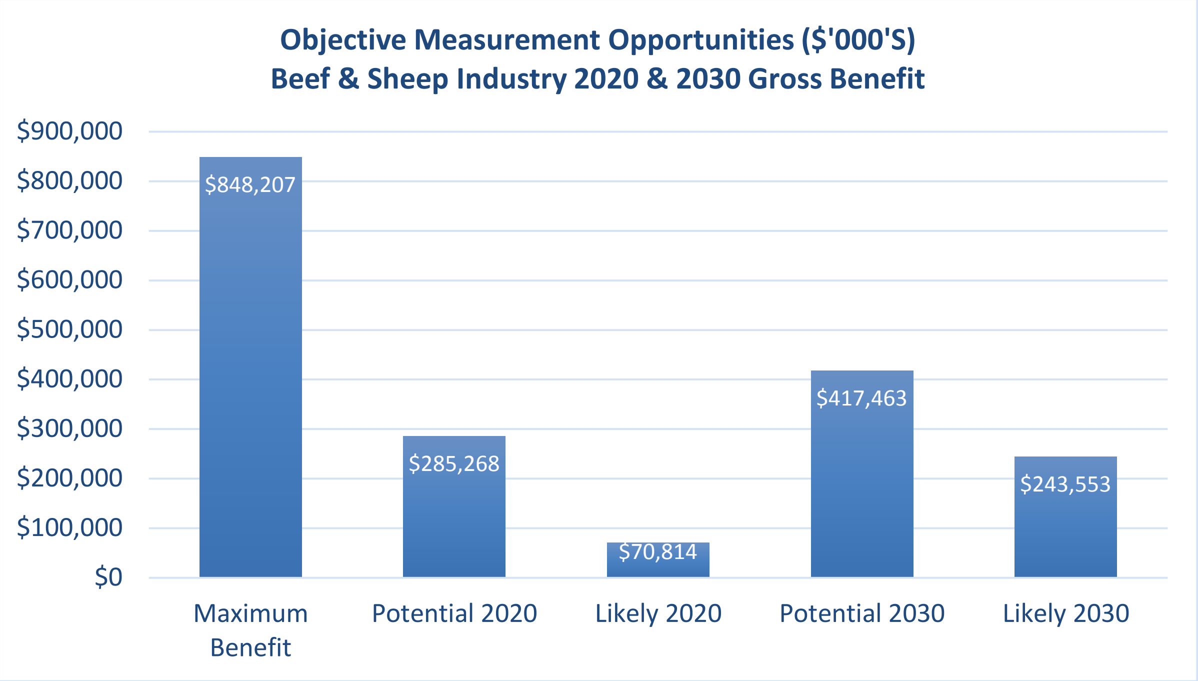

Figure 1: Objective measurement potential value opportunity for the red-meat industry by 2020 and 2030[1].

Note that estimates of 2020 value are considered optimistic given that some objective measures such as IMF in lamb and LMY in beef are not yet available. Unless some other strategy is developed to increase rate of change, these estimates will be difficult to achieve.

Potential benefits have been calculated for the following:

- Potential benefit – considers where in the chain the measure is applied, likely measurement accuracy and magnitude of change that can be effected when measured at that point assuming 100% adoption of the measure.
- Likely adoption benefit – potential benefit adjusted downwards for expected adoption rate at each supply chain measurement point. Note that the adoption rates used for modelling benefits exclude fast tracking the rollout of DEXA systems for lean meat yield measurement, as currently being considered by the red meat industry.

As noted above, to identify the opportunities that may be available from improved measurement systems across the red meat supply chain, several benefit scenarios were developed and modelled. Benefit scenarios estimate the combined value of a group of attributes or characteristics that may be impacted using objective measurement. These scenarios are summarised in Table 1, along with the species and production system to which they apply. The benefit scenarios considered attributes such as:

- What measurement traits are important – and to whom are they important and who might benefit?
- Where can / should these traits be measured?
- What level of accuracy may be needed – and who will benefit from improvements in accuracy?
- Are there any important correlations between traits – either favourable or unfavourable?

Table 1: Industry sector potential value realisation from each scenario

OM benefit scenarios	BEEF				SHEEP		
	Extensive Northern	Reliable Environment	Feedlot	Processing	Lamb	Hogget	Processing
S1 - Increasing lean meat yield but maintaining eating quality		✓	✓	✓	✓	✓	✓
S2 - Increasing lean meat yield but maintaining pH	✓			✓		✓	
S3 - Increasing feedlot quality but maintaining turn-off times			✓	✓			
S4 - Improving animal health	✓	✓	✓	✓	✓	✓	✓
S5 - Optimise livestock purchased to market specifications				✓			✓
S6 - Fabrication of purchased livestock to optimise value				✓			✓
✓ *where the most value will be realised*							

For scenarios 1 through to 4, benefits are estimated to be equally split between producer and off-farm sectors of the supply chain. For scenarios 5 and 6, initial benefits would accrue to the processing sectors, although in the long-term it is anticipated that redistribution would accrue to other supply chain sectors.

Each scenario is briefly summarised below:

1. **Increasing lean meat yield but maintaining or improving eating quality –** Together, Lean Meat Yield (LMY) and Eating Quality (EQ) largely determine total carcase value. This scenario applies to 100% of **lamb** production and 60% of **beef** production where reliable environment and broad market access reward a mix of quality and yield.
2. **Increasing lean meat yield but maintaining pH** – 'Dark cutters' impose significant discounts on beef carcases[2]. This scenario applies primarily to 30% of beef production in more unreliable environments where conditions make it more difficult to get a return on investment in EQ in Scenario 1.
3. **Increasing feedlot marbling quality but optimising turn-off times -** This scenario applies to feedlot animals destined for high quality markets where marbling (MB) has a greater impact on finished product value than lean meat yield (estimated to be 10% of beef production), but more efficient feed conversion (negatively correlated to MB[3,4,5]) is required for higher profitability.
4. **Improving animal health -** This scenario considers the value opportunity for managing animal health issues that impact both the production and processing sectors across the beef and lamb industries by the provision of animal health feedback from processors to producers.
5. **Improved processing efficiencies -** Initially a processor benefit of improved carcase sortation to customer specifications using accurate carcase objective measures to increase productivity within the processing plant.

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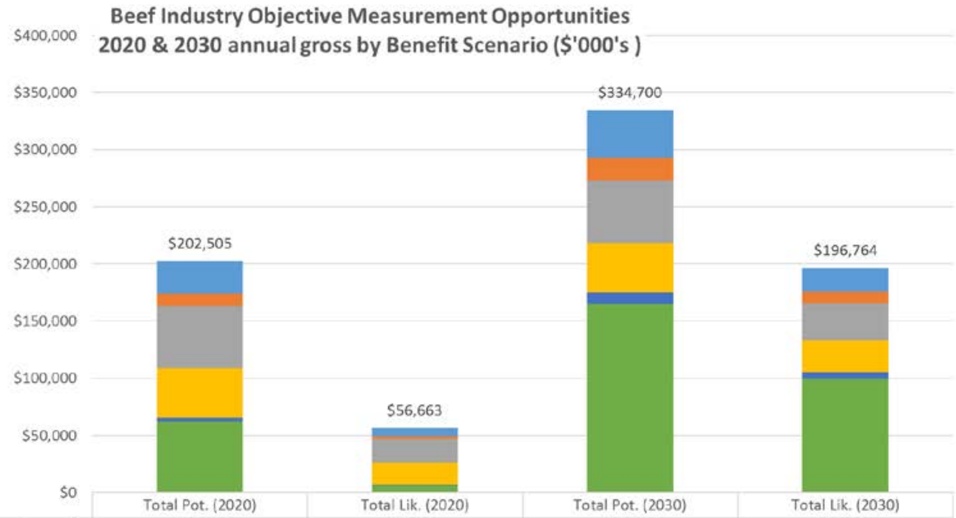
[2] McGilchrist P (2012). Beef CRC Fact Sheet: Producers can eliminate 'Dark Cutting'. *CRC for beef genetic technologies*.
[3] Ewers (et. al.) (1999) Saleable beef yield and other carcass traits in progeny of Hereford cows mated to seven sire breeds
[4] Cartens G, Genho P, Miller R, Moore S, Pollak J, Tedeschi L (2005). Determine the genetic and phenotypic variance of meat quality traits and their interrelationships with economically important traits in bos indicus type cattle. *National Cattlemen's Beef Association*. The Beef Checkoff. Page 4.
[5] Arthur J, Herd R (2008). Residual feed intake in beef cattle. *Revista Brasileira de Zootecnia* (37). ISSN 1806-9290.

6. **Fabrication of purchased livestock to optimise value -** Objective measures will enable more accurate processor sales pricing decisions that support boning schedules to extract increased value from carcases.

Beef and lamb industry benefits for each scenario in Figure 2 and Figure 3 indicate:

- Scenarios 1 through 4 deliver the greatest short-term value for beef.
- Scenarios 1 and 4 deliver the greatest short-term value for lamb (Scenarios 2 and 3 do not readily apply to lamb).
- Scenario 6 delivers far greater value over the longer-term (2030) than the shorter term (2020) for both beef and lamb, and assumes that processor profit is distributed up and down the chain over time.



	Total Pot. (2020)	Total Lik. (2020)	Total Pot. (2030)	Total Lik. (2030)
S1 - Increasing lean meat yield but maintaining eating quality	$28,310	$7,236	$42,106	$21,057
S2 - Increasing lean meat yield but maintaining pH	$11,009	$2,196	$19,878	$10,099
S3 - Increasing feedlot quality but maintaining turn-off times	$54,522	$21,334	$54,522	$32,546
S4 - Improving animal health	$42,946	$19,326	$42,946	$27,915
S5 - Optimise livestock purchased to market specifications	$3,718	$372	$9,915	$5,949
S6 - Fabrication of purchased livestock to optimise value	$61,999	$6,200	$165,332	$99,199
Cumulative total of Benefit Scenarios	$202,505	$56,663	$334,700	$196,764

Figure 2: Potential beef industry value created from OM by benefit scenario relative to maximum opportunity

Figure 3: Potential sheep industry value created from OM by benefit scenario relative to maximum opportunity

If the above opportunities are to be realised by industry, transformational changes are required. These include the use of new measurement technologies, changes to existing pricing systems, producer extension and capability building as well as successful implementation of new business processes and systems in areas such as information exchange, decision support tools, market reporting, communication and traceability. The priority and timing of key enablers have been summarised in Table 2.

Table 2: Key enablers to realise industry value

Key Enablers	Description	Priority+
Technologies / objective trait measurement	1. Commercial installation of objective measurement systems at processing	
	a. Lamb intramuscular fat (IMF)	1
	b. Beef and Lamb LMY	1
	c. Beef pH/MC – inaccuracy of current measures which do not align to consumer value	2
	d. Beef eating quality – replace existing MSA assessments with objective measures to predict EQ	3
	2. Objective measures in live animals:	
	a. Genomic testing to aid management decisions (e.g. lamb yield and IMF, beef marbling pre-feedlot etc.)	2
	b. Scanning for prediction of yield and quality+	3
	+*Important but likely more difficult and not at the expense of processor measures that will have faster and wider industry adoption.*	
	3. Management decisions enhanced by individual sheep ID – will speed genotypic and phenotypic gain but not as significantly as objective measures.	3
Calibration of measurements / trust	4. Coordinated third party maintenance of standards and accuracies across (potentially) multiple measurement technologies and installations.	2
	5. Industry visibility of measurement standards and accuracy demonstrated to instil confidence and trust in new measurement and trading systems.	2

Data transfer standards	6. Agreed standards and mechanisms for data transfer from measurement technologies to support interoperability between supply chains. 7. Animal health data capture and transfer protocols established.	3 3
Value based trading (VBT)	8. Support for industry uptake of VBT that is aligned with consumer value traits (including eating quality, yield, and pH) and animal health.	1
Feedback systems / price transparency	9. Development of company and industry feedback systems that link objective measures to value for improved price transparency. 10. Capture and feedback of subjective/objective animal health data captured within a processing plant. 11. Support for integration of objective measures into multiple decision support systems along the supply chain. *(for example, breeding values, on-farm and processor decision support tools, online auction systems, pricing grids, market reporting, underpinning of consumer value propositions)*	1 1 3
Market reporting	12. New market reporting approaches that align objective measures to consumer value and support industry to adopt VBT. 13. Increase in industry awareness and understanding of the role of objective measures in new market reporting approaches.	1 2
Internal processor traceability and decision support systems	14. Support for development of sortation and fabrication systems at processing that realise increased value of higher-worth livestock to maximise value from VBT.	1
Producer/seedstock extension programs	15. Greater understanding of objective measures, their relationship with consumer value and how on-farm activities and management decisions impact them to enable continuous improvement. 16. Development and delivery of industry-based training programs to maximise industry understanding and use of feedback systems.	1 2

*+**1** - Critical to realising direct industry value or indirectly (trust, information transfer etc.). Limits benefit of other correlated factors that would otherwise deliver value.*
***2** - Improves on existing effective measures, delivering greater value increases (increased accuracy or rate of information transfer).*
***3** - Provides efficiency or cost effective alternatives to existing measures / assessments with less industry benefit but potential adoption increase.*

Transitioning to greater industry value might progress as follows:

Short term (2-3 years)

The most likely impacts in moving to a system which is based on more objective measurement and value-based pricing include the following:

- There will be both winners and losers amongst producers as new payment methods reward better quality more accurately and identify where current systems overpay for waste / lower quality[6].
- There will be a lag in value increase because initially (at least) livestock supplied will be no different – and this will not change until feedback is provided and the next generation of improved animals reaches sale.
- Processor risks will remain the same during this period. The same average price will be paid for livestock and the same livestock will be supplied, although differences between

[6] Rosenthal E, Savell J. Value-Based Marketing of Beef. *Meat Science*. Texas A&M University.

supply chains may occur. For example, assuming partial adoption of VBT, supply chains paying a premium for better quality may attract higher quality from other supply chains that only pay average price across a range of quality levels.

Industry equilibrium – There is a lag between adoption of actions and change being realised. Simplistically, there will be no net difference in value at an industry level in the first 2-3 years.

Medium term (>3 years)

- The next generation of livestock (resulting from increased objective feedback) will progressively deliver improved quality and value. That assumes the price signal to improve is incentive enough to stimulate improved genetic selection and management practices.
- Producers will benefit because of feedback that is more accurate and with pricing premiums incentivising improved genetic selection and management decisions.
- Processors will benefit if they can receive more value from the increased quality than they pay for (this may be a risk as outlined below). There is also the opportunity to increase market share because of better meeting customer requirements.
- Sustaining price premiums for higher quality is another consideration. Processors also need systems and processes internally to help them realise the extra value they have paid for, and market activities that sustain value attribution.

***Objective measurement technologies** must be coupled with new **pricing signals** (Value Based Trading) that align decisions along the supply chain to consumer needs to **increase industry value**.*

Key activity areas have been summarised in the following draft recommendations. Each area should be developed in parallel but in the following order. As each challenge is addressed the next one is more likely to be overcome.

Recommendation 1 – Form an Objective Measurement Adoption Group (OMAG) that focuses industry activities on outcomes that enable increased adoption of objective measurement and value-based transactions.

Recommendation 2 – Prioritise research and development of objective technologies and enabling capabilities for commercial use within certain timeframes. The OMAG should consider how this activity progressively supports industry and the remaining recommendations.

Recommendation 3 – Support the industry to adopt objective technologies (becoming "objective measurement ready") via widespread availability of commercial systems.

Recommendation 4 – Increase supply chain participant (especially producer) understanding of the impact of objective measurement on their businesses by working collaboratively to educate and to support opportunities to increase value (becoming "objective measurement aware").

Recommendation 5 – Develop standards for objective measurement, data transfer and reporting that build confidence and integrate with industry support systems, on-farm and off-farm extension activities and reporting functions to facilitate “whole of industry” adoption of objective measurement and VBT systems (becoming “OM and value based trading ready”).

Recommendation 6 – Support the widespread adoption of VBT to achieve the critical mass required to be sustainable (becoming “value based trading active”).

Recommendation 7 – Continue to expand the base of commercial objective measures and integrate complementary programs to leverage ongoing industry improvement and competitive advantage from objective measures (leading “global competitive advantage”).

Summary of recommendations

Were these 7 draft recommendations supporting adoption of objective measures and value based trading accepted, they would need to be progressively rolled out over time. An indicative timeframe for this is included in Figure 4.

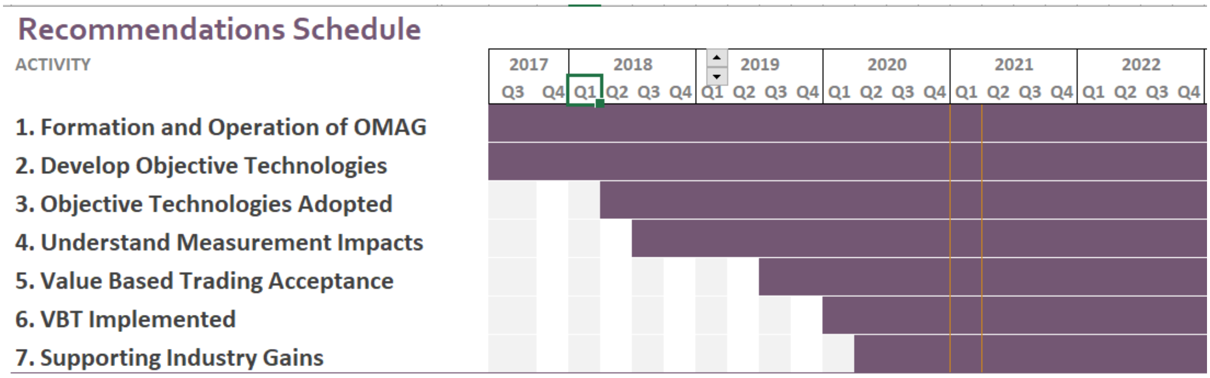


Figure 4: Objective Measurement Strategy Recommendations Schedule

Contents

Glossary

Term	Description
CBA	Cost / benefit analysis
EBV	Estimated breeding value
EDIS	Endemic Disease Information System
DEXA	Dual-energy X-ray absorptiometry (also referred to as DXA)
IMF	Intramuscular fat
LDL	Livestock Data Link
LMY	Lean meat yield
LNF	Lamb nucleus flock
MLA	Meat and Livestock Australia
MSA	Meat Standards Australia (MSA)
OM or OCM	Objective measure(ment) or objective carcase measure(ment)[7]
RFID	Radio frequency identification
VBT[8]	Value based trading
VBM[9]	Value based marketing
VBP[10]	Value based pricing
ROI	Return on investment

[7] Measured with some device or technology as compared to subjective measures taken by human assessment. Subjective assessments tend to have more variability in application of a standard, but this does not mean an objective measure is more accurate.
[8] VBT – the transfer of ownership based on a set of measures that estimate the value of the product and are used to establish the transfer price. Value based marketing and value based pricing are variations of VBT and are defined below.
[9] VBM – specifies the 'value' characteristics of the live animal prior to sale commitment and using these measures to offer the animal to prospective purchasers. The accuracy of live animal measurements in describing post-slaughter value will need to be accurate enough for VBM to substitute for VBP.
[10] VBP – is the process by which a buyer (e.g. processor) will pay a seller (e.g. producer) based on the specific 'value' characteristics of the carcase (or potentially the live animal in the future) after the commitment to sell has been made. Although price for different values is usually agreed prior to sale, the actual value of the product is unknown until after the commitment to sell/buy.

1 Background

Meat and Livestock Australia (MLA) has invested considerable industry (levy) and MLA Donor Company (MDC) project funding into the development of eating quality, live animal and carcase measurement (linked to automation) technologies, as well as associated supply chain models. It has also invested in associated areas of animal genetics, health, animal identification and information systems etc.

While all these investments have the potential to create value across the supply chain, there are a number of gaps in understanding how best to realise the value opportunities. A robust framework and essential decision tool (model) is required to address these knowledge gaps so that further investment in technologies and business models can be prioritised and focused for maximum benefit to the value chain.

This project has addressed a range of questions including but not limited to the following:

- What types of interventions/measurements in each supply sector impact consumer value?
- How much value?
- To whom?
- Where should these measurements be taken and who pays?
- How important is accuracy and integrity of the measurements in each sector?
- What synergies between measures exist in different sectors?
- What are the key trade-offs between some measures, and how can they be resolved?
- What are the opportunities and barriers to adoption of any such new technologies (including non-financial ones)?
- What enabling tools, systems or business models could help realise value opportunities?
- How might all these elements seamlessly fit together?
- What are the implications of these for industry adoption, supply chain alliances and industry investment in innovation?

Consultation with industry informed outputs from this project and will help inform and guide MLA's strategy for improved information flow and business decisions to increase value throughout the supply chain.

1.1 Objectives

The objective of this project is to achieve a high-level strategic review of potential industry benefits from adoption of further objective measurements, associated pricing signals and resultant on-farm management changes.

2 The opportunity

Compliance to market specifications for the beef industry has been estimated to be between 75% and 95%, depending on the required specifications and market segments targeted[11]. The ability to deliver or purchase animals to meet market specifications can provide huge financial incentives to both buyer and seller. A recent study using a subset of Australian beef industry feedlot data found that cattle out-of-specification for marbling incurred a loss of $105/head[11] MLA estimates put the total cost of non-compliance at over $100 million annually for cattle producers[12]

Advances in objective measurement (OM) on the live animal, carcase or cuts have the potential to improve efficiency of compliance to specifications and underpin a new value-based transaction model in the red meat industry. New technologies and platforms, including the Internet of Things (IoT) and emerging power of data analytics, will enable these new measures to be used in future to inform better decisions. This places the industry on the verge of a new era in supply chain innovation.

OM of important value characteristics can drive decisions and increase value as demonstrated in the more intensive poultry, pork, aquaculture and dairy industries. Rapid productivity gains in these industries have been driven by the need for control of higher input costs and thus the risk of becoming uncompetitive on a global market. While less intensive industries with more uncontrolled variables (e.g. the red meat industry) have been harder to monitor, the technology for gathering accurate data and making more precisely informed decisions has the same potential to transform them as in intensive industries. Precision agriculture demonstrates the ways broad land areas can be managed with multiple external data inputs (drones, satellite, weather, soil etc.) to improve management for profitability[13,14].

New technologies that more accurately measure red meat traits are close to commercialisation. There is considerable opportunity to increase value from existing supply chains in areas such as genetic improvement, on-farm management and better market alignment to increase productivity and product quality. This will need to be facilitated by increased data sharing between sectors to improve management decisions that align to consumer demands.

All sectors of industry recognise that value is being lost through inaccurate measurement or appraisal systems and that this could be improved by addressing the current OM-related limitations. However, adoption of new measurement technologies and, as importantly, appropriate pricing systems, requires a significant industry transition.

The aim of this report is to outline:

- **Whether** an OM and value-based transaction strategy will be beneficial to industry;

[11] Slack-Smith A, Griffith G, Thompson J, (n.d.). Appendix 14- The Cost of Non-Compliance to Beef Market Specifications. *Beef CRC Exit Report*.
[12] Condon (2015). LDL project will counter $100m annual losses in carcase compliance. *Beef Central, 18 May 2015*
[13] Craighead M, Yule I. Opportunities for increased profitability from precision agriculture. *The Regional Institute Online Publishing*, New Zealand.
[14] Hough C (2015). Precision agriculture driving productivity in the livestock sector. *ABC Rural.*

- **What** an OM and value-based transaction strategy needs to address (what industry requires and the role of technologies and information flow in that requirement); and
- **How** an OM and value-based transaction strategy could be implemented (how pricing signals could be improved and the role of OM to enable this).

In a future state where the value of data is clearly understood by all parties, the industry could see the vision of the *Australian Beef Language White Paper*[15] realised.

By 2040 the 'landscape' of beef products is significantly different to what it was in 2015, reflecting the impact of transformational technologies throughout the value chain which have changed the structure and focus of the Australian beef industry. The industry is now capturing optimum value from every carcase as it pursues product and branding strategies for differentiated markets both domestically and globally.

***Within the boning room**, product description pathways based on cooking and eating quality outcomes have helped reduce operational complexity as the attribute inputs required by language are vastly simpler, reducing carcase sorting prior to boning. Use of tighter eating quality portion/weight bands has resulted in greater fabrication of individual muscles and new trimming specifications. Greater automation will improve the ability to fabricate beef portions to specification.*

Technology has dramatically changed the way required language traits are measured and how carcases are valued. This has changed boning room infrastructure and processes as the point of ownership transfer has moved from over-the hooks (OTH) trading to payments based on the true value of each carcase for targeted markets.

***At the slaughter-floor** to boning room interface and chiller assessment – as carcases pass from the slaughter floor they are accompanied by substantial electronic data relating to their composition, individual cut yields and the eating quality potential of individual muscle portions.*

These changes have been underpinned by ongoing trial and development of new technologies which provide accurate objective measurements of key inputs.

***At the live animal** to slaughter-floor interface new slaughter-floor measures include animal stress indicators, muscle and carcase yield estimates and both external and marbling fat readings. True value-based trading (VBT) is the norm with producers paid on the yield and quality of carcase components and related 'value' items including raising claims, market eligibility and individual brand attributes.*

Producer-generated data will be accessed electronically and linked to the individual animal electronic ID and intrinsic properties of the animal. Producer-to-processor relationships will be based on open and shared data and closer to an 'open book' partnership than the adversarial nature of past decades.

The paradigm shift from trading on averages to VBT will have driven a dramatic efficiency improvement in the production and processor sectors.

Australian Beef Language White Paper

[15] Biddle R, Pattinson R, Philpott J, Polkinghorne R, Thompson J, Troja P, Williams S (2016). Australian Beef Language White Paper. A paper submitted to Meat and Livestock Australia, Sydney.

This is an ideal future state and a facilitated pathway is required to overcome barriers to realising this opportunity.

3 Approach to this study

This study was undertaken as follows:

1. All sectors of industry were engaged in a consultation process to understand 'what do industry participants require to realise more value within their respective businesses and organisations?' The following questions were explored:
    - How can value be created?
    - Where are the actions required?
    - What will stimulate action and what are the trade-offs?
    - What are the limitations – R&D priorities?
    - What are the enablers?
2. Six 'benefit scenarios' were developed in consultation with MLA and other experts from across the supply chain. Benefit scenarios are defined as the application of one or more OMs, anywhere in the supply chain, to create value through a specified improvement in supply chain efficiency.
3. Desktop research was conducted and the industry consulted in order to derive and validate parameter estimates (such as measurement accuracies, product prices, expected adoption rates for new technologies) for the modelling of the benefit scenarios.
4. The six benefit scenarios were modelled using Excel®.
5. Sensitivity analysis of modelling inputs and assumptions was undertaken for each benefit scenario using @Risk® software.
6. Conclusions and recommendations were developed in light of the consultation findings and modelling outcomes.

4 Benefit scenarios: outcomes of modelling

4.1 Introduction

The six benefit scenarios are summarised in Table 3. In each case, the development of the scenario considered:

- What measurement traits are important – and to whom are they important?
- Where can / should these traits be measured?
- What level of accuracy may be needed – and who will benefit from improvements in accuracy?
- Are there any important correlations between traits – either favourable or unfavourable?

Please note: OM technologies have been assumed for carcase measurements only by 2020 as this is the point of fastest adoption in the supply chain. For simplicity of comparison across both time periods, final 2030 scenarios also assume OM technologies on carcase only despite live animal OM technologies potentially being commercially available by this date. OM on live animals and at multiple points in the chain are important and would generate additional value (enabling feed-forward reporting, value based marketing and earlier on-farm management interventions for example) making the benefits estimated in 2030 somewhat conservative for most of the modelled scenarios,

Each scenario is summarised in the following sections.

4.2 Benefit scenario 1: Increasing lean meat yield but maintaining (or improving) eating quality

Introduction

Together, lean meat yield (LMY) and eating quality (EQ) largely determine total carcase value. There is a negative genetic correlation between LMY and EQ[16,17] which means that great care must be taken not to drive strong gains in one trait at the expense of the other.

This scenario involves selecting for one trait while at least maintaining the other. LMY defines the amount of saleable meat produced, measured by one of several objective systems for both beef and lamb. EQ is reflected in the consumers' willingness to pay[18], and is assessed by Meat Standards Australia (MSA) in beef and a to-be-developed objective measure of intramuscular fat (IMF) in lamb.

This scenario applies to:

- 60% of **beef** production where reliable environment and access to a range of markets make an optimised mix of quality and yield the most profitable output for the supply chain.
- 100% of **lamb** production.

Analysis

The scenario was analysed as follows. First, the *maximum* possible benefit was calculated assuming the full adoption of an OM technology with 100% accuracy. Second, the *potential* benefit was estimated by adjusting the maximum benefit for realistic accuracy of the OM technology and the proportion of the total possible benefit that could be realised by the application of OM in a given sector (for example, measurement of LMY may occur at the on-farm or processing stages but differing amounts of the total possible benefit will be captured

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[16] Mortimer S. et. al (2010) Preliminary estimates of genetic parameters for carcass and meat quality traits in Australian sheep. Animal Production Science, 2010, 50, 1135–1144.
[17] AGBU (2016). Genetic models.
[18] Allen P, Belasco E (2010). Is willingness to pay (WTP) for beef quality grades affected by consumer demographics and meat consumption preferences? *Australasian Agribusiness Review*, (18).

based on accuracy of the measurement, and the degree of change possible in the live animal prior to slaughter and relative to a carcase that is fixed). Third, the *likely* benefit was calculated by adjusting the potential benefit using realistic adoption rates. This process is set out below.

Step 1: Yield

Yield is assessed via objective measurement technology.

Maximum value opportunity from increasing yield in *beef* and *lamb* (Y_{BM}, Y_{SM}) = R_a * SY * CW * P, where

	Beef	Lamb
R = genetic potential gain / generation	*2.0%*	*2.0%*
L = generation interval	*5-7 years*	*3-4 years*
R_a = R/L = maximum yield gain / annum	0.4%	0.7%
SY = saleable meat yield value (retail cut value)	$8.22/kg	$13.23/kg
CW = cold carcase weight	300kg	22kg
P = population slaughtered	9.2m	22m

Potential value opportunity from increasing yield in *beef* and *lamb* (Y_{BP}, Y_{SP}) = (Y_{BM} or Y_{SM}) * TA * C_m, where

	Beef	Lamb
TA = technology accuracy	Depends on technology*	
C_m = magnitude of change possible by measuring in a sector	Depends on sector*	

*See adoption rate tables (page 74)

Likely value opportunity from increasing yield in *beef* and *lamb* (Y_{BL}, Y_{SL}) = (Y_{BP} or Y_{SP}) * A, where

	Beef	Lamb
A = adoption	See adoption tables (page 74)	

Step 2: Eating quality

EQ for beef is assessed through changes in the MSA index. EQ for lamb is assessed by changes in IMF.

Maximum value opportunity from increasing eating quality for *beef* (EQ_{BM}) = MSA_V * G_i * CW * P, where

	Beef
MSA_V = MSA value as a per kilogram premium over non-MSA	$0.20/kg
G_i = increase in the percentage of carcases graded MSA nationally	12%
CW = cold carcase weight	300kg
P = population slaughtered	9.2m

Note: while improvements in beef EQ are likely to increase overall beef demand, this has not been assumed in this study as the value of that increase is difficult to quantify.

Maximum value opportunity from increasing eating quality for *lamb* (EQ_{SM}) = IMF_V * IMF_i * CW * P, where

	Lamb
IMF_V = value premium for IMF	$0.00/kg
IMF_I = increase in the percentage of IMF	0%
CW = cold carcase weight	22kg
P = population slaughtered	22m

Note: because lamb meat eating quality has been assumed to be maintained rather than increased in this scenario, the 'potential' and 'likely' benefit values have not been derived.

Potential value opportunity from increasing eating quality for *beef* (EQ_{BP}) = EQ_{BM} * TA * C_m, where

	Beef
TA = technology accuracy	Depends on technology*
C_m = magnitude of change possible by measuring in a sector	Depends on sector*

*See adoption rate tables (page 74)

Likely value opportunity from increasing eating quality for *beef* (EQ_{BL}) = EQ_{BP} * A, where

	Beef
A = adoption	See adoption tables (page 74)

Step 3: Combining yield and eating quality for each of beef and lamb

Potential value opportunity from increasing LMY and maintaining EQ for *beef*

($S1a_P$) = (Y_{BP} * G_{CE} + EQ_{BP}) * P_{S1a}, where

	Beef
Y_{BP} = potential value opportunity from increasing yield	Derived above
G_{CE} = estimate of genetic correlation between LMY and EQ	-0.3
EQ_{BP} = potential value opportunity from increasing eating quality	Derived above
P_{S1a} = proportion of the population to which the scenario applies	0.6

Note: A simple estimate of genetic correlation was used for cost modelling as exact genetic calculations added complexity beyond the needs of this project. This approach was adopted in all relevant scenarios.

Likely value opportunity from increasing LMY and maintaining EQ for *beef*

$(S1a_L) = (Y_{BL} * G_{CE} + EQ_{BL}) * P_{S1a} * A$, where

	Beef
Y_{BP} = likely value opportunity from increasing yield	Derived above
G_{CE} = estimate of genetic correlation between LMY and EQ	-0.3
EQ_{BP} = potential value opportunity from increasing eating quality	Derived above
P_{S1a} = proportion of the population to which the scenario applies	0.6
A = adoption	See adoption tables (page 74)

Potential value opportunity from increasing LMY and maintaining EQ for *lamb*

$(S1b_P) = (Y_{SP} * G_{CE} + EQ_{SP}) * P_{S1b}$, where

	Lamb
Y_{SP} = potential value opportunity from increasing yield	Derived above
G_{CE} = estimate of genetic correlation between LMY and EQ	-0.3
EQ_{SP} = potential value opportunity from increasing eating quality	Derived above
P_{S1b} = proportion of the population to which the scenario applies	1.0

Likely value opportunity from increasing LMY and maintaining EQ for *lamb*

$(S1b_L) = (Y_{SL} * G_{CE} + EQ_{SL}) * P_{S1b} * A$, where

	Lamb
Y_{SL} = likely value opportunity from increasing yield	Derived above
G_{CE} = estimate of genetic correlation between LMY and EQ	-0.3
EQ_{SP} = potential value opportunity from increasing eating quality	Derived above
P_{S1b} = proportion of the population to which the scenario applies	1.0
A = adoption	See adoption tables (page 74)

Findings and key assumptions

The modelling of scenario 1 estimated potential annual gross benefits for beef of approximately $28m and likely benefits of $7.2m by 2020. By 2030, these estimates rose to $42m and $21m. For the sheep industry, equivalent figures were $17m / $4.5m by 2020, and $17m / $10m by 2030.

As noted above, these figures include only those benefits calculated where the OM technology has been adopted by the processing sector. The key assumptions behind these outputs for measurement by the processing sector are shown in the following tables.

Beef: Lean meat yield

Parameter	Value	Comments
Measurement location	Processor	Measurement would establish differential value paid to the supplier for different yield. Feedback of carcase information would support the evaluation and enable suppliers to adjust management practices to improve yield in line with price incentives. The greater the accuracy of the measure and price incentives for better performance, the faster the rate of yield increase. But the majority of improvement will result from genetic selection pressure increasing in response to pricing signals sent. This increase is over time, in line with the LMY rate of improvement that already takes into account phenotypic variation.
Measurement technology	2020: prediction with current measures 2030: DEXA/MEXA or other technologies	Estimates for 2020 assume application of predictive algorithms using existing carcase measures with an accuracy of 30%. Estimates for 2030 assume OM technologies will deliver commercial LMY results to 80% accuracy similar to DEXA measures of LMY in sheep.
Technology accuracy (TA)	2020: 30% 2030: 80%	
Magnitude of change (C_m)	70%	C_m is highest in the live animal sector (90%) because management changes can be made to deliver to market specs before the animal is sold. However, on-farm technology accuracy (TA) is likely to be lower, as is acceptance of on-farm measurement by the processing sector. The 70% is based on use of OM for carcases only.
Adoption		
Seedstock	2020: 45% 2030: 60%	It is estimated the leading 35% of breeders are already selecting for LMY as part of an index. VBT for LMY would increase that portion but not above that of producer adoption.
Live animal	2020: 45% 2030: 60%	Pricing signals will influence but not 100%. Many don't have scales to select for existing market specs and are unlikely to invest in new measures. Note that the estimated value cannot be higher than that of the measurer.
Processor	2020: 20% 2030: 60%	Changing procurement strategy has many unclear risks. Market adoption by 2020 assumes the two largest processors introduce VBP.

Beef: Eating quality

Parameter	Value	Comments
Measurement location	Processor	Measurement of MSA EQ already occurs at processor and includes some subjective measures.
Measurement technology	Plant grading	Use of historical performance to inform future decisions lowers impact of OMs for MSA EQ. Many of the factors known at point of grading are known prior to slaughter and can be managed in the live animal.
Technology accuracy (TA)	70%	
Magnitude of change (C_m)	50%	Approximately 30% of the factors affecting EQ occur post-slaughter, but feedback informing live animal interventions increases this.

Parameter	Value	Comments
Adoption		
Seedstock	2020: 60% 2030: 84%	Measurements contributing to the existing MSA score such as marbling and growth rate are already well established EBVs and actively selected for. The majority of seedstock producers will adopt new measures if they can select for them AND market signals reward them. Year-on-year adoption rates are estimated at 4% post 2020 although not linear with faster adoption towards 2030 as critical mass builds.
Live animal	2020: 60% 2030: 84%	Some producers still don't adopt MSA even with a high premium offered to them.
Processor	2020: 40% 2030: 56%	Already adopted with 40% of livestock graded.

<u>Sheep: Lean meat yield</u>

Parameter	Value	Comments
Measurement location	Processor	Measurement would establish differential value paid to the supplier for different yield. Feedback of carcase information would support the evaluation and enable suppliers to adjust management practices to improve yield in line with price incentives. The greater the accuracy of the measure and price incentives for better performance, the faster the rate of yield increase. But the majority of improvement will result from genetic selection pressure increasing in response to pricing signals sent. This increase is over time, in line with the LMY rate of improvement that already takes into account phenotypic variation.
Measurement technology	DEXA/MEXA	Current DEXA systems have proven accuracies of 88% against CT validation trials. Estimates for 2030 assume DEXA or MEXA technologies will deliver commercial LMY results at current accuracy levels.
Technology accuracy (TA)	88%	
Magnitude of change (C_m)	70%	C_m is highest in the live animal sector (90%) because management changes can be made to deliver to market specs before the animal is sold. However, on-farm technology accuracy (TA) is likely to be lower, as is acceptance of on-farm measurement by the processing sector. The 70% is based on use of OM for carcases only.
Adoption		
Seedstock	2020: 45% 2030: 60%	It is estimated the leading 35% of breeders are already selecting for LMY as part of an index. VBT for LMY would increase that portion but not above that of producer adoption.
Live animal	2020: 45% 2030: 60%	Pricing signals will influence some but not apply to 100% of producers. A large proportion still sell on a per head basis through saleyards and are unlikely to invest in new measures. Note that the value estimated cannot be higher than at point of measurement (processor in this scenario).
Processor	2020: 20% 2030: 60%	Changing procurement strategy has many unclear risks. Market adoption by 2020 assumes a small number of processors introduce VBP.

<u>Sheep: Eating quality (IMF)</u>

Parameter	Value	Comments
Measurement location	Processor	Measurement of IMF will enable the current level of quality to be maintained while selecting for improved LMY with DEXA OM.

Parameter	Value	Comments
Measurement technology	TBC	A commercial OM technology has not been finalised but could include visual or hyperspectral camera. The accuracy required needs to match the level of selection placed on LMY. For example, VBT for LMY that penalizes for LMY exceeding a certain percentage will require less accuracy than LMY payments rewarding LMY without a cap.
Technology accuracy	TBC	
Magnitude of change (C_m)	50%	Although an estimate has been provided it does not factor in the costing of this trait (IMF). This benefit scenario is about maintaining quality and the value impact is a reduction in the rate of LMY increase.
Adoption		
Seedstock	2020: 45% 2030: 60%	The adoption rates for LMY have been assumed given the measures will be part of a combined VBT scenario.
Live animal	2020: 45% 2030: 60%	
Processor	2020: 20% 2030: 60%	

Barriers to adoption

- Objective measurement technology adoption risk – Existing measures for payment estimate the value of the finished product, albeit with lower than optimum accuracy. There are already prediction equations for LMY using existing measures as well as objective systems like ViaScan that are more accurate than current payment measures. These are claimed to give accuracies of around R^2 ~0.5-0.6 but have not been adopted. Accuracy of OMs is not the main barrier to adoption of VBP.
- VBP adoption risk – In the processing sector there is a real risk that VBP will not be adopted broadly enough to generate the critical mass needed to be a sustainable trading method. Focus on availability of livestock is a key focus for processors and impacts on allocation of fixed cost. Some processors are concerned that if they pay less for lower LMY livestock (to help pay for higher value livestock), suppliers that are worse off could shift supply to competitors.
- Resistance of producers to continue with VBP –There is a perception among some producers that they will automatically receive more money for livestock with VBP. However, in the short term at least, there will be a balance between 'winners' and 'losers' while the incentives to improve drive longer-term change become embedded. If the multi-year transition period is not managed well (education and knowledge transfer) processors that introduce VBP could limit livestock supply and revert to current lower accuracy methods of attributing value.

Future enablers / opportunities

- Live animal measurement of LMY – LMY measurements made prior to sale may engage the broader processing sector in adopting LMY measures. Rather than rely on a processor to send pricing signals at the risk of losing supply, processors would be free to utilise the objective results accompanying livestock as part of their purchasing decisions. A wider group of processors would use the information from this VBM approach compared to those leading a VBP approach. However, on-property live animal measurement is likely to have low adoption among producers considering many producers do not have scales even for basic weighing. Accuracy of on-farm measures would be also low compared with carcase measures. Sales through online platforms like AuctionsPlus could be increased if live assessment with objective measurements increased accuracy over subjective visual assessment.

- Installing OM technologies like 3D scanning at saleyards – This would encourage wider adoption of OM without relying on producer investment in on-farm systems. There are a number of factors that would need to be considered carefully for this option including:
  - Challenges of live animal scanning at saleyards, cost of infrastructure and labour for extra work, reliability of systems etc.
  - Implication of saleyards becoming a preferred method of sale when research has shown negative impacts on eating quality as well as barriers to information transfer between producers and end customer.
- Market reporting of OMs – Widespread reporting would increase awareness and use of technologies. Processors may be reluctant to report results publicly. On the other hand, they need a national accreditation system to demonstrate the OMs they are using are accurate and reliable. A middle ground will need to be found between accreditation, reporting and company privacy.

4.3 Benefit scenario 2: Increasing lean meat yield but maintaining pH

Introduction

This scenario involves selection for LMY as in scenario 1 but replaces EQ with pH. LMY defines the amount of saleable meat produced, measured by one of several objective systems for both beef and lamb. High pH imposes a significant discount on beef carcases estimated to cost Australian beef producers more than $35 million annually[2].

This scenario applies primarily to the 30% of beef production in more extensive and unreliable environments where live export is often the primary market. These conditions make it difficult to focus on EQ at the expense of yield gain. Selecting bulls with genetics appropriate for the herd (increasing LMY while maintaining pH / MC) is the only input adjustment required to apply this scenario.

The impact of pH has not been applied to the sheep industry. However, this scenario could be a way to improve the value of hoggets where increased risk of poor meat colour (MC) is the primary reason for lower value[19].

The negative genetic correlation[20] between LMY and pH means great care must be taken not to drive strong gains in LMY at the expense of pH and thus MC.

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[19] MLA (2006). Improving lamb and sheepmeat eating quality – a technical guide. MLA Tips & Tools "The effect of breed and age on sheepmeat eating quality" (MSAS4)
[20] Kelman, K.R., Pannier, L., Pethick, D.W., Gardner, G.E. (2014). Selection for lean meat yield in lambs reduces indicators of oxidative metabolism in the longissimus muscle. *Australian Sheep CRC Meat: Meat Science Special Issue*. 96(2), 1058-1067.

Analysis

Scenario 2 was analysed similarly to scenario 1 (but applied only to beef). Key calculations and assumptions are shown below.

Step 1: Yield (as per scenario 1)

Step 2: pH

pH for beef is assessed through changes in the MSA index.

Maximum value opportunity from improving pH for *beef* (pH_{BM}) = MSA_V * HpH_i * CW * P, where

	Beef
MSA_V = MSA value as a per kilogram premium over non-MSA	$0.20/kg
HpH_i = high pH incidence causing MSA downgrade nationally	8.1%[21]
CW = cold carcase weight	300kg
P = population slaughtered	9.2m

Note: because MSA is the most consistent method for dealing with high pH across industry, the value premium for MSA has been used to quantify the opportunity cost of high pH.

Note: because it has been assumed that there is no opportunity for increase in value from lamb meat colour, 'potential' and 'likely' benefit values have not been derived.

Potential value opportunity from increasing pH for *beef* (pH_{BP}) = pH_{BM} * TA * C_m, where

	Beef
TA = technology accuracy	Depends on technology*
C_m = magnitude of change possible by measuring in a sector	Depends on sector*

*See adoption rate tables (page 74)

Likely value opportunity from increasing pH for *beef* (pH_{BL}) = pH_{BP} * A, where

	Beef
A = adoption	See adoption tables (page 74)

Step 3: Combining yield and pH for beef

Potential and **likely** value opportunities from increasing LMY and maintaining pH for *beef*

$S2_P = (Y_{BP} * G_{CE} + pH_{BP}) * P_{S2}$, and

$S2_L = (Y_{BL} * G_{CE} + pH_{BL}) * P_{S2}$

where

[21] Jose C, McGilchrist P, Perovic J, Gardner G, Pethick D (2015). The economic impact of dark cutting beef in Australia. *61st International Congress of Meat Science and Technology*. Clermont-Ferrand, France.

	Beef
Y_{BP} = potential value opportunity from increasing yield	Derived above
Y_{BL} = likely value opportunity from increasing yield	Derived above
G_{CE} = estimate of genetic correlation between LMY and pH	-0.1
pH_{BP} = potential value opportunity from improving pH	Derived above
pH_{BL} = likely value opportunity from increasing eating quality	Derived above
P_{S2} = proportion of the population to which the scenario applies	0.3

Findings and key assumptions

The modelling of scenario 2 estimated potential annual gross benefits of approximately $11m and likely benefits of $2.2m by 2020. By 2030, these estimates rose to $20m and $10m.

As noted above, these figures include only those benefits calculated where the OM technology has been adopted by the processing sector. The key assumptions behind these outputs for measurement by the processing sector are shown in the following tables (key assumptions for LMY are the same as for scenario 1).

Beef: Meat colour / pH

Parameter	**Value**	**Comments**
Measurement location	Processor	Assumes accuracy of current subjective meat colour and objective pH measures could be improved. Objective measures of pH and new understanding of consumer acceptance will improve allocation to market. Change in incidence of poor meat colour assessed at processor due to increased measurement accuracy will assist intervention at the live animal.
Measurement technology	Vision camera or colorimeter	Current technology accuracy is at 70% and no improvement in accuracy of technology is assumed to 2030.
Technology accuracy	70%	
Magnitude of change	20%	Only a portion of current downgrades will be reduced with improved grading in this scenario. No ability to adjust measured carcase. Can only predictively adjust for future supply.
Adoption		
Seedstock	2020: 60% 2030: 84%	Commercial producers will select from existing genetic pool.
Live animal	2020: 60% 2030: 84%	This is a direct benefit from processor re-grading, assuming benefit is passed onto the producer.
Processor	2020: 60% 2030: 84%	Measurements and pricing incentives already in place. Further processing measures will not improve colour, but may find grading methods to reallocate a percentage of current downgrades to higher value markets in line with new understanding of consumer acceptance. Adoption for this trait is much higher than for LMY because VBT mechanisms are already in place.

Sheep: Meat colour / pH – Does not apply to sheep benefit scenarios

Barriers to adoption

- VBP Adoption risk – This is similar to scenario 1 in that processors risk loss of supply and may consider the loss of supply from lower performing producers more important than the upside gain. This scenario is most relevant to producers in extensive northern regions. Many enterprises do not have scales or the ability to manage improvement. Genetic selection is still a viable and effective improvement strategy by itself for increasing LMY. But introduction of value-based payment methods will drive some producers, who have options for both live export and boxed markets, to focus on live export instead. Alternative commodity markets will limit the adoption of value-based payments and therefore the improvement in LMY (productivity) addressed in scenario 1 and scenario 2.

4.4 Benefit scenario 3: Increasing feedlot marbling quality but optimising turn-off times

Introduction

This scenario applies to feedlot animals destined for high-quality markets where marbling (MB) has a much greater impact on finished product value than LMY. This is estimated to be approximately 10% of the beef market.

MB increases with animal age[22]. However, there are several financial and non-financial trade-offs between age and marbling. For example, quicker turn-off for a particular market specification can lead to more efficient input utilisation (e.g. feed conversion efficiency) and higher profitability. On the other hand, extending turn-off times may increase marbling but at a potentially higher direct cost (feed) and currently hidden factors (such as potentially methane in the longer term). With price differentials for increased marbling extreme, especially in high marble score cattle, the trade-off between the two is important.

The two areas of value enabled by OM in this scenario include:

- Increased selection pressure for genetic improvement of growth rate (G) and marbling; and
- Improved feedlot management decisions to optimise feeding time.

Analysis

Scenario 3 was analysed similarly to scenarios 1 and 2 (but, as for scenario 2, applied only to beef, and in this scenario was based on 400-day weight for feeder cattle). Key calculations and assumptions are shown below.

Step 1: Growth rate

[22] MSA (2012). Meat Standards Australia beef information kit. Meat and Livestock Australia, Sydney.

Maximum value opportunity from increasing growth rate in *beef* (G_M) = WG_I * WG_V * CW * P, where

	Beef
WG_I = maximum G gain / annum	3.5%
WG_V = value of weight gain based on CW value/kg	$5.60/kg
CW = cold carcase weight	300kg
P = proportion of population of beef slaughter feed-fed for higher quality markets	0.1

Potential value opportunity from increasing growth rate in *beef* (G_P) = G_M * TA * C_m, where

	Beef
TA = technology accuracy	Depends on technology*
TA_{SS} = TA at seedstock	0.45
TA_{CP} = TA at commercial production	0.32
TA_{PS} = TA at post slaughter	N/A
C_m = magnitude of change possible by measuring in a sector	Depends on sector*

*See adoption rate tables (page 74)

Likely value opportunity from increasing growth rate in *beef* (G_L) = G_P * A, where

	Beef
A = adoption	See adoption tables (page 74)

Step 2: Marbling

Maximum value opportunity from increasing marbling in *beef* (MB_M) = (VM * H * S) / L * CW * P, where

	Beef
VM = value of marbling (average CW based on distribution of marbling scores and associated values for both medium and long-fed carcases. Converts non-linear value differences between marbling scores into average value per marbling score)	$0.57/kg
H = heritability of marbling	0.3
L = generation interval	5-7 years
S = selection pressure	1
CW = cold carcase weight	300kg

MB_M = $0.17/kg

Potential value opportunity from increasing marbling in *beef* (MB_P) = MB_M * TA * C_m, where

	Beef
TA = technology accuracy	Depends on technology*
C_m = magnitude of change possible by measuring in a sector	Depends on sector*

*See adoption rate tables (page 74)

Likely value opportunity from increasing marbling in *beef* (MB_L) = MB_P * A, where

	Beef
A = adoption	See adoption tables (page 74)

Step 3: Combining growth rate and marbling

Potential and **likely** value opportunities from increasing growth while at least maintaining marbling for *beef*

$S3_P = (G_P * G_{CE} + MB_P) * P_{S3}$, and

$S3_L = (G_L * G_{CE} + MB_L) * P_{S3}$, where

	Beef
G_P = potential value opportunity from increasing growth	Derived above
G_L = likely value opportunity from increasing growth	Derived above
G_{CE} = genetic correlation between G and MB >400-day growth	Not significant
MB_P = potential value opportunity from increasing marbling	Derived above
MB_L = likely value opportunity from increasing eating quality	Derived above
P_{S3} = proportion of the population to which the scenario applies	0.1

Findings and key assumptions

The modelling of scenario 3 estimated potential annual gross benefits of approximately $55m and likely benefits of $21m by 2020. By 2030, these estimates rose to $55m and $33m.

As noted above, these figures include only those benefits calculated where the OM technology has been adopted by the processing sector. The key assumptions behind these outputs for measurement by the processing sector are shown in the following tables.

Beef: Growth

Parameter	**Value**	**Comments**
Measurement location	Processor	Processors do not directly measure weight gain although carcase weight is important feedback for producers who do not have scales. Price signals for LMY and marbling will indirectly promote selection for growth rate as LMY selection increases. Depending on the price differences between marbling and LMY and producers' current performance, they will select more heavily for marbling or weight gain but hopefully both. Without a LMY pricing grid producers are unlikely to increase weight and maintain marbling above the current rate of improvement.
Measurement technology	Scales and LMY measures	Scales are already in place. The LMY assumptions from scenario 1 apply here for both 2020 and 2030. Weight gain accuracy measured at processor for future live animal growth rates is low.
Technology accuracy	20%	

Magnitude of change	8%	MB measures are direct but LMY is indirect and after the fact. Weight gain is already known for the majority of producers that have scales.
Adoption		
Seedstock	2020: 75% 2030: 100%	Seedstock sector will respond to producer demands.
Live animal	2020: 75% 2030: 100%	Incentive via LMY grids would increase adoption. If OM tests on farm become cheaper adoption rates will increase further.
Processor	2020: 20% 2030: 28%	Assume same adoption rate of OM as in LMY and EQ benefit scenario given the same processors will deliver these scenarios. However, marbling increase has a bigger value impact in this scenario so the adoption rates for OM grading of marbling in the table below have been assumed in this benefit scenario.

<u>Beef: Marbling</u>

Parameter	**Value**	**Comments**
Measurement location	Processor	Marbling measured at processing is passed back up the chain and genetic selection occurs based on these performance results in latter generations. MB is already measured with subjective chiller assessment. X-ray based scanning is still unable to measure muscle, fat and bone composition in beef and measuring of marbling is more difficult given the need to identify distribution as well as amount. Visual scanners of the cut surface are the most realistic but miss out on pre-chiller and pre-quartering decisions that would be adjusted if marbling was known prior to chilling.
Measurement technology	Image scanning or other	Current subjective measures set the baseline of accuracy. Any OM would need to demonstrate equivalence or better. Increasing accuracy at processor will speed improvement but has minimal magnitude of change relative to obtaining the information in the live animal enabling management decisions on that specific animal.
Technology accuracy	90%	
Magnitude of change	30%	Excludes ability to manage environmental impact and adjust management post-slaughter.
Adoption		
Seedstock	2020: 20% 2030: 28%	Seedstock will benefit from information collected but this is not financial, depends on whether the information is shared, and will not vary much from what is already available in subjective grading.
Live animal	2020: 20% 2030: 28%	Same as processor by default.
Processor	2020: 20% 2030: 28%	Replacing subjective grading would require cost saving or some other benefit for adoption to occur. Assume increase in ease of use of technologies as well as a reduction in cost by 2030 for those processors willing to transfer from subjective to objective grading.

Weight Gain:

- <u>Value of weight gain</u> is calculated using the average annual rate of gain per year over a 20-year period for some of the leading genetics companies while selecting for increases in marbling simultaneously. Figures of 3.3-3.5% growth increase per year and at a carcase value of $5.60 per kilogram gives a value impact of $56/head but this will vary widely for each production situation.

  Growth rate is one of the most significant traits commercial producers currently select and get paid for. Increasing rate of change is unlikely to be through pricing signals (which already exist) but through more precise application of existing EBVs (computer based mating), increased accuracy of EBVs through genomic tests providing easier linking of genetics to sire and dam performance and therefore selection accuracy.

- Accuracy – assumes heritability's of 0.32 for additive direct genetic effects for 200-d weight[23]
- Magnitude of change
    - Seedstock sector adoption of technologies for improved weight gain (such as genomic testing) is likely to generate the most value for industry due to higher adoption rates than in the commercial production sector.
    - Some processor grids already pay on marbling grade and all pay on weight. There is already a value incentive at the producer to select for weight while maintaining marbling.
    - Leading producers and feedlots are already selecting for increased marbling while maintaining growth rates. Growth rate is a producer benefit so it is unlikely adoption will increase above current rates unless genomic testing becomes cheaper and easier. Low likelihood of adoption is expected by 2020.

Marbling:

- Value of marbling depends on the market and how premiums are assigned. Premiums are not linear as marbling content increases. An industry average value has been estimated for this exercise of $50.95/head per annum. This reflects the difference in value between marbling grades and captures the annual increase in propensity to marble across a population through genetic selection (apart from environmental conditions) as in Figure 5. This takes into account heritability for marbling and selection pressure interactions with weight gain and generation interval (4 years at seedstock for maximum gain). MSA willingness to pay data (50% value increase for "better than every day" and 100% more for "premium") is in line with these assumptions[9].
- Measurement accuracy is greatest at processing. Because marbling is an established standard used to determine end customer value, marbling will still need to be measured at processing even if processors were willing to pay producers based on a measure occurring in the live animal. Improved accuracy in live animal technologies even if not as accurate as post-slaughter measures would help drive increased value and improved production efficiency.
- Measurement location considers the "magnitude of change" (genotypic and phenotypic variation)
    - Measurement in commercial production has the greatest opportunity to improve marbling. This includes selection of the right genetics as well as management decisions during growing and finishing to determine which animals to feed and for how long. If grading performance is poor, it is the producer that makes a loss on large feed costs. For this reason, competitively priced objective measurement systems at the live animal will bring the most

[23] Bennett G, Gregory K (1996). Genetic (co)variances among birth weight, 200-day weight, and post weaning gain in composites and parental breeds of beef cattle. *Journal of Animal Science*, 74(1), p 2598-611.

value to industry in the immediate term and will have the greatest rate of adoption.

- Adoption rates require selection pressure
  - o Processors already have a method for assessing marbling and although accuracy is sometimes questioned, the likelihood for widespread processor adoption is low unless there are secondary benefits like grading labour saving or other efficiencies.
  - o Of seedstock producers providing quality markets, 100% are focused on marbling (personal communication). The number that will use genomic testing to increase their accuracy of selection is assumed to be low until test costs reduce.
  - o Producer adoption will be lower than at seedstock for genomic testing and other technologies due to the poor ROI on current cost of tests. As genomic tests reduce in cost adoption will increase.

Beef Marbling Improvement			
	Livestock	Medium-fed	Short-fed
MB Score	Price/CCW	Percentage	Percentage
5	$ 7.80	8%	0%
4	$ 7.15	27%	5%
3	$ 7.15	50%	10%
2	$ 6.89	9%	25%
1	$ 4.94	4%	30%
0	$ 4.55	2%	30%
		100%	100%
Average MB		3.2	1.3
Dollar Value		$ 7.04	$ 5.64
Premium over baseline		155%	124%
Assumptions			
Generation Interval		4	4
Heritability		0.3	0.3
Selection pressure		0.6	0.6
Change after selection			
New Average marbling score		3.34	1.36
New Dollar Value		$ 7.35	$ 5.90
Change in Value		$ 0.32	$ 0.25

Figure 5: Change in distribution of marbling scores through genetic selection pressure for marbling

Barriers to adoption

Processes and technologies at seedstock flow through to the commercial producer but with slower adoption. Introduction of VB payments for LMY and quality and increased supply chain connection through improved information transfer is hoped to encourage more of the producer population than the top 50% as communication of benefits and methods to achieve them become clearer.

4.5 Benefit scenario 4: Improving animal health

Introduction

This scenario considers the value opportunity from managing animal health issues that impact both the production and processing sectors across the beef and lamb industries, by the provision of animal health feedback from processors to producers.

Treatment and prevention costs, along with production losses, from sheep and cattle diseases are an important variable in farm profitability (along with animal welfare and owner / manager peace of mind). They can also negatively impact on carcase value. Some of these diseases (e.g. fluke, ovine Johne's disease) can be detected in abattoirs, providing an opportunity to enable more effective animal health management practices to address one-off or persistent animal health and carcase dressing issues.

Current subjective assessments of animal health conditions at processing are not being systematically transferred to producers. The value proposition is for digital capture and transfer of current subjective data for those conditions that impact on both the producer and the processor. Development of OMs of animal health conditions could be possible but utilisation of existing subjective data is considered a higher priority.

Analysis

Scenario 4 was analysed as shown below. Key calculations and assumptions are provided.

Potential value opportunity from reducing the cost of health conditions in *beef* and *sheep* ($S4_P$) = H_{BM} * TA_{PS} * Cm_{PS} * P where

	Beef	Sheep
H_{BM} = maximum cost of health conditions	\$96.4m	\$57.8m
P = population of animals processed / annum	9.2m	32.3m
TA = technology accuracy	0.4%	0.7%
TA_{SS} = TA at seedstock	0.3	0.3
TA_{CP} = TA at commercial production	0.6	0.6
TA_{PS} = TA at post slaughter	0.8	0.8
C_m = magnitude of change possible by measuring in a sector	\$8.22/kg	\$13.23/kg
CM_{SS} = CM at seedstock	0.2	0.2
CM_{CP} = CM at commercial production	0.7	0.55
CM_{PS} = CM at post slaughter	0.55	0.35

(Note that only those conditions that impact on both the producer and the processor and that can be detected during processing have been considered in the costing. These are internal parasites, as well as grass seed in sheep and bovine Johne's disease in beef. A number of detailed studies[24,25,26] have been conducted since 2009 on the cost of health conditions to the beef and sheep industries. These costs are summarised for each condition in Appendix

[24] GHD (2009). Report quantifying the benefits and costs of E-surveillance Sheep and goats. Report prepared for Animal Health Australia, Canberra
[25] GHD et al (2015). Priority list of endemic diseases for the red meat industries
[26] Bryan et al (2016). Review of the National Sheep Health Monitoring Project.

6: Animal health conditions. Different methods were used across the reports and all acknowledge that more work is required to fully understand the impact of some conditions. In some cases, where numbers and methodologies for costing differed across reports, a combination of the methods was used. The magnitude of impact is consistent with previous reporting and sufficient for this broad assessment of objective measurement technologies.

Likely value opportunity from reducing the cost of health conditions in *beef* and *sheep* ($S4_L$) = $S4_P$ * A, where

	Beef	Sheep
A = adoption	See adoption tables (page 74)	

Findings and key assumptions

The modelling of scenario 4 estimated <u>potential</u> annual gross benefits for beef of approximately $43m and <u>likely</u> benefits of $19m by 2020. By 2030, these estimates were $43m and $28m. For the sheep industry, equivalent figures were $16m / $7.4m by 2020, $16m / $11m by 2030.

The key assumptions behind these outputs for measurement by the processing sector are shown in the following table.

<u>Beef: Animal health status</u>

Parameter	**Value**	**Comments**
Measurement location	Processor	Digital capture of carcase conditions observed during mandatory in-plant inspection enables animal health data to be analysed and transferred along the chain to support improved decisions by producers.
Measurement technology	Visual inspection	Detection is currently manual with some human error (90% accuracy estimated from discussions with senior AQIS vets and research vets). But determining the time period of infection (current or old scarring from previous infestation) is more difficult (90% ability to estimate, noting this data is not currently captured) so accuracy has been further reduced (=90% x 90%).
Technology accuracy	81%	
Magnitude of change	55%	If collected data is analysed and transferred with insights through broader data integration, information could be applied on farm for treatment of other live-animals (in advance of slaughter). There is limited data available on many of the diseases considered including efficacy of treatment and return on investment in treatment. Efficacy of approximately 50% has been assumed with a slight increase above that due to enhanced analysis and earlier information transfer.
Adoption		
Seedstock	2020: 45% 2030: 65%	No action required by the seedstock sector.
Live animal	2020: 45% 2030: 65%	Processors' pricing signals in some plants have increased producer awareness of disease issues resulting in increased on-farm prevention activities.
Processor	2020: 60% 2030: 65%	A broad section of processors (~60%) are moving toward improved data capture and transfer. Not all will move to VBT hence the lower adoption at live animal. A processor based measurement that includes payment incentives would increase the value proposition

		for processors to invest in enhanced data collection, analysis and transfer.

Sheep: Animal health status

Parameter	**Value**	**Comments**
Measurement location	Processor	Digital capture of carcase conditions observed during mandatory in-plant inspection enables animal health data to analysed and transferred along the chain to support improved decisions.
Measurement technology	Visual inspection	Detection is currently manual with some human error (90% accuracy estimated from discussions with senior AQIS vets and research vets). But determining the time period of infection (current or old scarring from previous infestation) is more difficult (90% ability to estimate, noting this data is not currently captured) so accuracy has been further reduced (=90% x 90%).
Technology accuracy	81%	
Magnitude of change	35%	Change is harder than in beef given a large portion of sales are mixed saleyard lots so information cannot be linked back to individual producers.
Adoption		The same adoption rates and assumptions also apply in sheep.
Seedstock	2020: 45% 2030: 65%	
Live animal	2020: 45% 2030: 65%	
Processor	2020: 60% 2030: 65%	

4.6 Benefit scenario 5: Improved processing efficiencies

Introduction

Sorting carcases into boning runs based on levels of trimming required within customer production runs and most suitable allocation of primals to those specifications can lead to more efficient use of labour and an increase in line speeds. Objective measures of lean meat yield in plants would allow carcases to be sorted into chillers in boning runs.

Value in this scenario results from increasing precision by which carcases are allocated to primal fabrication, in the following ways:

- Boning labour reduction: reducing the amount of work required to complete production, by reducing the number of over-fat carcases that need to be trimmed to meet specification[27]; and
- Boning room throughput: making the same amount of work occur more efficiently, because of aligning like carcases within the same fabrication specification to improve room "rhythm". Automation systems in lamb removed spikes in speed into the room resulting in >18% throughput increase[28]. Although not the same driver of throughput it indicates the potential for improvement for beef.

Analysis

Scenario 5 was analysed as shown below. Key calculations and assumptions are provided.

[27] MLA project P.PSH.0629
[28] MLA projects A.SCT.0045, A.SCT.0051, P.PIP.0327

Maximum value opportunity from improved boning efficiencies resulting from improved cut allocation and carcase sortation in *beef and sheep* (BE_M) = (SL_R + RT) * P, where

	Beef	Sheep
SL_R = boning labour reduction – see below*	$0.99/hd	$0.30/hd
RT = boning room throughput – see below*		
P = proportion of the total slaughter to which the scenario is applicable		

*Refer to model table in Appendix 7: Processing Calculations

Boning labour reduction (SL_R) = ((M*(1- WD_F*(BT_S-1)*L+ M*(1- WD_F*(BT_T-1)*L + M*(1- WD_F*(BT_P -1)* L)) / H, where

	Beef	Sheep
BT = boning time (labour units per carcase boned[29])		
BT_S = BT for slicers	1.4	1.4
BT_T = BT for trimmers	2.0	2.0
BT_P = BT for packers	1.3	1.3
WD_F = frequency with which wrong decisions are made (assumes a linear relationship between accuracy and reduction in frequency of wrong decisions)	10%	10%
L = labour cost per hour for each job position	Refer to model table (page 77)	
M = manning levels per position	Refer to model table (page 77)	
H = number of head boned per hour	Refer to model table (page 77)	

Boning room throughput (RT) = DL_{KG} * TR_I * CW, where

	Beef	Sheep
DL_{KG} = direct labour cost for boning (conservative estimates based on wide variation across plant environments and customer specifications)	$0.10/kg	$0.50/kg
TR_I = throughput rate improvement (no. of head processed per hour)	1.1%	1.1%
CW = cold carcase weight	300kg	22kg

Potential value opportunity from improved boning efficiencies resulting from improved cut allocation and carcase sortation in *beef and sheep* (BE_P) = BE_M + TA * SCF, where

	Beef	Sheep
TA = technology accuracy	Depends on technology	
SCF = supply chain flexibility to make different fabrication options (% of supply chains)	62% (45%*domestic, 70%*export)	

Likely value opportunity from improved boning efficiencies resulting from improved cut allocation and carcase sortation in *beef and sheep* (BE_L) = BE_P * A, where

[29] Sourced from consultation with processors

	Beef	Sheep
A = adoption (cannot exceed PC)	10%	
PC = processor capability to sort and fabricate according to optimised cut breakdown	50%	

Findings and key assumptions

The modelling of scenario 5 estimated potential annual gross benefits for beef of approximately $3.7m and likely benefits of $0.4m by 2020. By 2030, these estimates rose to $9.9m and $6.0m. For the sheep industry, equivalent figures were $5.2m/$0.5m by 2020, $5.2m/$3.1m by 2030. Key assumptions in this scenario are:

- Value of processing efficiency is based on $220/head for beef processing costs. A 1.1% increase in throughput has been calculated using actual boning room production runs. This equates to a $2.43/head reduction in processing costs. Automation of primal cutting in the sheep industry has demonstrated increases in throughput exceeding 15% in a number of plants, a level of improvement which was not imagined possible. Although a slightly different driver of change, the efficiencies in this scenario are considered conservative.
- Measurement accuracy of LMY and primal weight will not be sufficient for beef by 2020 (R^2 >0.6 required) as measurements are expected to still be in development. Higher accuracies have been assumed by 2030.
- Adoption is assumed to be by a subset of processors adopting LMY OM technologies in scenarios 1 through 4. It has been assumed only half of processors will adopt the additional internal sortation decision making (half of 20% = 10%) due to prioritisation of other initiatives that generate greater value.

4.7 Benefit scenario 6: Fabrication of purchased livestock to optimise value

Introduction

This scenario improves processor allocation of carcases to the most valuable markets. Carcase weight ranging and fat score are currently used to segregate carcases into market specific boning runs but current LMY estimates are inaccurate. Objective measures will enable more accurate sales pricing decisions linking to alternative boning specifications and production schedules. Improved boning allocation helps extract increased value from carcases.

How livestock are fabricated and allocated to different markets has a big impact on the value realised from each animal purchased. For example, selling a lean muscular bone-in shoulder to a market that is happy to pay for internal seam fat while boning and trimming a very fat shoulder for a market that does not accept internal fat seams would be a poor allocation of carcase to consumer value. Additional trimming labour would be required, along with reduction in value of fat that now must be rendered. No processor would intentionally do this but it occurs in the absence of measures to identify between the high and low yielding carcase.

Benefit scenario 1 drives the genetic increase in lean meat yield which provides some benefit to the whole chain while this scenario focuses on enabling processors to realise the benefit through better market alignment. Previous MLA economic modelling[30] has demonstrated that a portion of value generated at the processor is transferred to the producer as pricing premiums over the long-term.

Analysis

Scenario 6 was analysed as shown below. Key calculations and assumptions are provided.

Maximum value opportunity by increasing precision with which carcases are allocated to primal fabrication to maximise boning room sales order profitability for *beef and sheep*

$(F_M) = C_{VR} * WD_F$, where

	Beef	Sheep
C_{VR} = range in carcase value depending on fabrication options (based on 300 kg / 25 kg carcase)	$18.33/hd	$28.92/hd
WD_F = frequency with which wrong decisions are made	10%	10%

Potential value opportunity by increasing precision with which carcases are allocated to primal fabrication to maximise boning room sales order profitability for *beef and sheep*

$(F_P) = F_M * TA$, where

	Beef	Sheep
TA = technology accuracy (assumes a linear relationship between accuracy and reduction in frequency of wrong decisions)	Depends on technology	

Likely value opportunity by increasing precision with which carcases are allocated to primal fabrication to maximise boning room sales order profitability for *beef and sheep*

$(F_L) = F_P * A$, where

	Beef	Sheep
A = adoption (cannot exceed PC)	10%	
PC = processor capability to sort and fabricate according to optimised cut breakdown	50%	

Findings and key assumptions

The modelling of scenario 6 estimated potential annual gross benefits for beef of approximately $62m and likely benefits of $6.2m by 2020. By 2030, these estimates rose to $165m and $99m. For the sheep industry, equivalent figures were $44m and $4.4m by 2020, $44m and $26m by 2030. Key assumptions in this scenario are:

[30] CIE Economic modelling of dispersion of value from R&D outcomes

- For beef:
  - o The value of make/sell improvement is based on a carcase value of $5.60 per kilogram. The livestock cost price has been used rather than a sales price. The assumption is that a 1% increase in total carcase yield will result from improved allocation of cuts to markets. This is an unusual way to cost out the market opportunity but the wide variation in markets, customer specifications and product availability will not add any more accuracy. In-plant trials undertaken in unrelated work indicates larger opportunities so this figure is considered conservative.
  - o Measurement accuracy of LMY and primal weight will not be sufficient for beef by 2020 (R^2 >0.6 required) as measurements are expected to still be in development. Higher accuracies have been assumed by 2030.
  - o Adoption rates are a subset of processors adopting LMY OM technologies in scenarios 1 through 4.
  - o It has been assumed only half of processors will adopt the additional internal sortation decision making (half of 20% = 10%) due to prioritisation of other initiatives that generate greater value. This increases to 60% adoption by 2030. It assumes measurement technologies will be adopted but does not require value based payments to be made for this scenario to be realised.
  - o The production sector will receive benefits transferred from processors in the form of more competitive livestock purchase prices. Previous work18 and supply chain alliances are examples of producer share in increased supply chain value.
- For sheep:
  - o The value of make/sell improvement was estimated at $0.12 per kilogram on 16 kilograms of saleable meat per carcase.
  - o Measurement accuracy of LMY is assumed at R^2 >0.8 by 2020 with no increase in accuracy by 2030, making the number conservative.
  - o Adoption rates are a subset of processors adopting LMY OM technologies in scenarios 1 and 4.
  - o It has been assumed only half of processors that implement LMY technologies will adopt the additional internal sortation decision making (half of 30% = 15%) due to prioritisation of other initiatives that generate greater value. This increases to 60% adoption by 2030.

4.8 Summary of benefits

Using a range of assumptions based on previous research and industry data, modelling of the six scenarios identified that over $420 million per annum of potential gross benefit exists from the adoption of further objective measurements, associated pricing signals and resultant on-farm management changes by 2030. Less than $75 million of this could potentially be realised by 2020 while around $250 million may possibly be realised by 2030 (Figure 6)[31]. The difference between potential benefit and likely benefit is the gap between potential opportunity and the level of industry adoption.

[31] All values have been discounted back to 2017 dollars/

These benefits were estimated to be split equally between producer and off-farm sectors of the supply chain in most of the scenarios modelled.

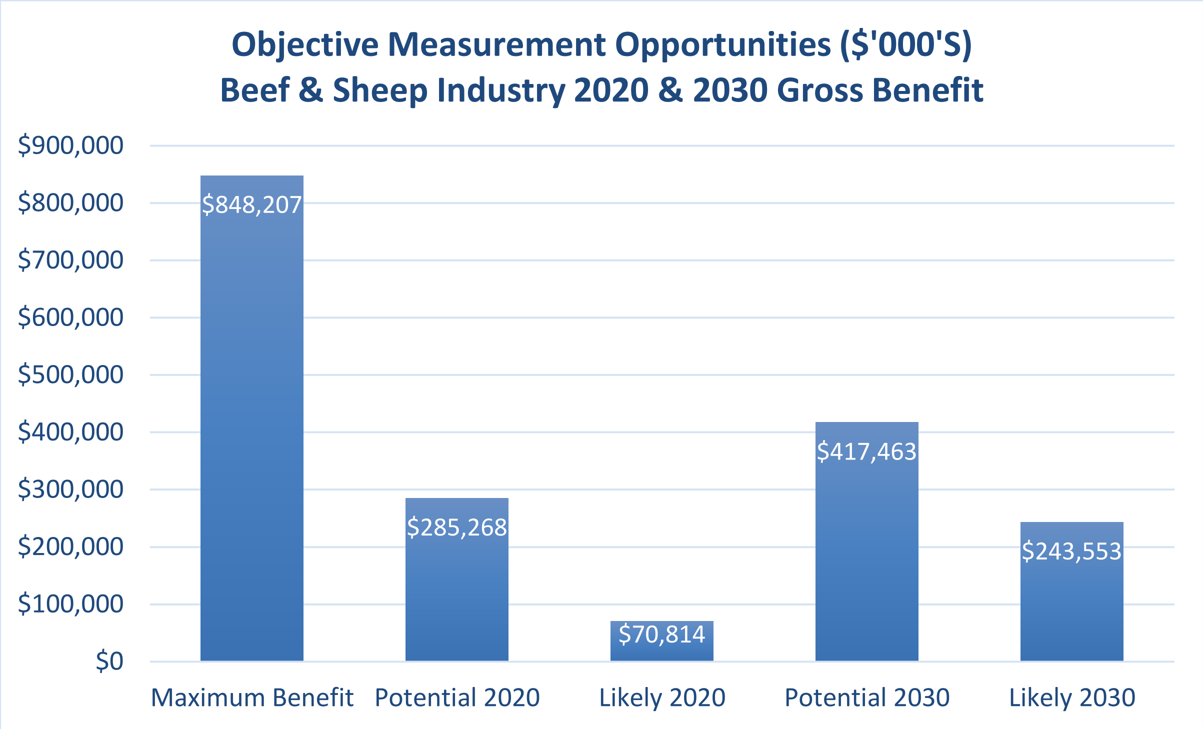
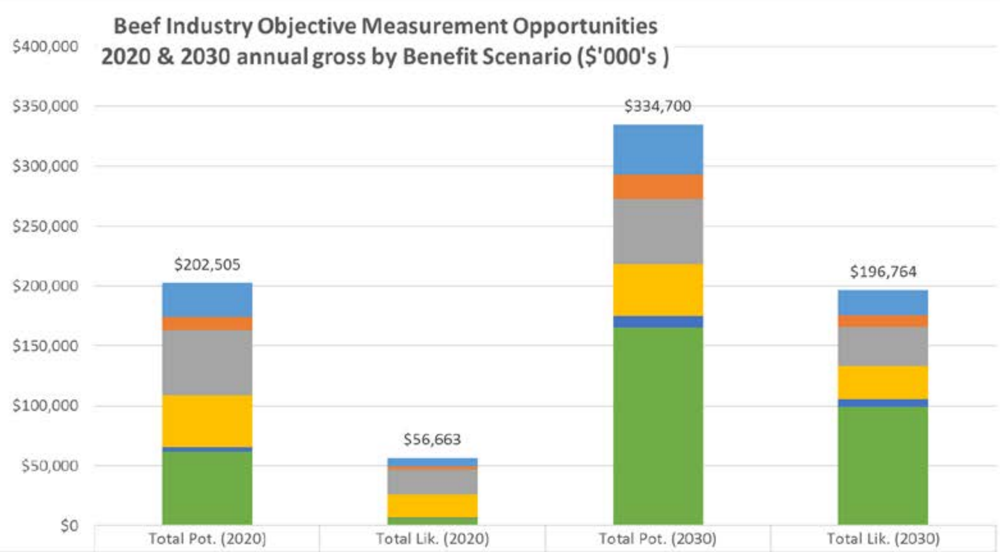


Figure 6: Objective measurement potential value opportunity for the red-meat industry by 2020 and 2030

Note that estimates of 2020 value are considered optimistic given that some objective measures such as IMF in lamb and LMY in beef are not yet available. Unless some other strategy is developed to increase rate of change, these estimates will be difficult to achieve.

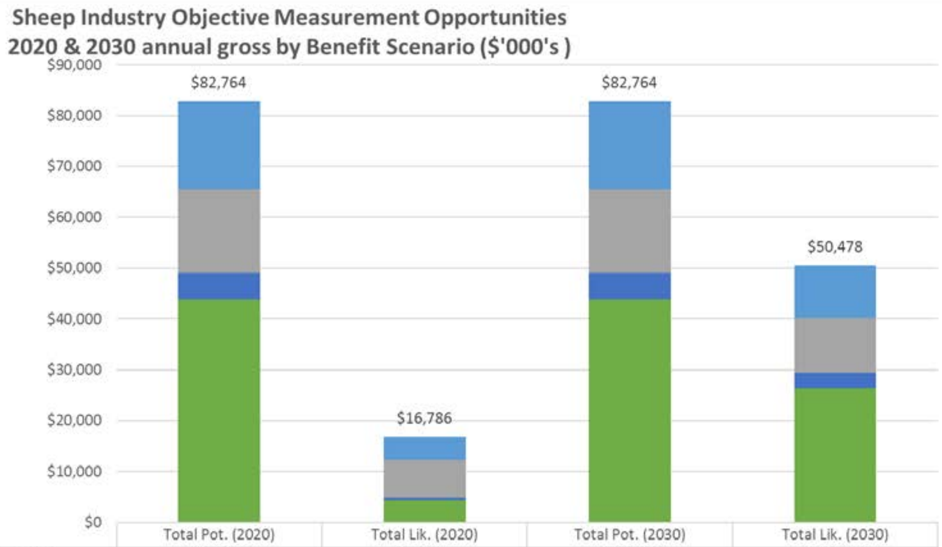
The value of the product attributes contributing to each benefit scenario were quantified in a detailed supply chain costing model as a project output. The full range of objective measurements considered for live and carcase measurements have been included in Appendix 2: Scenario modelling methodology. Measurement accuracies, impact in value transfer between sectors and other adoption assumptions have been described.

Beef and lamb industry benefits for each scenario have been detailed in Figure 7 and Figure 8 respectively. Scenarios 1 through 4 deliver the greatest short-term value for beef while scenario 1 and 4 deliver the most value for lamb (note scenarios 2 and 3 do not readily apply to lamb). Scenario 6 delivers the greatest value over the longer term for both beef and lamb.



	Total Pot. (2020)	Total Lik. (2020)	Total Pot. (2030)	Total Lik. (2030)
S1 - Increasing lean meat yield but maintaining eating quality	$28,310	$7,236	$42,106	$21,057
S2 - Increasing lean meat yield but maintaining pH	$11,009	$2,196	$19,878	$10,099
S3 - Increasing feedlot quality but maintaining turn-off times	$54,522	$21,334	$54,522	$32,546
S4 - Improving animal health	$42,946	$19,326	$42,946	$27,915
S5 - Optimise livestock purchased to market specifications	$3,718	$372	$9,915	$5,949
S6 - Fabrication of purchased livestock to optimise value	$61,999	$6,200	$165,332	$99,199
Cumulative total of Benefit Scenarios	$202,505	$56,663	$334,700	$196,764

Figure 7: Potential beef industry value created from OCM by benefit scenario relative to maximum opportunity



	Total Pot. (2020)	Total Lik. (2020)	Total Pot. (2030)	Total Lik. (2030)
S1 - Increasing lean meat yield but maintaining IMF	$17,315	$4,503	$17,315	$10,389
S2 - Increasing lean meat yield but maintaining pH	$0	$0	$0	$0
S3 - Increasing feedlot turn-off times but maintaining quality	$0	$0	$0	$0
S4 - Improving animal health	$16,393	$7,377	$16,393	$10,655
S5 - Optimise livestock purchased to market specifications	$5,159	$516	$5,159	$3,095
S6 - Fabrication of purchased livestock to optimise value	$43,897	$4,390	$43,897	$26,338
Cumulative total of Benefit Scenarios	$82,764	$16,786	$82,764	$50,478

Figure 8: Potential sheep industry value created from OCM by benefit scenario relative to maximum opportunity

It is noteworthy that total potential value for lamb is the same in 2020 as it is for 2030. This reflects the conservative assumption that the accuracy of technologies used in the scenarios will not improve by 2030.

The distribution of benefits between industry sectors within the supply chain is shown in Table 3.

Table 3: Industry sector value realisation from each scenario

OM benefit scenarios	BEEF				SHEEP		
	Extensive Northern	Reliable Environment	Feedlot	Processing	Lamb	Hogget	Processing
S1 - Increasing lean meat yield but maintaining eating quality		✓	✓	✓	✓	✓	✓
S2 - Increasing lean meat yield but maintaining pH	✓			✓		✓	
S3 - Increasing feedlot quality but maintaining turn-off times			✓	✓			
S4 - Improving animal health	✓	✓	✓	✓	✓	✓	✓
S5 - Optimise livestock purchased to market specifications				✓			✓
S6 - Fabrication of purchased livestock to optimise value				✓			✓
✓ *where the most value will be realised*							

The right of the table indicates where in the supply chain the benefit is most likely to be realised in the short term. For scenarios 1 through to 4, benefits are estimated to be equally split between producer and off-farm sectors of the supply chain. For scenarios 5 and 6, initial benefits would accrue to the processing sectors, although in the long-term redistribution would likely accrue to other supply chain sectors. Details of the modelling and assumptions for each scenario are included in the appendix.

4.9 Benefit results sensitivity analysis

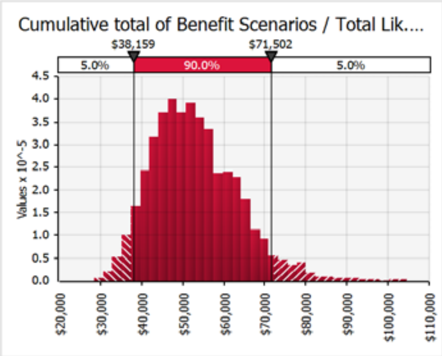
Given the number of inputs to the model, the sensitivity of the benefit scenario results was assessed to ensure their robustness. A third party analytic software program ran risk analysis using Monte Carlo simulation on all inputs to the spreadsheet models that generated the results. This allowed thousands of different possible combinations of input variables to be run and determined the probability and risks associated with each different combination. The risk analysis shows that the reported gross benefits for both beef and sheep are a reasonable estimate after taking into account risk factors that might affect key assumptions around accuracy and adoption.

The variation observed within each model are summarised here.

Beef benefit scenario sensitivity

The Risk analysis for beef shows that the total likely cumulative benefits for 2020 and 2030 (Figure 9 and Figure 10 respectively) are reasonably skewed to the left (i.e. to the lower end of possible values). For the 2030 figures, the mode is calculated at $194,412,000 which is around the calculated static mean presented throughout the report, while the mean calculates as $232,299,000 (which is $36M above the static figures in the report).

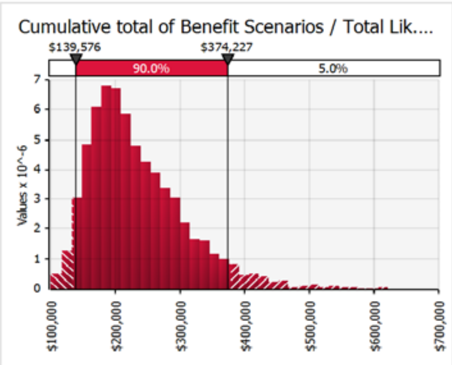
@RISK Output Report for Cumulative total of Benefit Scenarios / Total Lik. (2020) AH8



Summary Statistics for Cumulative total of Benefit Scenarios / Total Lik. (2020)			
Statistics		**Percentile**	
Minimum	$28,359	**1.0%**	$33,541
Maximum	$104,635	**2.5%**	$35,919
Mean	$52,960	**5.0%**	$38,159
Std Dev	$10,473	**10.0%**	$40,689
Variance	109676141.2	**20.0%**	$44,021
Skewness	0.707161757	**25.0%**	$45,381
Kurtosis	3.843741348	**50.0%**	$51,733
Median	$51,733	**75.0%**	$59,613
Mode	$46,971	**80.0%**	$61,564
Left X	$38,159	**90.0%**	$66,408
Left P	5%	**95.0%**	$71,502
Right X	$71,502	**97.5%**	$77,178
Right P	95%	**99.0%**	$81,584
#Errors	0		

Figure 9: Sensitivity analysis for cumulative total of six beef benefit scenarios – Likely 2020 results ($'000's)

@RISK Output Report for Cumulative total of Benefit Scenarios / Total Lik. (2030) AJ8



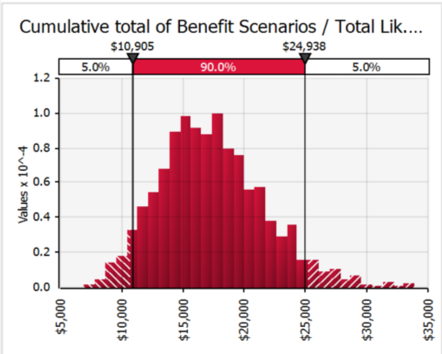
Summary Statistics for Cumulative total of Benefit Scenarios / Total Lik. (2030)			
Statistics		**Percentile**	
Minimum	$101,048	**1.0%**	$119,498
Maximum	$621,456	**2.5%**	$131,061
Mean	$232,299	**5.0%**	$139,576
Std Dev	$73,355	**10.0%**	$152,376
Variance	5380893224	**20.0%**	$170,826
Skewness	1.053544822	**25.0%**	$178,807
Kurtosis	4.331337117	**50.0%**	$217,158
Median	$217,158	**75.0%**	$272,535
Mode	$194,412	**80.0%**	$288,009
Left X	$139,576	**90.0%**	$333,450
Left P	5%	**95.0%**	$374,227
Right X	$374,227	**97.5%**	$414,357
Right P	95%	**99.0%**	$455,100
#Errors	0		

Figure 10: Sensitivity analysis for cumulative total of six beef benefit scenarios – Likely 2030 results ($'000's)

Sheep benefit scenario sensitivity

The Risk analysis for sheep shows that the total likely cumulative benefits for 2020 and 2030 (Figure 11 and Figure 12 respectively) are roughly normally distributed. The mean and mode results for 2030 is $61-62M (which is around $11-12M higher than the static figures in the report).

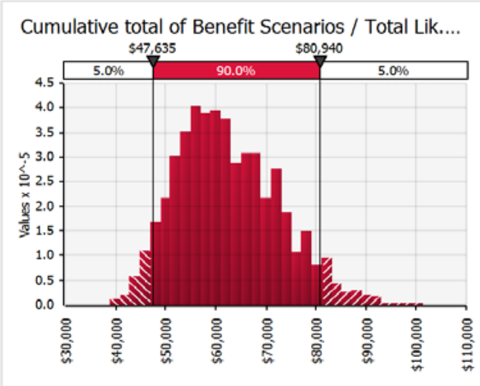
@RISK Output Report for Cumulative total of Benefit Scenarios / Total Lik. (2020) AH8



Summary Statistics for Cumulative total of Benefit Scenarios / Total Lik. (2020)			
Statistics		**Percentile**	
Minimum	$6,929	**1.0%**	$9,124
Maximum	$33,907	**2.5%**	$9,897
Mean	$17,399	**5.0%**	$10,905
Std Dev	$4,311	**10.0%**	$12,133
Variance	18586833.32	**20.0%**	$13,735
Skewness	0.533068191	**25.0%**	$14,359
Kurtosis	3.413621997	**50.0%**	$17,109
Median	$17,109	**75.0%**	$19,975
Mode	$18,328	**80.0%**	$20,858
Left X	$10,905	**90.0%**	$23,177
Left P	5%	**95.0%**	$24,938
Right X	$24,938	**97.5%**	$27,082
Right P	95%	**99.0%**	$28,969
#Errors	0		

Figure 11: Sensitivity analysis for cumulative total of four sheep benefit scenarios – Likely 2020 results ($'000's)

@RISK Output Report for Cumulative total of Benefit Scenarios / Total Lik. (2030) AJ8



Summary Statistics for Cumulative total of Benefit Scenarios / Total Lik. (2030)			
Statistics		**Percentile**	
Minimum	$38,883	**1.0%**	$43,658
Maximum	$101,228	**2.5%**	$45,721
Mean	$62,539	**5.0%**	$47,635
Std Dev	$10,205	**10.0%**	$50,001
Variance	104143616.8	**20.0%**	$53,580
Skewness	0.481833742	**25.0%**	$54,983
Kurtosis	2.944344997	**50.0%**	$61,322
Median	$61,322	**75.0%**	$69,150
Mode	$61,381	**80.0%**	$71,501
Left X	$47,635	**90.0%**	$76,673
Left P	5%	**95.0%**	$80,940
Right X	$80,940	**97.5%**	$84,254
Right P	95%	**99.0%**	$89,394
#Errors	0		

Figure 12: Sensitivity analysis for cumulative total of four sheep benefit scenarios – Likely 2030 results ($'000's)

More detailed risk sensitivity results tables are included in Appendix 10: Sensitivity analysis for individual benefit scenarios.

5 Realising the potential benefits of OM

5.1 A new value-chain model

Several barriers to adoption of technologies and associated pricing signals were identified during the consultation process for this project. These challenges in transitioning from 'sector-focused' to 'consumer-focused' production are described in Figure 13. The diagram summarises why adoption of improved measurement accuracy, pricing signals and information sharing will be limited without industry facilitation and describes phases of industry transition including:

1. Current industry state (S1) at the top. This identifies why the industry needs to change if the new value is to be realised.
2. Partial adoption (S2 in the middle) identifies transition challenges. As the industry transitions, there are significant financial risks across the supply chain and instability around competitive advantage depending on how different sectors of industry respond.
3. Full integration (S3 at the bottom) describes a new industry environment where full productivity gains are being realised across the industry.

The text boxes in Figure 13 summarise the factors that need to be addressed and are expanded below.

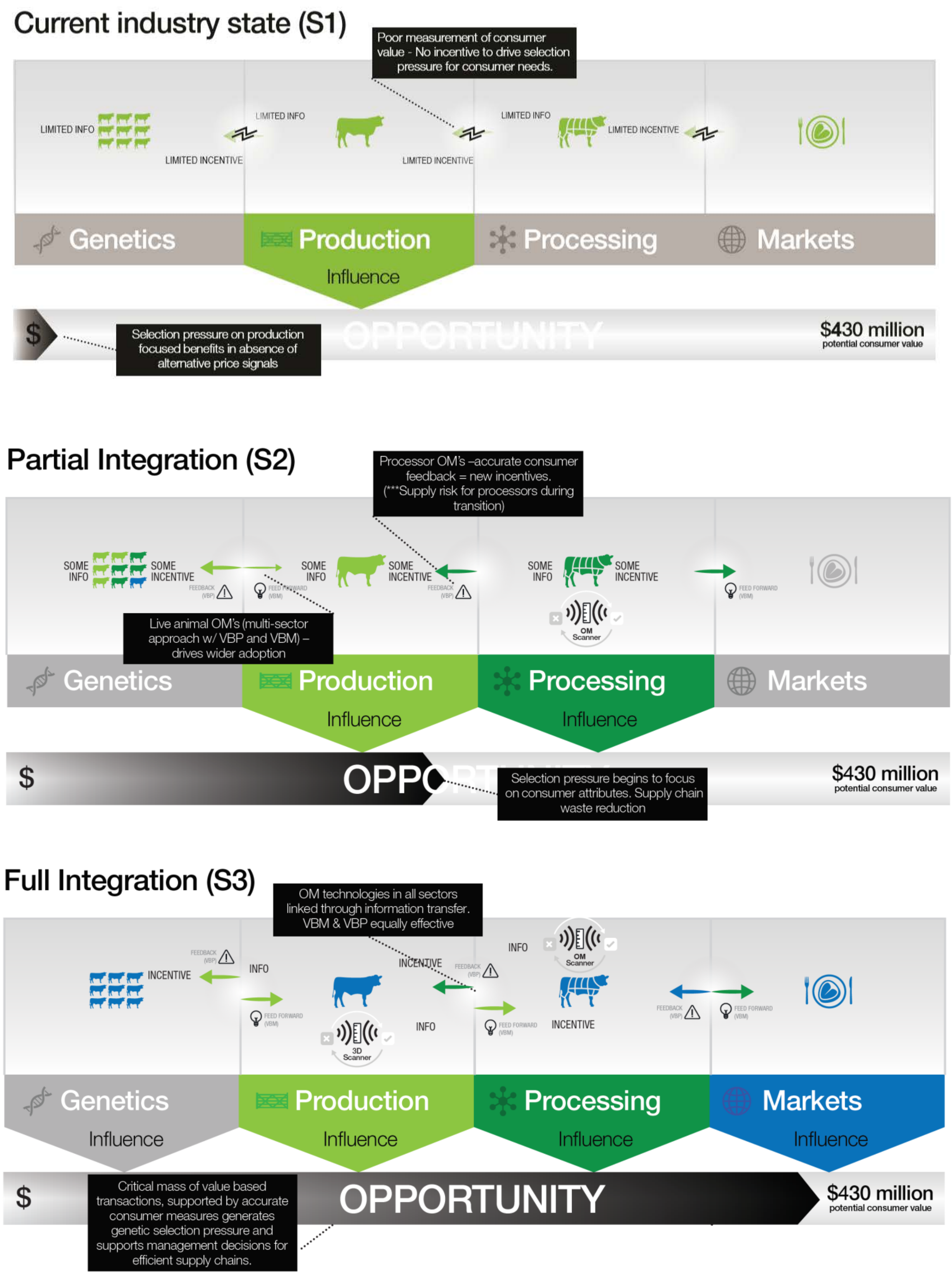


Figure 13: Industry transition from current sector focused supply chains to consumer alignment for increased industry value

Further detail in relation to these 3 phases is described below:

Current Industry

1) Measures do not align to value – The current industry descriptors of value do not accurately align to processor and consumer requirements. Thus, pricing signals from the market do not focus genetic improvement in the correct areas. Lamb pricing grids, for example, do not differentiate fat and weight for almost 80% of production although there are significant differences in value (yield and quality) within this single payment bracket. The average price is paid for different values. Some livestock attract higher prices than their worth to the processor and consumer and others are undervalued.
2) Selection pressure is not optimised to consumer value – As current measures and thus pricing may not fully align with processor and consumer value then selection pressure is toward on-farm factors and is not optimised. Waste is produced at a cost to the whole supply chain. Overfat lambs are produced because they are paid on weight and not yield. Aligning the direction of on-farm selection pressure to consumer needs is critical for the red meat industry to increase value but will not occur without pricing signals. Several important objective measures such as yield and eating quality are negatively correlated[32]. Therefore, it is important that new objective measurements are developed that support industry improvement across all traits that are of value to consumers.

Partial Adoption

3) Supply risk is a barrier to adoption – Objective measures at processing will enable feedback providing the opportunity to lead to product improvement. There will be some winners and some losers in the short-term – misalignment of value from current measures means some producers are underpaid while others are overpaid. This is a major supply risk for many processors and a barrier to adoption. A number of processors mentioned during consultations for this project that they would not be the first or the only ones to adopt value-based trading (VBT) as it might result in them losing supply to competitors. The temptation is to continue paying on existing terms rather than adopting VBT.
4) Adoption risk is reduced with both pre-and post-slaughter OM technologies – Objective measures pre-sale in the live animal would provide feed-forward information. However, live animal OM technologies will be adopted more slowly (hence the weaker arrow). Many producers do not currently have scales but mobile measurement technologies could be provided as part of live assessment services or at central locations like saleyards. This would encourage processors to adopt value-based measures without risking supply. This also gives the producer the power to market their livestock based on known attributes to the highest bidder.
5) VBT shifts selection pressure – As VBT is adopted the direction of selection pressure begins to shift from benefiting only one sector to larger whole-of-chain benefits.

[32] Sheep CRC (2007). On-farm impacts on meat eating quality. *Sheep CRC*. PW 009-2007.

Full Integration

6) Objective measures in both on-farm and off-farm are correlated through information sharing to further improve accuracy of OM technologies. Management decisions on farm are supported by on-farm OM technologies increasing the efficiency of the chain with more immediate decision making capabilities.
7) Feed-forward and feedback mechanisms create more transparency, enable new ways to market livestock and focus genetic selection and management decisions for efficiency in delivering consumer value.

5.2 Trading platforms

A number of different trading methods are used in the red meat industry including auction systems, over-the-hooks, paddock sale with or without visual assessment, and vertical integration. Each of these methods facilitates the assessment of value and transfer of ownership between the buyer and seller. Buyers and sellers generally agree that the accuracy of value assessment is less than optimal – hence the need for new objective measurements supported by technologies and industry standards that describe end consumer value much more accurately.

Value-based pricing (VBP) and value-based marketing (VBM) are different activities. They are dependent on where objective measures are located in the supply chain (pre- or post-sale). Each will impact differently on value that can be generated and on the likelihood of adoption of the technologies and their measurements. Note that live animal OM measurement and hence use of VBM has been excluded from all scenario gross benefits as live animal LMY and EQ measurement technologies are unlikely to be commercially available in the near future.

Value-based pricing is defined here as the process by which a buyer (e.g. processor) will pay a seller (e.g. producer) based on the specific 'value' characteristics of the carcase (or potentially the live animal in the future) after the commitment to sell has been made. Although prices for different values are usually agreed prior to sale, the actual value of the product is unknown until after the commitment to sell/buy.

Value-based marketing is defined as specifying the 'value' characteristics of the live animal prior to the sale commitment and using these measures to offer the animal to prospective purchasers. The accuracy of live animal measurements in describing post-slaughter value will need to be accurate enough for VBM to substitute for VBP.

The opportunity with VBM over VBP is that the buyer does not need to commit to buy product they do not actually want (i.e. that may not meet their specifications). Under a VBM scenario the buyer knows precisely what they are getting before they commit to it. Furthermore, the seller may choose to sell the livestock to another market that is better suited to handle their now-known product, or they may choose to keep the product for longer to create additional value that will make it more marketable and more profitable. The benefits and disadvantages of each approach are summarised in Table 4.

Table 4: Comparative strengths and weaknesses of VBP and VBM systems

Factors	Value-based pricing	Impact	Value-based marketing	Impact
Supply chain impact	Lag measure - limits management decisions on immediate animals and limits value increase.	↓	Lead measure - support live animal management decisions	↑
Standards	Calibration of standards needed	↑	Harder standards calibration (currently)	↓
Accuracy	Higher OM accuracy	↑	Lower OM accuracy	↓
Adoption	Centralised OM will drive faster adoption.	↑	Reduced pricing signal clarity with lower initial supply volume and slower adoption	→
Barriers	Transition risk for processors (potential for reduced supply numbers)	↓	Does not require buyer leadership of VBT, therefore wider indirect adoption by processors (less risk of supply numbers to buy on OM)	↑

5.3 Managing the transition

To firmly establish new objective measurement technologies and related VBT, industry initiatives tend to address one or two challenges but in this case, all factors require a multifaceted approach that will need to be implemented and supported until industry has made the transition. The following activities are all required to make this transition sustainable:

- Efficient, accurate and commercially cost-effective OM technologies made available to capture the right information;
- Data transfer mechanisms made available including but not limited to pricing signals;
- Extension activities undertaken to help increase understanding of new measures and the implications of associated pricing signals and strategies to align supply to increased value; and
- Supporting framework including standards and system integrity to build confidence.

Figure 14 highlights three critical parts of an industry transition.

1. **More accurate measures** delivered by objective technologies describe product value more accurately than current language and enable the general value proposition.
2. **Value-based payments** encourage improved decisions using these measures to add value, monetary or otherwise, back to industry.
3. Adoption increases selection pressure, genetic gain and competitive advantage. As data moves along the 'data value chain' to decisions, **extension programs increase understanding** and adoption so the industry value generated is increased exponentially.

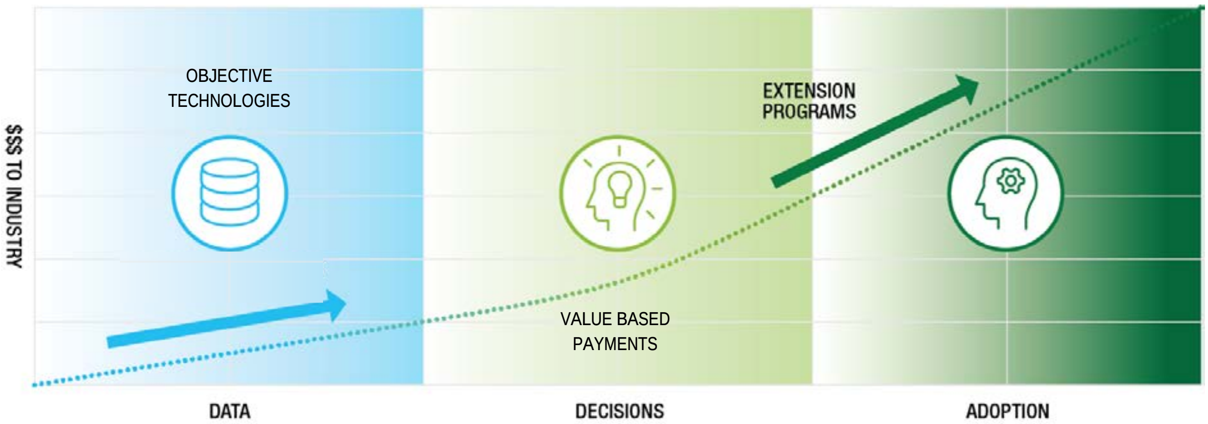


Figure 14: Data Value Chain

A multi-pronged approach to seek the adoption of additional OM and related VBT should be progressed including a combination of VBP and VBM. Figure 15 describes the likely limited adoption of VBP (estimated optimistically at around 20% of industry) by 2020. However, introduction of VBM through live animal measurement technologies would reduce adoption barriers and likely increase adoption of OM technologies post-slaughter.

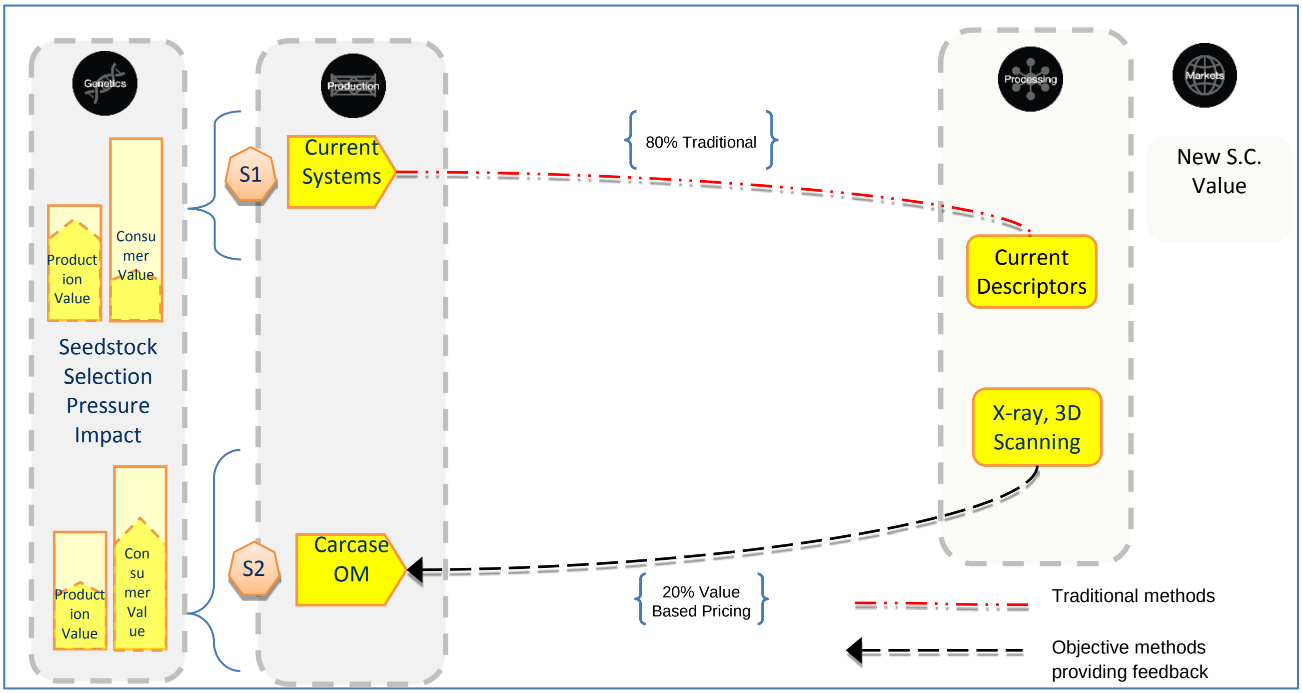


Figure 15: Limited adoption of value based trading with single pricing mechanism

Use of accurate live animal measurement technologies as shown in Figure 16 would increase awareness and use of objective measures by processors, even if they do not outwardly promote VBT. This is discussed in more detail in recommendation 5 below. Multiple measures will support industry change from all sectors.

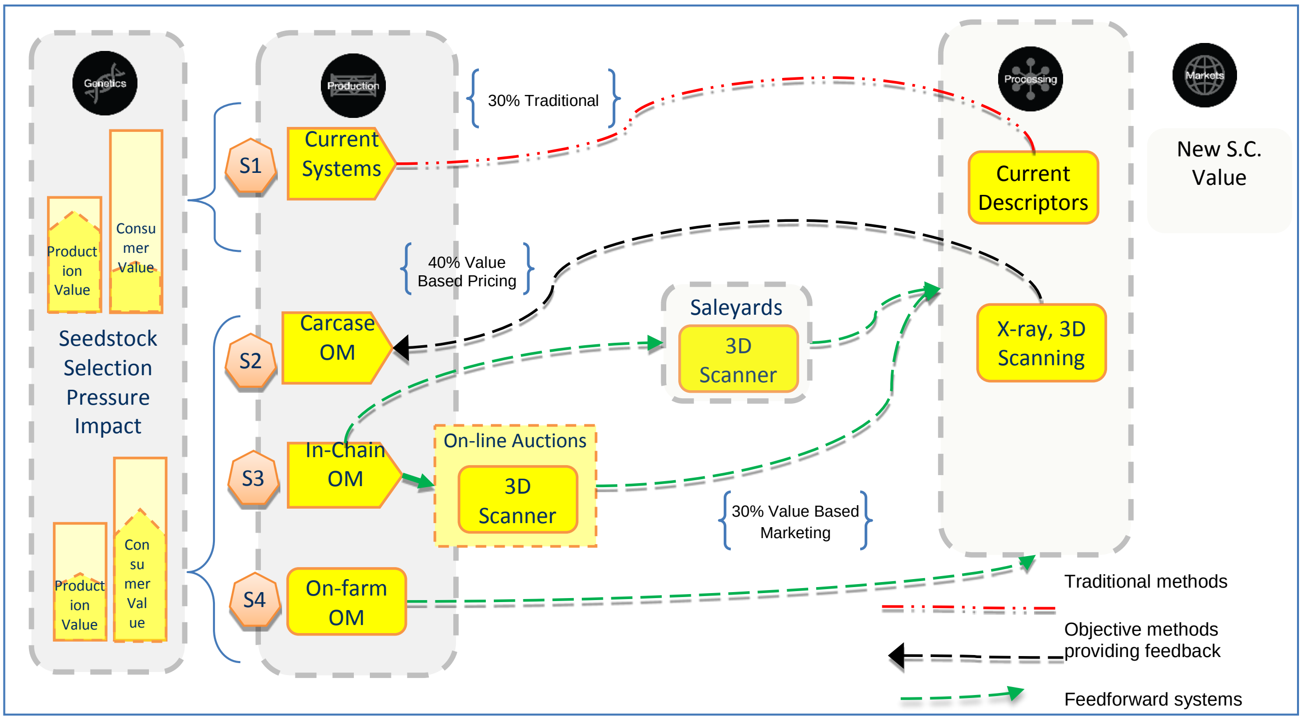


Figure 16: Multiple measurement locations with feed forward and feedback of information supports wider industry adoption and value increases

5.4 Key challenges and recommendations

This final section summarises the key challenges faced by the red meat industry in moving to additional OM and related VBT and improved supply chain and production efficiencies, and recommendations to address these.

The challenges are prioritised in order of implementation timeline. All areas should be developing in parallel but in the following order of implementation. As each challenge is addressed the next one is more likely to be overcome.

Challenge 1 – Leadership to OM and value based trading

Experience from other industries, and within the red meat industry as well, suggests that a dedicated industry-based group will be required to set direction on prioritised actions and keep a focus on the successful conclusion to the anticipated challenges.

It is recognised that such a group will have many varied and opposing needs and agendas. The facilitation of this group will need at its core a leadership group with key industry representative members highly respected and trusted by the groups they represent that are seen to act in their best interest. The group should have a broad base of skills and representation.

Recommendation 1 – Form an OM Adoption Group (OMAG), that will focus industry activities on outcomes that enable adoption of OM and related value-based transactions for increased value across the red meat supply chain.

The group's structure should include:

- **Leadership Group** – consisting of industry leaders representing all sectors of the chain across the red meat industry. One role is bringing key groups together for projects and commercial solutions both publicly and privately funded. Strategic leadership will focus industry on adoption of OM and related value-based transactions and decision support for increased supply chain value. This group should focus on the end goal and maintain industry adoption momentum.
- **Industry Think Tank** – consisting of commercial sector participants, researchers and solution providers with a focus on commercial adoption of solutions. The existing OM Technology group may fill this role with guidance from the Leadership Group.
- **Standards Technical Group** – an independent group that will build and maintain standards and registers for application of OM technology measurements, and provide advice, information and guidance on a range of technical measurements and technology development activities to encourage industry adoption and confidence.

Challenge 2 – Develop the right objective measurement technologies

Commercially available objective measurement technologies are required before VBT can occur in a fully efficient manner.

There is considerable enthusiasm for the possibilities for objectives technologies to increase value. This includes development of technologies for new measurements, improvements in accuracy of existing subjective assessments and exploration of ways to measure new attributes. These are important for the longer term, however, to facilitate the initial adoption of key OM and value-based transactions, only a few are important to help overcome the remaining challenges that are listed in points 3 to 7 below.

For example, only benefit scenario 3 *('Increasing beef feedlot quality and turn off times'*) and scenario 4 (*'Improving animal health')* can be delivered currently. To implement all scenarios, several objective measures need to become commercially available. These are listed in order of priority in Table 5. Post-slaughter measurement location is suggested initially for faster initial adoption, although live-animal measurement would introduce additional efficiencies (but these have not been included in the modelled scenario benefits).

Table 5: Objective technology development priorities (post slaughter)

Traits	Development priority
Lamb IMF	1
Beef and Lamb LMY	2
Beef pH/MC	3
Beef Eating Quality	4

Enabling capabilities – Data capture and transfer capabilities are not objective measures per se' but are important to facilitate adoption in Challenge 3. For example, digital capture of subjective animal health data is an important area of capability development that will enable data transfer and extension in Challenge 4.

Points of note -

- Additional OM technologies in the above areas and in other locations in the supply chain will become important but are not required until after Challenge 3 is addressed.
- Individual animal ID in sheep may speed genetic gain but is not considered critical to sheep industry productivity and quality gains for the following reasons:
    1. Multiple rams are generally joined across a mob. Rams are generally selected as a group and managed on a whole-of-flock basis.
    2. Even with individual ID feedback, rams would not normally be replaced outside the planned replacement cycle.

Recommendation 2 – Prioritise research and development of objective technologies and enabling capabilities for commercial use by certain timeframes. The OMAG should consider how this activity progressively supports industry and the remaining recommendations.

Challenge 3 – Objective measurement adoption

Installation of objective technologies is required at points in the supply chain where published measures (whether in price grids or sale catalogues) will enable VBT to occur.

> Priority installations – Supply risks discussed earlier in transitioning to VBT make faster and more widespread adoption important for industry to proceed. Widespread adoption by processors should be encouraged to facilitate acceptance of value-based pricing signals by industry in Challenge 5.
>
> Secondary installations – Seedstock and live animal sectors of the chain should be encouraged to install 'on-farm; measurement technologies as early as possible once available, but as a secondary priority as this should not be at the expense of processor installations. For example, 3D scanning for LMY in live animals ready for processing and genetic testing of animals targeted as feeder steers for quality markets can facilitate VBT in multiple sectors. These secondary activities will help address Challenge 5.

Recommendation 3 – Support industry to adopt objective measurement technologies via widespread availability of commercial systems (becoming "objective-measurement-ready"), initially at the processor level but progressively on the live animal.

Challenge 4 – Understanding the impact of objective measurement (education phase with supply chain participants)

Understanding of OM results is required for each sector of the chain and will only be achieved through the provision of results from commercial OM technologies. This activity heavily engages the subsector of industry where OM technologies from Challenge 3 have been installed. This stage answers many of industry's questions such as: will I be better or worse off with OM and VBT; what should our VBP grids look like; which of my suppliers will be disadvantaged and what can I do to help them improve; do I trust the measures and how they are being delivered; would I be better off supplying to another company; and so on. This phase is a chance to link industry talk to reality. It addresses commercial questions before they occur. A precursor to adoption of OM based pricing signals is an understanding of what they mean to both the buyer and the seller including:

i. Correlation between existing and new measures;
ii. Differences in value distribution between existing and new measures;
iii. Advantages and disadvantages created by new measures and relative pricing differences; and
iv. Actions possible and time required to bridge the gap if worse off than current.

Activities may include:

- Running existing and VBP grids in parallel;
- Delivering extension activities through processor and producer networks encouraging discussions around actions to improve value;

- Leverage of discussions to create secondary value for both buyer and seller such as alignment of forward supply to killing space availability;
- Data sharing to create compelling value propositions for those who do adopt OM and VBT; and
- Development of on-farm decision support tools to facilitate the application of new measured traits.

Recommendation 4 – Increase supply chain participant (especially producer) understanding of the impact of objective measurement on their businesses by working collaboratively to educate and support opportunities to increase value (becoming "objective-measurement-aware").

Challenge 5 – Standards for objective measurement and reporting

A multi-pronged approach is required to familiarise the broader industry with technology, measures and value discussions demonstrating that VBT can be advantageous. A willingness from the larger portion of industry to adopt VBT is required to drive industry improvement and to overcome the risks of partial adoption. A range of activities that build confidence in the transition to objective technologies and demonstrate the momentum of the industry transition should be undertaken including:

- The Standards Technical Group described in challenge 1 should oversee measurement accuracy, especially where different technologies are applied. Display of these activities should help to achieve widespread awareness and build confidence in the systems as independently verified from the companies using them.
    i. Validate objective measures for each technology
    ii. Validate accuracy correlations between different technologies for a given measure obtained at different locations in the chain and the impact that has on value in each sector of the chain
    iii. Inform industry of these systems in a way that builds confidence and trust in measures.
- Industry should facilitate adoption of new OM language and trading platforms that will shift the basis by which competitive advantage is sought by supporting the following activities:
    i. Develop new OM based reporting that extends the outputs from challenge 2 to the wider industry;
    ii. Encourage measurement visibility in all directions in the chain. For example:
        1. Integration of objective measurements into on-line auction platforms
        2. Development of decision tools that allow sharing of objective measurement data between producers, agents, seedstock and processors so the measures and their value within new trading platforms are established;

iii. Create value propositions through data sharing that encourage data sharing while, at the same time, supporting commercial-in-confidence data security (refer to V.IIP.1610 value chain information project report);
iv. Encourage through proactive enablers (decision tools, measures, data sharing, extension activities and industry case studies) of the adoption of new objective measures;
v. Support increased transfer and adoption of information between genetics and consumer where there is a current lack of alignment; and
vi. Transfer health data (which is considered non-competitive) to facilitate wider information sharing.

- New business models that support planned value increase for both the buyer and seller through new OM's should be encouraged.
- A multi-pronged approach to objective measures should be taken in which:
  i. Different systems measuring the same traits in different locations of the chain are connected and correlated.
  ii. Trait data linked with management inputs helps users make better decisions.
- Multi-discipline programs (see recommendations in V.IIP.1610 report around industry '*thought leadership*' group) such as genetics, management inputs, and market insights to increase supply chain efficiency should be integrated.
- Efforts should be made to increase awareness of the value of these new measures and associated tools through smart marketing activities that redesign old carcase competitions and industry field days to new "supply chain challenges".
- OMs should be integrated with data transfer and information sharing – in some cases measurement technology is not the barrier to increased value, even where technologies do not exist. Animal health is an example of this.
- Pricing signals are critical to industry transition. As a result, there is a need for development of technologies and information systems that are communicated to industry that support transparent price signal understanding.
- New methods for auction systems that facilitate communication of carcase information and are visible to the wider industry through market reporting initiatives (for example) should be developed.

Recommendation 5 – Develop standards for objective measurement, data transfer and reporting that build confidence and integrate with industry support systems, on-farm and off-farm extension activities and reporting functions to facilitate whole-of-industry adoption of objective measurement and VBT systems (becoming OM and "value-based-trading-ready").

Challenge 6 – Value-based trading

Adoption of VBT price signals is the critical step in realising value where product is paid for on the basis of new measures. There will be some winners and some losers in this transition. It is important that adoption is sufficiently widespread that losers are encouraged to improve, rather than enticed to opportunistic markets and risk reverting to price averaging. It is expected that activities arising from Recommendation 5 will reduce this risk.

- Many of the activities required here are an extension of those associated with Challenge 5 but with agile delivery that collaboratively supports and reports industry's findings and next steps to increase momentum of adoption.
- MLA should continue to facilitate development and adoption of OM technologies in multiple locations in the chain, not just at processing.
- There should be support for the development of VBM as well as VBP to build stability, transparency and confidence in the measurement language and value based trading.
- There should be continued development and eventual launch of stage 2 objective measures, such as:
  i. Animal health conditions
  ii. Eating quality (building on MSA traits)
  iii. Live animal LMY (beef and sheep)
  iv. Live animal IMF (sheep and beef)

Recommendation 6 – Support the widespread adoption of VBT to achieve a critical mass required to be sustainable (becoming "value-based-trading-active".

Challenge 7 – supporting ongoing industry gains

Development of accurate measures of value and subsequent pricing signals addressed in challenges 1-6 is a critical first step to increasing industry efficiency, value and global competitiveness. However, it is only the first and enabling step to a range of longer term activities that will deliver greater industry value. Associated genetics programs, decision support initiatives and extension activities are all connected as part of a wider industry digital strategy. Part of the OMAG's role should be to craft the ongoing integration of these other activities which will be underpinned by OM and VBT foundation. This should involve two aspects:

Industry improvement – Transition the activities in challenge 5 that were aimed at increasing awareness and acceptance of OM and VBT to facilitate industry to adopt information and technology for improved decision making and faster rates of genetic gain.

Strategic alignment – Rapid change and progress is exciting and a hopeful outcome of VBT but it can also get off-track quickly. Part of the OMAG's role should be strategic leadership around emerging issues as they relate to OMs and VBT that could impact industry competitiveness and profitability such as:

- Mitigating the risk of misaligned industry improvement like some industries' focus on yield at the expense of eating quality and consumer acceptance
- Protection of industry genetics data to enable ongoing improvement.

Topics such as genetics, data, technology, measurement language and market access would continue to be considered and improved on.

Recommendation 7 – Continue to expand the base of commercial objective measures and integrate complementary programs to leverage ongoing industry improvement and competitive advantage from objective measures (leading "global competitive advantage").

Summary of recommendations

The ordered rollout of the seven recommendations which support the adoption of VBT underpinned by objective measures in the Australian red meat industry are summarised in Figure 17:

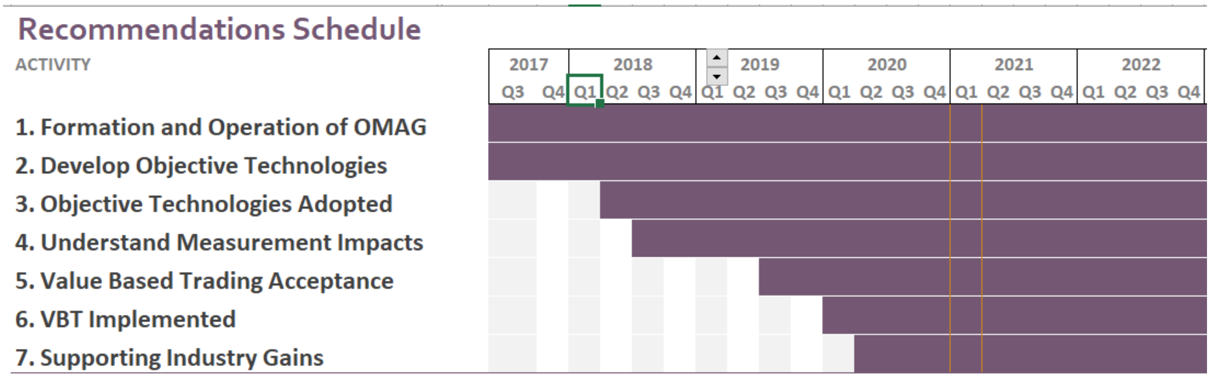


Figure 17: Recommendations schedule

Greenleaf Insight Innovation Growth miracle dog SCOTT WILLIAMS

Tables

Figures

Appendix 1: Industry consultation

The following provides a list of consultations undertaken throughout the project.

Group	Industry Participants	Contacts
Breed societies	Angus Australia	Peter Parnell
	Australian Wagyu Association	Carel Taseling, Graham Truscott
	Herefords Australia	Alex Ball
RD&E service providers	ABRI (Agricultural Business Research Institute)	Hugh Nivison
	AGBU (Australian Genetics and Breeding Unit)	Rob Banks
	Sheep CRC	James Rowe, Johan Boshoff
	UNE (Supply Chain/Economic Modelling)	Derek Baker, Julius van der Werf
	CRC for Spatial Information	Phil Delaney
Solution providers	Telstra	Lavina Muscat
	Rezare	Andrew Cooke
	Austin Labs	Simon Drake, Dave Brown
	AusVet / Omnisyan	Jenny Hutchison
Peak industry councils	National Farmers' Federation (NFF)	Charlie Thomas
	Animal Health Australia	Duncan Rowland, Lorna Citer, Rob Barwell
	Sheepmeat Council of Australia (SCA)	Mark Harvey-Sutton
	Cotton RDC	Jane Trindall
MLA	Innovation, Adoption, Commercialisation	George Waldthausen
	Red Meat Innovation	Richard Apps
	Marketing / Data	Lisa Sharp, Ben Thomas
	On-farm Innovation and Adoption	Matt McDonagh, Mary Goodacre
	Livestock Data Link (LDL)	Jo Quigley
	Genetics / Data Insights	Sam Gill
	National Livestock Identification System (NLIS)	Stephen Doughty
Processors	JBS	Mark Inglis
	Teys	Tom McGuire
	ACC	Paul Gibson
	AACo	Jason Strong, Gerard Davis
Producers	Beef Producer - Te Mania Beef Producer Sheep Producer Sheep Producer	Tom Gubbins Ian Mc Camley Ken Baldry Michael Craig

Appendix 2: Scenario modelling methodology

Overview

An Excel® model was created and populated with quantitative data and qualitative information based on the team's experience, and the research and industry consultation conducted for the project. The model is effectively a 5-dimensional matrix where a combination of elements describes the detail within a benefit scenario. The elements of the matrix are explained below and include:

- Trait
- Benefit
- Measurement sector
- Behaviour / reward sharing relationship
- Benefitting sector

For each combination of the above elements, maximum, potential and likely benefits were calculated. These types of benefits are defined for each trait as:

Maximum theoretical benefit – full genetic potential for improvement without environmental and adoption limitations.

Potential benefit – specific to the sector of the chain where the OM is applied and assumes 100% adoption of the future OM technology measurement. It considers the accuracy of the measurement and the magnitude of change that can be effected when the measurement is made at that point in the chain. For example, measurement of meat colour post-slaughter will be much more accurate than live animal prediction of post-slaughter meat colour. However, there is no ability to change the meat colour post slaughter, whilst measurement pre-slaughter may enable corrective action. The potential value each option provides is different and both are less than the maximum value of improved meat colour.

Likely adoption benefit – the potential benefit adjusted downwards after taking account of expected adoption rate at the supply chain measurement points and adoption of that measurement by other sectors of the chain.

The model is based on estimates of industry adoption by 2020 and 2030 and helps identify where the largest opportunities lie. It also identifies areas that could generate large value but due to measurement location or limited adoption, for example, are unlikely to deliver much of that benefit opportunity. These matrix outcomes will help test alternative measurement and business model solutions that might deliver a greater portion of maximum industry benefit.

Traits

While not every trait can currently be measured or predicted at the optimum or at all points in the supply chain, the following table is a known list from which the traits of most value for objective measurement were selected.

Physical characteristic / Trait - Beef	Physical characteristic / Trait - Sheep
• Ultimate pH • Juiciness • Flavour • Tenderness • Meat Colour • Maturity (age) • Maturity (ossification) • Basic (Veal, Beef, Bull) and alternate categories (numerous) • Lean meat yield – Carcase and Primal • Eye Muscle Area • Sex • Weight • Fat Depth • Marbling • Hump Height – Bos Indicus content indicator • Bruising • Offal quality / Disease status • Skin & Hide quality • Microbial counts • Market/specification compliance • MSA eating quality • AUS-MEAT trim • Frame score • Horned status • Grain/grass finished	• Meat colour • Ultimate pH • Juiciness • Flavour • Tenderness • Maturity (age and proxies) • Lean meat yield – Carcase and Primal • Eye Muscle Area/Depth • Breed type • Weight • IMF • Fat Depth • Bruising • Seed contamination • Offal quality / Disease status • Skin, Hide & Wool quality • Microbial counts • Market/specification compliance • MSA eating quality • AUS-MEAT standard and hygiene trim

Benefits described

Benefit categories summarise specific benefits enabled by measuring each trait or combination of traits. While the range of benefits are many and varied, the value generated fits into one of the following categories:

- Process improvement – decreasing the costs associated with product throughput through increasing the consistency of products.
- Market alignment – obtaining more information or other enabling capabilities to better align existing product to the highest value markets.
- Product value - Increasing the value the customer is willing to pay per unit (increased eating quality, longer shelf life, shape/size etc.). This represents an increase in the TOTAL value generated by the supply chain.
- Productivity - A change in the amount of output per unit of input. This may result in more product at the same cost or the same amount of product at a reduced cost. E.g. Increasing the volume of units sold (LMY for same feed inputs; genetic gain), improving yield in boning room, reducing disease load to improve feed conversion.

Benefits in these categories may come about through the introduction of new information, new technology or new processes.

Prioritising benefits in each scenario focus on a few key traits that would give the greatest benefit if measured by OM technologies, acknowledging the full value for industry is much broader. Within each benefit scenario we have grouped the benefits to aid communication as follows:

- Primary benefits are the focus of each scenario (e.g. LMY and EQ, Animal Health, Marbling and Meat Colour). The maximum possible industry benefit is calculated as described in section 4.

- Secondary benefits were also considered. These are more specific and do depend where the trait is measured and where benefit is attributed to. For example, an objective measure of lean meat yield in the live animal may increase rate of genetic gain for the whole supply chain but may also save drafting costs or feed costs for the live animal. These have a big impact on adoption of OM measures. Some primary benefits have marginal value when viewed in isolation. But when other secondary benefits are included the primary benefits (the focus of the benefit scenario) become a more important value proposition (e.g. LMY OM's in processing could also improve boning efficiency and market alignment). These types of additional benefits are very specific to each commercial operation. For example, some processors have the ability to automatically sort carcases in chillers for LMY and boning runs to remove labour costs while others do not have enough chiller space. Given this is a higher-level industry review, secondary benefits have been excluded from the calculations and therefore the numbers are conservative. Secondary benefits will be important to consider in more detail in future supply chain specific activities.

Specific benefits considered while developing the final benefit scenarios is included here:

- Yield increase (meat)
- Decreased consumable cost along the supply chain
- Rework reduced
- Shrink reduced
- Labour saving
- Reduced dark cutters
- Increase retention and quality of offal
- Reduced disease impacts on farm
- Increase processing efficiency
- Improved value of meat
- Improved decision making regarding marketing and animal production management
- Increasing branding premiums (provenance for example)
- Improved shelf life
- Increased weight at sale
- Increase value
- Reduced mortality
- Increase number of units for sale

- Reduced transport costs
- Increased processing efficiency
- Increase feed conversion efficiency

Measurement sector

For each primary and secondary benefit, consideration is given to whether or not the trait could be measured at each sector in the chain and a subsequent total potential realisable benefit is calculated based on the following factors:

- Ease to implement – a percentage rating of how easy it is for the measurement to be implemented.
- Technical likelihood – a percentage rating of how likely it is to be able to undertake this measurement in this sector. This was set at 100% to demonstrate the full value assuming it could be measured at that point. It could be adjusted in future modelling to estimate the risk/return ratio for future R&D investment.
- Accuracy of measurement – the degree of accuracy (5 confidence limits) of this measurement in this sector
- Magnitude of change – when measured at this sector and the measurement is fully used, the percentage of the total potential benefit that can be realised across the whole industry.

Behaviour / reward sharing relationship

The last step in the modelling considers the sector in which the benefit will be realised. In undertaking this assessment, consideration is given to the behaviour / reward sharing relationship between the 'buyer' and 'seller' at the point the measurement is taken and value transferred. This has an impact on the likelihood to adopt.

The current list of behaviour / reward sharing relationships are listed below.

- Auction system
- Forward selling
- OTH and other retained ownership models
- Integrated supply chain
- Value-based pricing (VBP)

This component of the model has been bypassed to simplify data capture. Adoption rate inputs are the sole entry point into the model and reflects the type of pricing systems above.

Benefitting sector

Finally, the distribution of total realisable benefit is considered under each behaviour / reward sharing relationship. In some cases, the sector where the measurement is taken may receive all the benefit, part of the benefit or none whatsoever. In the latter case, in a behaviour / reward sharing relationship other than a fully integrated supply chain, the question was asked, what incentives if any would need to be applied to encourage such measurements to be undertaken at all. These are included in section *Appendix 4: Detailed assumptions for OM traits* for each detailed scenario.

This question gives rise then to two more figures for each matrix element - Potential Sector Benefit (when measured at a specific point in the supply chain) and Likely Benefit. Potential Benefit is simply the distribution of the total realisable benefit attributed to that sector under the particular Behaviour / Reward sharing relationship.

The Likely Benefit is a calculation based on the following factors. These factors are used in the information capture section of the model but in order to keep clear simple communication of results, have not be used in industry reporting:

- Ease to Implement – a percentage rating of how easy is it for the benefiter to use the measure
- Likely to measure – a percentage rating of the likelihood that the measuring sector will measure the trait given it is going to be used by this benefitting sector

Appendix 3: Example of method for combining OM traits within scenario

Calculation for LMY Gain - BEEF

Maximum Value Increase		
Single trait rate of gain per generation for LMY	2%	0.15%
Generation interval	5	7
Gain per year	0.4%	0.021%

Maximum possible increase per year on single trait selection	
Beef carcase SMY $/kg	$8.48
CCW	300
Maximum Gain - Value $/hd	$10.18

Potential Value Increase	Seedstock	Commercial	Processor
Accuracy of measurement being used to improve management decisions	50%	50%	30%
Ability to make changes to final product	30%	70%	50%
Realisable benefit if measured in that sector of the chain	$1.53	$3.56	$1.53

Adoption rates faster than current baseline without pricing signals

		Seedstock	Commercial	Processor
Assumptions need explanation around how value flows	Seedstock	0%	0%	0%
	Commercial	30%	30%	
	Processor	60%	60%	40%

Likely Value Increase	Seedstock	Commercial	Processor
Supply Chain VALUE increase when measured at this location	$0.00	$1.07	$0.61

Calculation of EQ increase

Current premium for MSA/kg	$ 0.20
Increase in animals graded MSA per annum	12%
Value per head	$ 7.20
No assumption on increasing the MSA index	

	Seedstock	Commercial	Processor
Accuracy of measurement being used to improve management decisions	50%	50%	30%
Ability to make changes to final product	30%	70%	50%
Realisable benefit if measured in that sector of the chain	$1.08	$2.52	$1.08

Adoption rates faster than current baseline without pricing signals

	Seedstock	Commercial	Processor
Seedstock	0%	0%	0%
Commercial	30%	30%	
Processor	60%	60%	40%

Likely Value Increase	Seedstock	Commercial	Processor
Supply Chain VALUE increase when measured at this location	$0.00	$0.76	$0.43

Benefit Scenario - Select for yield and at least maintain eating quality'

Estimate of genetic interaction between Yield and EQ*	-0.3

**Genetic correlation equations were not applied as this was too complex and did not add any additional value to the quality of the cost modelling for the purposes of this project*

The values in each sector here are ***not additive****. They estimate different exclusive scenarios of value created for the whole chain if only measured at that one point in the chain.*

	Benefit Scenario POTENTIAL BENEFIT			Benefit Scenario LIKELY BENEFIT		
	Seedstock	Commercial	Processor	Seedstock	Commercia	Processor
Yield value realised	$ 1.07	$ 2.49	$ 1.07	$ -	$ 0.75	$ 0.43
Conversion to LMY% increase/year in the ENTIRE commercial population	0.04%	0.10%	0.04%	0.00%	0.03%	0.02%
EQ value realised	$1.08	$2.52	$1.08	$0.00	$0.76	$0.43
	1.8%	4.2%	1.8%	0.0%	1.2%	0.7%
Measure at single point in chain	$ 2.15	$ 5.01	$ 2.15	$ -	$ 1.50	$ 0.86

The values below ***are additive*** *across sectors where OM occurs in multiple sectors. They estimate the proportion of measurement information that allows additional value from management decisions.*

	Seedstock	Commercial	Processor	Seedstock	Commercia	Processor
Additive factor for multiple locations *(Portion of sector OM value duplicated by measurement in other sectors)*		0.4	1			
Measure at multiple locations in chain		Yes	Yes		Yes	Yes
		$ 2.01	$ 2.15		$ 0.60	$ 0.86
Per Head Value Increase		per head	$ **4.15**		per head	$ **1.46**

INDUSTRY BENEFIT

Percentage of the Population this Scenario Applies to (Cannot double count - only one scenario for an animal)

Appendix 4: Detailed assumptions for OM traits

Disease status			
Value Proposition	Through better detection and communication of animal health conditions, live-animal interventions could be more accurately applied to manage conditions, increasing the health and productivity of animals and increasing the rate of offal collection for sale in processing plants. CONSIDERATIONS: - Some health issues only impact on live animal production (no offal or processed value impacts) but can only be measured at the processor. Information transfer back to production sector is required for producers to make management decisions that realise value. Sector specific benefits have been costed separately and reflected in the Benefit distribution section. - It is not feasible to eliminate 100% of health issues. This figure is used to report the estimated total cost to industry.	Maximum Industry Value	$ 96,400,000

Assumptions

Percentage of industry impacted	All animal processed	Value impact per head	$ 10.45	
Maximum annual rate of gain	100%	Combined cost to live animal and processing sectors (GHD 2009-2014). Only includes conditions measurable at processing.	$ 10.45	hd

Many factors impact on how much of the maximum industry value can potentially be captured. E.g., where the Objective Measure is taken in the supply chain, how accurate it is, and the magnitude of change that can be effected by using that measure determine the POTENTIAL benefit. How likely industry is to adopt the measure indicates the LIKELY benefit from that measurement and its location in the chain.
The table below summarises how much value could be expected from measurements at different places along the chain.

Sector where OM is measured — **Value Based Marketing - (Business Model Impact)**

Seedstock

DESCRIPTION: Disease resistance can be increased genetically but impacts only a small amount of the variables impacting animal health.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Genomic testing	30%	Many environmental factors impact on disease prevalence besides genetics.	20%	As per "Accuracy" comments.	0.0	$ -

Benefiting Sector	Potential Benefit	Description	Likely Adoption	Likely Benefit
Seedstock	$ 289,200	Unlikely to receive increased value so will only continue to develop as leading breeders.	35%	$ 101,220
Live Animal	$ 3,759,600	Whether directly adopting or not, there will be a benefit.	35%	$ 1,315,860
Processor	$ 1,735,200	Will not adopt directly but will get some of the benefit in improved offal capture.	35%	$ 607,320
TOTAL	**$ 5,784,000**			**$ 2,024,400**

Live Animal

DESCRIPTION: On-farm detection of conditions previously only detectable post-mortem that impact on productivity would increase the value generated through immediate treatment in that live animal. Cost and likelihood of adoption are both factors impacting how much value would be created.
If the same data could be collected in the processor the magnitude of change would be less but adoption would be higher due to a single processor collecting and transferring data, instead of individual producers investing in objective measurement methods on farm.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Some OCM & industry database.	60%	Live animal detection of conditions previously only detectible in the carcase is assumed to have a lower accuracy. No OCM technology has been assumed so this is purely an estimate for modelling purposes.	70%	Magnitude of change is not always immediate or the intervention 100% effective, depending on when measurement is taken relative to disease life cycle.	0.0	$ -

Benefiting Sector	Potential Benefit	Description	Likely Adoption	Likely Benefit
Seedstock	$ -	No action required by Seedstock.	30%	$ -
Live Animal	$ 20,244,000	Likely to be only the top producers actively improving management if information is available. Industry adoption findings from other studies indicate high levels of adoption at 30% of industry.	30%	$ 6,073,200
Processor	$ 20,244,000	Processors will receive the same improvement as live-animal. If payment incentives for increased offal capture rates (or deductions for lost offal) would increase live animal adoption.	30%	$ 6,073,200
TOTAL	**$ 40,488,000**			**$ 12,146,400**

Processor

DESCRIPTION: Current visual inspection systems monitor health information but don't collect it to enable feedback. This benefit arises from feedback of data collected, rather than from an increase in accuracy of measurement.
The adaptation of mandatory in-plant inspection has more impact than measurement in the live-animal although not as directly or immediately impacting, depending on the level of data analytics and information transfer to producers.
CONSIDERATION:
- Data aggregation to leverage multiple data sets to generate insights for producers is possible and able to effect change more broadly than specific carcases measured. This would increase the effectiveness of the measures (magnitude of change).
- If any OC measure was developed to assess health it would have to be as accurate as current visual inspection to meet international requirements.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Visual inspection & Feedback system	81%	Detection is currently manual with some human error (90%). But determining the time period of infection (current or old wound from previous infestation) is more difficult (90%) so accuracy has been further reduced (=90% x 90%).	55%	If collected data is analysed and transferred with insights through broader data integration, information could be applied on farm for treatment of other live-animals (in advance of slaughter).	0.0	$ -

Benefiting Sector	Potential Benefit	Description	Likely Adoption	Likely Benefit
Seedstock	$ -	No action required by Seedstock.	45%	$ -
Live Animal	$ 21,473,100	Processors pricing signals in some plants have increased producer awareness of disease issues resulting in increased on farm prevention activities.	45%	$ 9,662,895
Processor	$ 21,473,100	A processor based measurement that includes payment incentives would increase rate of adoption of management practices in live-animal.	60%	$ 9,662,895
TOTAL	**$ 42,946,200**			**$ 19,325,790**

Lean meat yield

Value Proposition	Increasing the lean meat yield of carcases will increase the proportion of lean to fat, increasing the effectiveness of live animal input costs and reducing trimming of waste in the carcase, resulting in higher returns. A maximum genetic gain in LMY is expected to be 2% per generation.	**Maximum Industry Value**	$ 93,854,185

Assumptions

Percentage of industry impacted	All animal processed	Value impact per head	$ 10.17	
Maximum annual rate of gain	0.4%	The average value of saleable lean meat on a carcase weight average.	$ 8.48	kg

Many factors impact on how much of the maximum industry value can potentially be captured. E.g., where the Objective Measure is taken in the supply chain, how accurate it is, and the magnitude of change that can be effected by using that measure determine the POTENTIAL benefit. How likely industry is to adopt the measure indicates the LIKELY benefit from that measurement and its location in the chain.
The table below summarises how much value could be expected from measurements at different places along the chain.

Sector where OM is measured	**Value Based Marketing - (Business Model Impact)**

Seedstock

DESCRIPTION: Computer calculated mating's based on matching the "best" sire to known genetics of dams would produce the best combination to drive genetic gain. This is possible but requires knowledge of the commercial dams genetics which is costly. Phenotypic variation could be estimated if commercial herd genetics was known.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Genomic test	30%	Accuracy of EBV's improve as more progeny performance data is collected. Genomic tests accurately determine the genetic composition. The correlation between genetic map and genetic marbling potential has some inaccuracy.	70%	Assume the heritability for LMY here. Covariance for multiple traits selection set on control sheet.	5.6	$ 9,226,100

Benefiting Sector	Potential Benefit	Description	Likely Adoption	Likely Benefit
Seedstock	$ -	Seedstock producers already have a culture of rigorous data collection and analytics to improve rate of genetic gain. Apart from ROI, commitment to move in this direction is already widespread. Assumed this % of SS are already selecting for improved LMY EBV's. SS benefit in the marketability of their livestock. There is currently selection preference for EQ (paid on) over LMY which limits rate of LMY gain.	35%	$ -
Live Animal	$ 7,883,752	Will only get benefit above existing baseline if processor pays for it. This is a 1:1 relationship on whether the processor adopts the Seedstock measure as accurate enough to pay on under a value based marketing scenario.	0%	$ -
Processor	$ 11,825,627	There is too much variation between genetics and environment for the final LMY to be accurate. Also processors would need to validate the accuracy of the measurement which could be done via trials and validation.	0%	$ -
TOTAL	**$ 19,709,379**			**$ -**

Live Animal

DESCRIPTION: Computer calculated mating's could by managed by commercial producers if they had access to the technology and knew their herd genetics. The benefit of producers managing this is first hand awareness of the phenotypic variation indicating their management practice influence on performance. This would move to a value based marketing activity. Accuracy of measure would need to be high for processors to pay a premium for higher yielding animals.
Objective measures such as ultrasound currently increase producer value against current pricing grids. A new LMY/EQ grid would not necessarily increase their ability to comply to a new grid structure. The producer improvement may be similar to current opportunities.
This assumes measurement early enough to adjust growth path and late enough to be accurate.
Need to include secondary benefits of management savings for better on-farm decisions.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
3D scanner	30%	Measurement closer to sale will be more accurate. A range of options are possible with varying accuracy (0.3-0.6). Sound performance under ideal conditions, but environmental variables (livestock movement, genetic variation, hair cover etc.) limit commercial accuracy.	90%	Difference to processor is environmental and management input when measured in live animal.	1.0	$ 2,029,742

Benefiting Sector	Potential Benefit	Description	Likely Adoption	Likely Benefit
Seedstock	$ -	0	0%	$ -
Live Animal	$ 10,136,252	Given many producers don't have weigh scales, the cultural and logistical barriers to implement and monitor with alternative pathways for livestock based on OM results, the ease to implement ranges from 10-90% and depends to an extent on extensiveness of operation.	0%	$ -
Processor	$ 15,204,378	This is driven by leadership in the producer sector to change from VBP to VBM. A barrier to 1:1 price distribution between a processor measured and producer measured pricing will be the loss in accuracy of live-animal measure. All processors would take LMY into account when purchasing. There would still be a commodity based pricing approach but higher lean meat yield would be paid more. The rate of genetic change would still occur. It is arguable as to whether pricing differentiation would be any different than if Processor measured LMY and paid on grid.	100%	$ -
TOTAL	**$ 25,340,630**			**$ -**

Processor

DESCRIPTION: Measurement would establish differential value paid to the supplier for different yield. Feedback of carcase information would support the evaluation and enable suppliers to adjust management practices to improve yield in line with price incentives. The greater the accuracy of the measure and price incentives for better performance, the faster the rate of yield increase.
But the majority of improvement will result from genetic selection pressure increasing in response to pricing signals sent. This increase is over time, in line with the LMY rate of improvement

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Prediction w/ current measures	30%	Predictive algorithms using existing measures R2 ~0.3. System like E+V and ViaScan already deliver accuracy of >R2~0.4. New DEXA or MEXA scanning could deliver >0.8 (based on correlation of sheep to CT LMY). Any LMY pricing signal will increase genetic selection pressure. If accuracy of measure improves difference between EBV's and actual result widens and creates further selection pressure.	70%	Feedback does not support production decisions in real time.	6.2	$ 10,148,710

Benefiting Sector	Potential Benefit	Description	Likely Adoption	Likely Benefit
Seedstock	$ -	0	45%	$ -
Live Animal	$ 7,883,752	Pricing signals will influence but not 100%. Many don't have scales to select for existing market specs - unlikely to invest in new	45%	$ 1,576,750
Processor	$ 11,825,627	Changing procurement strategy - many unclear risks. Assume low adoption by 2020. Two main processors introduce VBP.	20%	$ 2,365,125
TOTAL	**$ 19,709,379**			**$ 3,941,876**

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MSA Existing

Value Proposition	Increasing the number of livestock graded MSA is the assumed measure here of an increase in eating quality. The price premium for MSA is assumed as the increase in value or consumer willingness to pay for the eating quality increase. Although a range of brand attributes besides EQ are involved in establishing consumer value, MSA willingness to pay data indicates consumers will pay 50% more for better than everyday and 100% more for premium. No reduction in MSA value/kilogram has been factored as a result of increased supply. The rate of increase in livestock graded MSA could occur faster. Producers are already paid a premium and some still opt not to become MSA accredited. It is unlikely that significant improvements in MSA will occur unless price incentives for MSA increase. No increase in accuracy of EQ grade has been assumed. CONSIDERATIONS: - What is the STD in accuracy of EQ grade and what increased rate of EQ improvement would occur at an industry level if accuracy of grade was improved through OCM technologies? - increasing the average eating quality (MSA index) of the population would elevate consumer value from everyday to better than everyday and	**Maximum Industry Value**	$ 66,427,920

Assumptions

Percentage of industry impacted	All animal processed	Value impact per head	$ 7.20	
Maximum annual rate of gain	12%	June 2016 pricing grids and MLA market reporting	$ 0.20	kg

Many factors impact on how much of the maximum industry value can potentially be captured. E.g., where the Objective Measure is taken in the supply chain, how accurate it is, and the magnitude of change that can be effected by using that measure determine the POTENTIAL benefit. How likely industry is to adopt the measure indicates the LIKELY benefit from that measurement and its location in the chain.
The table below summarises how much value could be expected from measurements at different places along the chain.

Sector where OM is measured | **Value Based Marketing - (Business Model Impact)**

Seedstock

DESCRIPTION: Genomics tests are almost commercially available to predict MSA index at slaughter to within 2-3 index points with accuracy's towards 60% when tested at weaning.
CONSIDERATIONS:(Not costed as scenarios consider maintaining rather than increasing EQ) Factors impacting EQ include bred content, maturity, marbling, management practices (HGP's etc.).
- What impact within breed on EQ? If this was able to be tested for what increase in EQ would occur?
- What impact on increased EQ within BI content breeds could occur and what impact would this have on northern production systems, relative to increased value, production systems with variable environmental conditions etc.? This population has not been included in the benefit scenarios.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Genomics	50%	Environmental effects will still impact on final consumer result.	30%	0	0.0	$ -
Benefiting Sector	Potential Benefit	Description			Likely Adoption	Likely Benefit
Seedstock	$ 1,992,838	0			N/A	$ -
Live Animal	$ 3,985,675	0			N/A	$ -
Processor	$ 3,985,675	Too many factors post breeding and live-animal production impact on EQ for value of final meat product to be determined at Seedstock.			0%	$ -
TOTAL	**$ 9,964,188**					**$ -**

Live Animal

DESCRIPTION: Assuming an OCM of EQ could occur at property and then again pre-slaughter at processing, producer value could be delivered without inclusion of processor variation. Producer/Processor disputes about grading accuracy and value paid for livestock are common. OCM that can reduce disputes would increase the level of trust.
CONSIDERATIONS:
- Some companies consulted talked about increased awareness of the role and value of transferring genetic info along the chain to increase EQ value faster. This involves trust and collaboration between breeders and processors to improve market signals.
- Other EQ proxies like marbling, ossification/age, along with non-EQ value attributes like bruising, EMA and offal value would also have to be measured to determine value. But none of these OM's have been considered because the existing MSA EQ system is well advanced comparative to other OM needs like yield and health.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Genomics	50%	About 30% of factors affecting EQ occur at or post-slaughter. Measurement on-farm not accurate enough for final EQ grade and will not replace plant grading for the medium term.	70%	0	0.0	$ -
Benefiting Sector	Potential Benefit	Description			Likely Adoption	Likely Benefit
Seedstock	$ 4,649,954	0			N/A	$ -
Live Animal	$ 9,299,909	Many producers don't have the willingness or the ability to draft and hold back, or split consignments immediately prior to shipment to slaughter.			30%	$ -
Processor	$ 9,299,909	Too many factors post breeding and live-animal production impact on EQ for value of final meat product to be determined in the live animal.			0%	$ -
TOTAL	**$ 23,249,772**					**$ -**

Processor

DESCRIPTION: Measurement of MSA EQ already occurs at processor and includes some subjective measures.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Plant grading	70%	Use of historical performance to inform future decisions lowers impact of OM's for MSA EQ. Many of the factors known at point of grading are known prior to slaughter and can be managed in the live animal.	50%	0	0.0	$ -
Benefiting Sector	Potential Benefit	Description			Likely Adoption	Likely Benefit
Seedstock	$ 2,324,977	Measurements contributing to the existing MSA score such as Marbling and growth rate (Oss.) are already well established EBV's and actively selected for. The majority of Seedstock producers will adopt new measures if they can select for them AND market signals reward them.			60%	$ 929,991
Live Animal	$ 9,299,909	Some producers still don't adopt MSA even with a high premium offered to them.			60%	$ 3,719,964
Processor	$ 11,624,886	Already adopted grading without OM's so technology adoption will be slower.			40%	$ 4,649,954
TOTAL	**$ 23,249,772**					**$ 9,299,909**

Marbling

Value Proposition	Marbling or intramuscular fat content has a direct correlation to eating quality and is one of the key measures impacting on carcase value in quality markets. Increasing marbling scores will allow for higher value markets to be accessed, increasing the value of meat produced. Heritability for marbling at an average estimate is high at around 0.45 so market signals rewarding higher marbling will drive an increase in marbling and in effect eating quality. Although the reported range has been from 0.12 (barely worth the selection effort) and 0.88, or 88% effective selection. Echoing the differences in marbling ability across breeds and within breeds, the amount of genetic variation itself varies, and the relationship of marbling to other traits is probably not constant across all breed (Suther S. 2009). Lean meat yield is negatively correlated with marbling and eating quality so it is important to select for these traits when selecting for increased lean meat yield to avoid reduction in eating quality and over time, reduced product value. Research has demonstrated that selection can increase marbling ability without increasing external fat and without causing detrimental effects on other traits in the feedlot or grasslands.	**Maximum Industry Value**	$ 702,724,359

Assumptions

Percentage of industry impacted	All animal processed	Value impact per head	$ 76.17	
Heritability (Maximum annual rate of gain)	100%	Marbling value depends on the market and how premiums are assigned. Premiums are not linear as marbling content increase. An industry average value has been assumed for the exercise. MSA willingness to pay data (50% more value for "better than every day" and 100% more for premium is in-line with this.	$ 0.25	kg

Many factors impact on how much of the maximum industry value can potentially be captured. E.g., where the Objective Measure is taken in the supply chain, how accurate it is, and the magnitude of change that can be effected by using that measure determine the POTENTIAL benefit. How likely industry is to adopt the measure indicates the LIKELY benefit from that measurement and its location in the chain.
The table below summarises how much value could be expected from measurements at different places along the chain.

Sector where OM is measured — **Value Based Marketing - (Business Model Impact)**

Seedstock

DESCRIPTION: Marbling is already an important EBV for breeders supplying breed stock for quality markets. The rate of change impacted by this sector will be more accurate measurement technologies including genomic tests that more accurately link exact genetics to progeny's actual carcase performance.
Incentive for this sector to improve is their relevance to their customers (Producers). If producers are driven (through market signals) to place more importance on Marbling the Seedstock sector will respond under current market pressures.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Genomic test	50%	EBV accuracy's improve w/ more progeny performance data. Genomic tests accurately determine genetic composition. Correlation between genetic map and genetic marbling potential has some inaccuracy. Excluding environment and management decisions, genetics contributes about 30% to the end marbling grade.	50%	Change is greater than at processor because the same information is known earlier and impacts on joining's.	0.0	$ -

Benefiting Sector	Potential Benefit	Description	Likely Adoption	Likely Benefit
Seedstock	$ 52,704,327	Of Seedstock producers providing quality markets, 100% are focused on increasing marbling. The number that will actually use genomic tests and increase their accuracy of selection will be less than that. As Genomic test reduce in cost adoption will increase.	35%	$ 18,446,514
Live Animal	$ 52,704,327	Of producers targeting feedlot and quality markets this percentage use EBV's. Of those using EBV's genomic measures will integrated. Marbling is already paid based on grade at processor.	70%	$ 18,446,514
Processor	$ 70,272,436	By default processors already pay on marbling grade so will adopt the new measures by default.	100%	$ 24,595,353
TOTAL	**$ 175,681,090**			**$ 61,488,381**

Live Animal

DESCRIPTION: Genetic tests for individual animals already exist to direct whether a calf is suitable for feedloting. As these tests become cheaper, current ineffective production costs such as longer feeding of livestock that either don't marble or put on too much fat could be greatly reduced. This benefit quantifies genetic increases in Marbling only.
Secondary productivity benefits are itemised elsewhere.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Genomic test	60%	The same as in Seedstock, but by taking multiple times measures during feeding, accuracy of end grade improves. Feed forward is faster than feedback for genetic improvement of future genetics.	70%	With combination of genomic and scanning, real time decisions can effect more change than accurate abattoir systems.	0.0	$ -

Benefiting Sector	Potential Benefit	Description	Likely Adoption	Likely Benefit
Seedstock	$ -	Seedstock will benefit from information collected at live animal but this is not financial and depends on whether live animal sector share the information.	40%	$ -
Live Animal	$ 206,600,961	Current cost of tests and effort to take is not a good enough ROI for pre-feedlot, feedlot entry and during feeding on individual animals. As Genomic test reduce in cost adoption will increase. Adoption rate here assumes 2030 levels.	40%	$ 82,640,385
Processor	$ 88,543,269	By default processors already pay on marbling grade so will adopt the new measures by default.	100%	$ 35,417,308
TOTAL	**$ 295,144,231**			**$ 118,057,692**

Processor

DESCRIPTION: Marbling measured at processing is passed back up the chain and genetic selection occurs based on these performance results in latter generations. MB is already measured with subjective chiller assessment. X-ray based scanning is still unable to measure muscle, fat and bone composition in beef and measuring of marbling is more difficult given the need to identify distribution as well as amount. Visual scanners of the cut surface are the most realistic but miss out on pre-chiller and pre-quartering decisions that would be adjusted if marbling was known prior to chilling.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Image scanning or other	90%	Current subjective measures set the baseline of accuracy. Any objective measure would need to demonstrate equivalence or better. Increasing measurement accuracy will speed improvement but is minimal (30% above baseline is overstated) relative to obtaining the information in the live animal enabling management decisions on that specific animal.	30%	Excludes ability to manage environmental impact and adjust management post-slaughter.	0.0	$ -

Benefiting Sector	Potential Benefit	Description	Likely Adoption	Likely Benefit
Seedstock	$ -	Seedstock will benefit from information collected but this is not financial, depends on whether the information is shared, and will not vary that much from what is already available in subjective grading.	20%	$ -
Live Animal	$ 75,894,231	Same as processor by default.	20%	$ 15,178,846
Processor	$ 113,841,346	Replacing subjective grading needs cost savings or some other benefit for adoption to occur.	20%	$ 22,768,269
TOTAL	**$ 189,735,577**			**$ 37,947,115**

Meat colour/pH

Value Proposition	Improving pH will increase the value of meat processed, the processing and production sectors would both benefit. MC and pH is affected by genetics, feeding and other on-farm management practices prior to slaughter, sudden changes in air temperature and pre-slaughter stresses such as transport and handling as well as carcase chilling. Current measurement post slaughter does nothing to reduce the incidence of poor meat colour. Given many variables impact MC, measurement prior to slaughter that allowed intervention would have the largest impact. BACKGROUND: Ultimate pH is one of the important factors that impact on changes in meat colour in beef. High pH meat is often associated with darker meat and is often referred to as 'dark firm and dry' or DFD meat. Such carcases are heavily discounted in the market place. There is known grader bias in the allocation of meat colour scores. If meat colour remains an important measure on carcases, then the development of technology to measure meat colour in an accurate and repeatable manner is needed, most likely involving the use of a vision system or colorimeter	**Maximum Industry Value**	$ 44,916,667

Assumptions

Percentage of industry impacted	All animal processed	Value impact per head	$ 4.87	
Maximum annual rate of gain	8%	Cost of Dark cutting estimated at $60/head & ~8% incidence with $38-44M annual cost to industry.	$ 0.20	kg

Many factors impact on how much of the maximum industry value can potentially be captured. E.g., where the Objective Measure is taken in the supply chain, how accurate it is, and the magnitude of change that can be effected by using that measure determine the POTENTIAL benefit. How likely industry is to adopt the measure indicates the LIKELY benefit from that measurement and its location in the chain.
The table below summarises how much value could be expected from measurements at different places along the chain.

Sector where OM is measured	**Value Based Marketing - (Business Model Impact)**

Seedstock

DESCRIPTION: Genetic selection for meat colour is possible but only contributes a small amount to variation relative to on-farm environmental factors.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Genomic tests	10%	Many other factors impact on final meat colour which limit the ability to predict MC with genetics alone.	15%	Many other factors impact on meat colour which limit impact on end colour change.	0.0	$ -
Benefiting Sector	Potential Benefit	Description			Likely Adoption	Likely Benefit
Seedstock	$ 33,688	Unlikely to receive increased value so will only continue to develop as leading breeders.			35%	$ 11,791
Live Animal	$ 336,875	Whether directly adopting or not, there will be a benefit.			35%	$ 117,906
Processor	$ 303,188	Whether directly adopting or not, there will be a benefit.			35%	$ 106,116
TOTAL	**$ 673,750**					**$ 235,813**

Live Animal

DESCRIPTION: A stress test such as a patch placed on the nose of the animal that changes colour as an indicator of high risk meat colour would help draft out affected livestock. A measure could be based on measuring blood glycogen prior to transport to processor, at processor prior to slaughter. Holding animals at these points until glycogen balanced is possible but would come at a cost including additional cattle yard infrastructure and feeding costs at processor.
Advanced alerts of weather conditions and temperature changes may be as effective and far less costly as alternative indicators.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Stress test	60%	More research is required to see if a commercial test is accurate and cost effective.	50%	Potential to hold back 'at risk' livestock but only some will have flexibility to, or want to hold back some livestock.	0.0	$ -
Benefiting Sector	Potential Benefit	Description			Likely Adoption	Likely Benefit
Seedstock	$ -	No action required by Seedstock.			0%	$ -
Live Animal	$ 6,737,500	Unlikely to have measure developed by 2020.			0%	$ -
Processor	$ 6,737,500	Processors will receive the same improvement as live-animal.			0%	$ -
TOTAL	**$ 13,475,000**					**$ -**

Processor

DESCRIPTION: Assumes current subjective meat colour and objective pH measures could be improved from an operational point of view. Does not assume any major improvement in accuracy of current measures. The assumption is that change in incidence of poor meat colour will assist intervention at the live animal.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Vision or colorimeter	70%	Current subjective measures have bias and inaccuracy. Objective measures of pH also have variable accuracy.	20%	No ability to adjust measured carcase. Can only predictively adjust for future supply.	0.0	$ -
Benefiting Sector	Potential Benefit	Description			Likely Adoption	Likely Benefit
Seedstock	$ -	No action required by Seedstock.			60%	$ -
Live Animal	$ 3,144,167	This is a direct benefit from processor re-grading, assuming benefit is passed on to producer.			60%	$ 1,886,500
Processor	$ 3,144,167	Measurements and pricing incentives already in place. Further processing measures won't improve colour, but may find grading to increase % of current downgrades in line with new understanding of consumer acceptance.			60%	$ 1,886,500
TOTAL	**$ 6,288,333**					**$ 3,773,000**

Weight Gain

Value Proposition	Increasing rate of weight gain increases effectiveness of inputs such as feed and is reflected in improved feed conversion and weight for age. There is a negative correlation with marbling score. In the opposite direction, selection for increased marbling is negatively correlated to growth rate. Maximum rate of genetic gain in growth rate is about 3.5% per year (while selecting for increased IMF) but is variable across the population. Weight gain is a trait directly benefiting the producer. Processor focus on lean meat yield instead which is correlated positively with weight gain. To increase selection pressure beyond current rates for this benefit scenario, impact of pricing signals for LMY at the processor have been considered in that sector.	**Maximum Industry Value**	$ 516,661,600

Assumptions

Percentage of industry impacted	All animal processed	Value impact per head	$ 56.00	
Maximum annual rate of gain	3.3%	0	$ 5.60	kg

Many factors impact on how much of the maximum industry value can potentially be captured. E.g., where the Objective Measure is taken in the supply chain, how accurate it is, and the magnitude of change that can be effected by using that measure determine the POTENTIAL benefit. How likely industry is to adopt the measure indicates the LIKELY benefit from that measurement and its location in the chain.
The table below summarises how much value could be expected from measurements at different places along the chain.

Sector where OM is measured	**Value Based Marketing - (Business Model Impact)**

Seedstock

DESCRIPTION: Growth rate is one of the most significant traits commercial producers currently select and get paid for. Increasing rate of change is unlikely to be through pricing signals (which already exist) but through more precise application of existing EBV's (computer based mating), increased accuracy of EBV's through genomic tests providing easier linking of genetics to sire and dam performance and therefore selection precision.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Genomic test	45%	Accuracy of EBV's improve as more progeny performance data is collected. Genomic tests accurately determine the genetic composition. The correlation between genetic map and genetic marbling potential has some inaccuracy.	32%	Heritability's of additive direct genetic effects for 200-d weight (.32). J. Anim Sci 1996 Nov.	0.0	$ -

Benefiting Sector	Potential Benefit	Description	Likely Adoption	Likely Benefit
Seedstock	$ 14,879,854	0	35%	$ 2,975,971
Live Animal	$ 37,199,635	If Seedstock producers speed up rate of genetic gain producers will adopt the benefits through improved genetics sold to them. This is a higher adoption than if producers have to select the genetics.	20%	$ 7,439,927
Processor	$ 22,319,781	Some processor grids already pay on marbling grade and all pay on weight. There is already a value incentive at the producer to select for weight while maintaining marbling.	20%	$ 4,463,956
TOTAL	**$ 74,399,270**			**$ 14,879,854**

Live Animal

DESCRIPTION: Processes and technologies at Seedstock flow through to the commercial producer but with slower adoption. Introduction of VB payments for LMY and quality and increased supply chain connection through improved information transfer is hoped to encourage more of the producer population than the top 50% as communication of value benefits and methods to achieve become clearer.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
Genomic test, RTUS, 3D scanning.	45%	0	32%	Heritability of .32	0.0	$ -

Benefiting Sector	Potential Benefit	Description	Likely Adoption	Likely Benefit
Seedstock	$ 11,159,891	Some transfer of data will help Seedstock sector but not likely to transfer value back up the chain beyond current market differentiation.	10%	$ 1,115,989
Live Animal	$ 48,359,526	Leading producers and feedlots are already selecting for increased marbling while maintaining growth rates. Growth rate is a producer benefit so it is unlikely adoption will increase above current rates unless genomic testing becomes cheaper and easier. Low likelihood by 2020.	10%	$ 4,835,953
Processor	$ 14,879,854	Some processor grids already pay on marbling grade and all pay on weight. There is already a value incentive at the producer to select for weight while maintaining marbling.	10%	$ 1,487,985
TOTAL	**$ 74,399,270**			**$ 7,439,927**

Processor

DESCRIPTION: Processors do not directly measure weight gain although carcase weight is important feedback for producers that do not have scales, but somewhat limiting to drive improvement in those circumstances. Price signals for LMY and marbling will indirectly promote selection for growth rate as LMY selection increases. Depending on the price differences between Marbling and LMY and producers current performance, they will select more heavily for marbling or weight gain but hopefully both. Without a LMY pricing grid producers are unlikely to increase weight and maintain marbling above the current rate of improvement.

Measurement technology	Accuracy	Comments	Magnitude of change	Comments	Potential ROI (mths)	Industry Cost (p.a.)
HSCW and LMY	20%	xxx CONSIDERATION - this measure is not really relevant at the processor.	8%	MB measures are direct but LMY is indirect and after the fact. Weight gain is already known for the majority of producers that have scales.	0.0	$ -

Benefiting Sector	Potential Benefit	Description	Likely Adoption	Likely Benefit
Seedstock	$ 1,653,317	Seedstock will adopt selection pressure from producers in order to maintain relevance to producer needs.	75%	$ 330,663
Live Animal	$ 4,133,293	Incentive via LMY grids would increase adoption. If OM tests on farm become cheaper adoption rates will increase further.	75%	$ 826,659
Processor	$ 2,479,976	Assume same adoption rate as LMY and EQ benefit Scenario. Changing procurement strategy - many unclear risks. Assume low adoption by 2020. Two main processors introduce VBP.	20%	$ 495,995
TOTAL	**$ 8,266,586**			**$ 1,653,317**

Appendix 5: Adoption Rate tables

Table 6: Adoption assumptions by sector by 2020 and 2030 for beef industry traits that underpin various benefit scenarios

2020 Beef Industry Objective Measurement Value Opportunities - Summary of *adoption rates* and *gross benefits* by Benefit Scenario

	Measurement Location	Measurement technology	Accuracy	Magnitude of change	Seedstock Likely Adoption	Live Animal Likely Adoption	Processor Likely Adoption	Supply Likely Adoption
Disease status	Seedstock	Genomic testing	30%	20%	35%	35%	35%	35%
	Live Animal	Some OCM & industry database.	60%	70%	30%	30%	30%	30%
	Processor	Visual inspection & Feedback	81%	55%	45%	45%	60%	45%
Lean meat yield	Seedstock	Genomic test	30%	70%	35%	0%	0%	0%
	Live Animal	3D scanner	30%	90%	0%	0%	100%	0%
	Processor	Prediction w/ current measures	30%	70%	45%	45%	20%	20%
Marbling	Seedstock	Genomic test	50%	50%	50%	70%	100%	50%
	Live Animal	Genomic test	60%	70%	40%	40%	100%	40%
	Processor	Image scanning or other	90%	30%	20%	20%	20%	20%
Meat colour/pH	Seedstock	Genomic tests	10%	15%	35%	35%	35%	35%
	Live Animal	Stress test	60%	50%	0%	0%	0%	0%
	Processor	Vision or colorimeter	70%	20%	60%	60%	60%	60%
MSA Existing	Seedstock	Genomics	50%	30%			0%	0%
	Live Animal	Genomics	50%	70%		30%	0%	0%
	Processor	Plant grading	70%	50%	60%	60%	40%	40%
Enhanced Buy/Make decisions	Seedstock	0	0%	0%				0%
	Live Animal	0	0%	0%				0%
	Processor	Prediction w/ current measures	30%	70%	10%	10%	10%	10%
Enhanced Make/Sell decisions	Seedstock	0	0%	0%				0%
	Live Animal	0	0%	0%				0%
	Processor	Prediction w/ current measures	30%	70%	20%	20%	10%	10%
Weight Gain	Seedstock	Genomic test	45%	32%	20%	20%	20%	20%
	Live Animal	Genomic test, RTUS, 3D scanning.	45%	32%	10%	10%	10%	10%
	Processor	HSCW and LMY	20%	8%	75%	75%	20%	20%

2030 Beef Industry Objective Measurement Value Opportunities - Summary of adoption rates and gross benefits by Benefit Scenario

Measurement technology	Accuracy	Magnitude of change	Seedstock Likely Adoption	Live Animal Likely Adoption	Processor Likely Adoption	Supply Likely Adoption
Genomic testing	30%	20%	49%	49%	49%	49%
Some OCM & industry database.	60%	70%	42%	42%	42%	42%
Visual inspection & Feedback	81%	55%	65%	65%	65%	65%
Genomic test	30%	70%	49%	0%	0%	0%
3D scanner	30%	90%	0%	0%	100%	0%
DEXA	80%	70%	60%	60%	60%	60%
Genomic test	50%	50%	70%	98%	100%	70%
Genomic test	60%	70%	56%	56%	100%	56%
Image scanning or other	90%	30%	28%	28%	28%	28%
Genomic tests	10%	15%	49%	49%	49%	49%
Stress test	60%	50%	35%	35%	35%	35%
Vision or colorimeter	70%	20%	84%	84%	84%	84%
Genomics	50%	30%	0%	0%	0%	0%
Genomics	50%	70%	0%	42%	0%	0%
Plant grading	70%	50%	84%	84%	56%	56%
0	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%
DEXA	80%	70%	60%	60%	60%	60%
0	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%
DEXA	80%	70%	60%	60%	60%	60%
Genomic test	45%	32%	28%	28%	28%	28%
Genomic test, RTUS, 3D scanning.	45%	32%	50%	50%	50%	50%
HSCW and LMY	20%	8%	100%	0%	28%	0%

Table 7: Adoption assumptions by sector by 2020 and 2030 for sheep industry traits that underpin various benefit scenarios

2020 Sheep Industry Objective Measurement Value Opportunities - Summary of *adoption rate s* and *gross benefits* by Benefit Scenario

	Measurement Location	Measurement technology	Accuracy	Magnitude of change	Seedstock	Live Animal	Processor	Supply Chain TOTAL
					Likely Adoption	Likely Adoption	Likely Adoption	Likely Adoption
Disease status	Seedstock	Genomic testing	30%	20%	35%	35%	35%	35%
	Live Animal	Some OCM &	60%	55%	30%	30%	30%	30%
	Processor	Visual inspection	81%	35%	45%	45%	60%	45%
Lean meat yield	Seedstock	Genomic test	30%	70%	35%	0%	0%	0%
	Live Animal	EBV's, Genomics	30%	90%	50%	50%	100%	50%
	Processor	DEXA	88%	70%	45%	45%	20%	20%
IMF	Seedstock	Genomic test	50%	50%	50%	70%	100%	50%
	Live Animal	Genomic test	60%	70%	40%	40%	100%	40%
	Processor	Image scanning	90%	30%	20%	20%	20%	20%
Enhanced Buy/Make decisions	Seedstock	0	0%	0%	0	0	0	0%
	Live Animal	0	0%	0%	0	0	0	0%
	Processor	DEXA	88%	63%	10%	10%	10%	10%
Enhanced Make/Sell decisions	Seedstock	0	0%	0%	0%	0	0	0%
	Live Animal	0	0%	0%	0%	0	0	0%
	Processor	DEXA	88%	63%	20%	20%	10%	10%
Weight Gain	Seedstock	Genomic test	45%	32%	20%	20%	20%	20%
	Live Animal	Genomic test,	45%	32%	10%	10%	10%	10%
	Processor	HSCW and LMY	20%	8%	75%	75%	20%	20%

2030 Sheep Industry Objective Measurement Value Opportunities - Summary of *adoption rate s* and *gross benefits* by Benefit Scenario

	Measurement Location	Measurement technology	Accuracy	Magnitude of change	Seedstock	Live Animal	Processor	Supply Chain TOTAL
					Likely Adoption	Likely Adoption	Likely Adoption	Likely Adoption
Disease status	Seedstock	Genomic testing	30%	20%	42%	42%	42%	42%
	Live Animal	Some OCM &	60%	55%	36%	36%	36%	36%
	Processor	Visual inspection	81%	35%	65%	65%	65%	65%
Lean meat yield	Seedstock	Genomic test	30%	70%	42%	0%	0%	0%
	Live Animal	3D scanner	30%	90%	60%	60%	100%	60%
	Processor	DEXA	88%	70%	60%	60%	60%	60%
IMF	Seedstock	Genomic test	50%	50%	60%	84%	100%	60%
	Live Animal	Genomic test	60%	70%	48%	48%	100%	48%
	Processor	Image scanning	90%	30%	24%	24%	24%	24%
Enhanced Buy/Make decisions	Seedstock	0	0%	0%	0%	0%	0%	0%
	Live Animal	0	0%	0%	0%	0%	0%	0%
	Processor	DEXA	88%	63%	60%	60%	60%	60%
Enhanced Make/Sell decisions	Seedstock	0	0%	0%	0%	0%	0%	0%
	Live Animal	0	0%	0%	0%	0%	0%	0%
	Processor	DEXA	88%	63%	60%	60%	60%	60%
Weight Gain	Seedstock	Genomic test	45%	32%	24%	24%	24%	24%
	Live Animal	Genomic test,	45%	32%	50%	50%	50%	50%
	Processor	HSCW and LMY	20%	8%	100%	0%	24%	0%

Appendix 6: Animal health conditions

Table 8: Disease costs to the Australian beef industry including impact for animals processed

Beef Diseases	Production			
	Northern	Southern		
Ticks	$ 156,000,000			
Bovine viral diarrhoea virus	$ 50,900,000	$ 63,500,000		
Buffalo fly	$ 94,600,000	$ 4,100,000		
Bloat		$ 76,800,000		
Bovine ephemeral fever	$ 59,700,000	$ 100,000		
Botulism	$ 22,000,000	$ 6,000,000		
Grass Tentany		$ 24,300,000		
Vibrio	$ 12,700,000	$ 8,300,000		
Theileria	$ 1,600,000	$ 18,000,000		
Pink eye	$ 2,400,000	$ 10,900,000		
Tick fever	$ 4,300,000			
Clostridial		$ 6,700,000		
Internal Parasites	$ 11,600,000	$ 82,000,000	Organ downgrades	$ 93,600,000
BJD	$ 300,000	$ 2,500,000	Organ downgrades	$ 2,800,000
Dystocia	$ 38,000,000	$ 59,600,000		
Neonatal Mortalities	$ 53,900,000	$ 42,200,000		
Calf Scours Complex		$ 23,000,000		
Total disease cost		$ 936,000,000		$ 96,400,000
Total Herd numbers		26,456,905	Animals processed	9,226,100
Per head average for entire herd		$ 35.38	per head	$ 10.45

Table 9: Disease costs to the Australian sheep industry including impact for animals processed

Disease	Disease burden		Cost to industry		
	Lamb	Mutton	Lamb	Mutton	Total
Arthritis	0.50%	2.08%	$ 7,432,569	$ 18,153,785	$ 25,586,354
Caseous lymphadenitis	0.13%	6.31%	$ 757,113	$ 20,880,440	$ 21,637,553
Cancer	0.00%	0.23%	$ 29	$ 55	$ 84
Cysticercus tenuicollis	3.12%	10.65%	$ 491,086	$ 683,415	$ 1,174,500
Dog bite lesions	0.04%	0.05%	$ 56,326	$ 29,186	$ 85,512
Knotty gut/nodule worm lesions	0.01%	0.01%	$ -	$ -	$ -
Grass seed lesions	2.15%	4.33%	$ 12,544,134	$ 25,475,593	$ 38,019,727
Hydatids	0.00%	0.15%	$ 264	$ 10,330	$ 10,594
Liver flukes	0.19%	2.04%	$ 472,195	$ 6,768,107	$ 7,240,302
Lungworm	4.37%	3.35%	$ -	$ -	$ -
Melanosis	0.00%	0.00%	$ -	$ -	$ -
Ovine Johne's Disease	0.00%	0.18%	$ -	$ 1,009,807	$ 1,009,807
Pleurisy	1.89%	5.69%	$ 1,863,290	$ 2,538,124	$ 4,401,414
Pneumonia	0.45%	0.16%	$ 445,742	$ 71,784	$ 517,526
Sarcocystis	0.03%	2.11%	$ 141,580	$ 4,760,435	$ 4,902,015
Sheep measles	1.28%	3.55%	$ 697,594	$ 847,659	$ 1,545,252
Vaccination lesions of any cause	0.90%	2.38%	$ 593,105	$ 710,997	$ 1,304,102
Total			$ 25,495,025	$ 81,939,717	$ 107,434,742
Per head impact for entire flock					$ 1.42
All animal processed			$ 16,251,978	$ 41,571,714	$ 57,823,692
Per head impact for All animal processed			$ 0.73	$ 4.12	$ 1.79

Appendix 7: Processing Calculations

- Processing rates remain the same in the top half of the table.
- Percentage of the time wrong decisions are made by allocation of carcases to less than optimal cut breakdown is estimated half way down the table.
- Labour costs and additional time required (as a multiple of ideal boning time) are captured in the bottom half of the table.

Boning room manning calculations for improved boning efficiency resulting from improved fabrication decisions

Task	Rate / hour	WW Loading	Overtime Rate / hour	Number labour units per shift - Manual Process (Note - this is gross of labour savings - based on No. of Head above)		Extra Boning Time / Task / wrong decision	Avg. labour saving / Task
		35.00%					
Supervisor	$35.00	$47.25		1	1		0%
QA	$31.00	$41.85		0	0		0%
Admin	$24.00	$32.40			0		0%
Band Saw operator	$26.23	$35.41		6	6		0%
Ticketing	$23.10	$31.19			0		0%
Knife hand	$23.10	$31.19			0		0%
Trimmers	$23.10	$31.19		26	23	2.0	90%
Packer	$23.10	$31.19		41	40	1.3	97%
General Labor	$23.10	$31.19		3	3		0%
Maintenance	$19.00	$25.65			0		0%
Chiller - Carcase pushing	$16.92	$22.84			0		0%
AQIS	$22.11	$29.84			0		0%
Rail Boy	$16.92	$22.85			0		0%
Boners	$26.00	$35.10		14	14		0%
Slicers	$23.00	$31.05		14	13	1.4	96%
		$0.00			0		0%
		$0.00			0		0%
		$0.00			0		0%
		$0.00			0		0%
		$0.00			0		0%
Total FTE's required				105	101		

Appendix 8: Fabrication Decision Calculations

Opportunity to increase carcase value from improved fabrication decisions

Frequency that wrong fabrication decisions are made due to inaccurate measures of carcase composition: 10.0%
Precision of OM technology in measuring Actual Value differences: 0.80

Carcase weight/kg	Actual value variation (b/w carcases)	Value measured by current systems	Potential range in value of decisions		Estimated value of wrong decisions		Value measured by High Precision OM	Potential range in value of decisions		Estimated value of wrong decisions	
	$/head	$/head	$/head	$/kg	$/head	$/kg	$/head	$/head	$/kg	$/head	$/kg
200	$ 102.36	$ 68.25	$ 34.11	$ 0.17			$ 81.89				
215	$ 123.55	$ 78.78	$ 44.77	$ 0.21	$ 4.48	$ 0.02	$ 98.84	$ 20.06	$ 0.09	$ 2.01	$ 0.01
230	$ 144.74	$ 89.30	$ 55.44	$ 0.24	$ 5.54	$ 0.02	$ 115.79	$ 26.49	$ 0.12	$ 2.65	$ 0.01
245	$ 165.92	$ 99.83	$ 66.10	$ 0.27	$ 6.61	$ 0.03	$ 132.74	**$ 32.91**	$ 0.13	$ 3.29	$ 0.01
260	$ 187.11	$ 110.35	$ 76.76	$ 0.30			$ 149.69				

Source: *Value Variation - Beef CRC 2008 yield data set*

		$/head	$/kg
Supply chains able to realise benefit	62.50%	$ 1.66	$ 0.01
Processors with infrastructure to realise benefit	50%	$ 0.83	$ 0.00

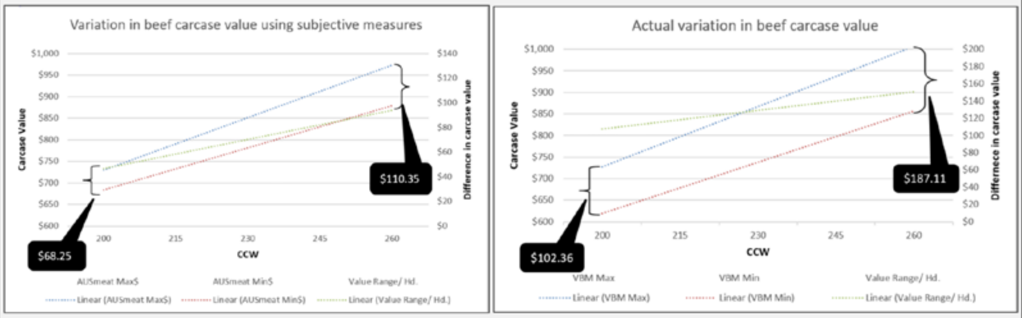


Figure 18: Beef yield data sets and fabrication decision calculations

Opportunity to increase carcase value from improved fabrication decisions

Frequency that wrong fabrication decisions are made due to inaccurate measures of carcase composition: 12.8%
Precision of OM technology in measuring Actual Value differences: 0.90

Carcase weight/kg	Actual value variation (b/w carcases)	Value measured by current systems	Potential range in value of decisions		Estimated value of wrong decisions		Value measured by High Precision	Potential range in value of decisions		Estimated value of wrong decisions	
	$/head	$/head	$/head	$/kg	$/head	$/kg	$/head	$/head	$/kg	$/head	$/kg
15	$ 31.91	$ 12.20	$ 19.71	$ 1.31			$ 28.70				
20	$ 42.97	$ 19.08	$ 23.90	$ 1.19	$ 3.05	$ 0.15	$ 38.64	$ 19.57	$ 0.98	$ 2.50	$ 0.12
25	$ 54.03	$ 25.95	$ 28.08	$ 1.12	$ 3.59	$ 0.14	$ 48.59	$ 22.64	$ 0.91	$ 2.89	$ 0.12
30	$ 65.09	$ 32.83	$ 32.27	$ 1.08			$ 58.53				
35	$ 76.15	$ 39.70	$ 36.45	$ 1.04			$ 68.48				

Source: *Value Variation - LNF 2010 yield calculations*

		$/head	$/kg
Supply chains able to realise benefit	62.50%	$ 1.81	$ 0.07
Processors with infrastructure to realise benefit	50%	$ 0.90	$ 0.04

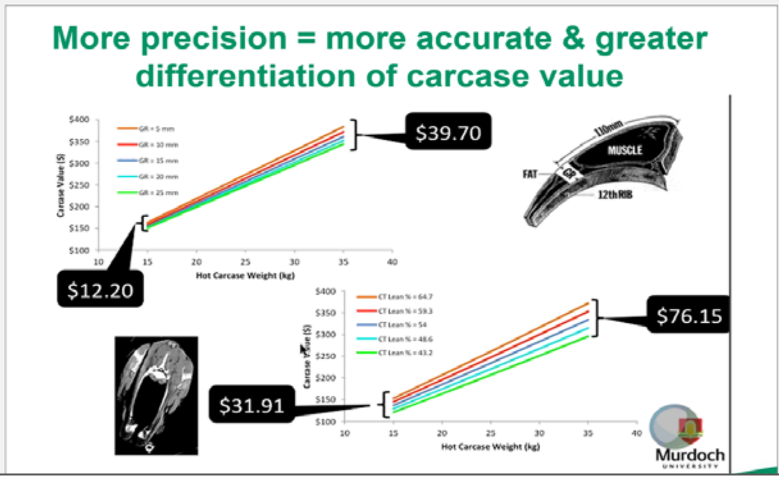


Figure 19: Sheep yield data set and fabrication decision calculations

Appendix 9: Yield Summaries

Yield increase calculation summaries - reference to multi-trait indexes			
Single trait rate of gain per generation for LMY			2%
Generation interval			5
Gain per year			0.4%

Factor limiting maximum LMY Increase		Potential LMY Increase in model	
		/year	/10 years
Measurement accuracy	30.00%	0.1200%	1.20%
Magnitude of change	70.00%	0.08400%	0.84%

Existing genetic improvement as part of Multi-trait Index	
Angus Breeding Index	Heavy Grass Index
0.10%	0.20%

Table 1 : Selection Index Descriptions

Angus Breeding Index	• Self replacing herd • Daughters are retained for breeding • Identifies animals that will improve overall profitability in the majority of commercial grass and grain finishing production systems
Domestic Index	• Self replacing herd • Daughters are retained for breeding • Steer progeny finished on either pasture, pasture supplemented with grain, or grain targeting the domestic supermarket trade • Steer progeny slaughtered at a carcase weight of 270 kg at 16 months of age • Eating quality traits important to suit MSA program
Heavy Grain Index	• Self replacing herd • Daughters are retained for breeding • Steer progeny pasture grown with a 200 day feedlot finishing period • Steer progeny slaughtered at a carcase weight of 420 kg at 24 months of age • Targeting high quality, highly marbled markets with a significant premium for superior marbling
Heavy Grass Index	• Self replacing herd • Daughters are retained for breeding • Steer progeny finished on pasture • Steer progeny slaughtered at a carcase weight of 340 kg at 22 months of age • Eating quality traits important to suit MSA program

Table 2 : Profit Drivers

	Angus Breeding Index	Domestic Index	Heavy Grain Index	Heavy Grass Index
Sale Liveweight Dir.	15%	14%	16%	17%
Sale Liveweight Mat.	4%	5%	3%	4%
Dressing %	10%	11%	9%	11%
Saleable Meat%	12%	13%	11%	13%
Fat Depth (Rump)	4%	2%	0%	7%
Cow Weaning Rate	20%	14%	23%	14%
Marbling Score	11%	7%	18%	6%
Cow Survival Rate	9%	13%	8%	11%
Cow Weight	-3%	-5%	-3%	-4%
Calving Ease Dir.	9%	11%	8%	10%
Calving Ease Mat.	3%	4%	3%	3%

Table 3 : EBV Weightings

	Angus Breeding Index	Domestic Index	Heavy Grain Index	Heavy Grass Index
Calving Ease Dir.	10%	15%	9%	12%
Calving Ease Mat.	5%	7%	5%	6%
Birth Weight	-1%	-1%	0%	-2%
Milk	-3%	-3%	-3%	-3%
200 Day Growth	-4%	-2%	-6%	-3%
400 Day Weight	3%	19%	3%	3%
600 Day Weight	19%	1%	18%	21%
Intramuscular Fat	11%	9%	16%	7%
Days to Calving	-19%	-12%	-20%	-14%
Scrotal Size	0%	0%	0%	-1%
P8 Fat Depth	6%	6%	3%	8%
Eye Muscle Area	2%	2%	1%	3%
Retail Beef Yield	12%	17%	13%	12%
Mature Cow Weight	-4%	-6%	-2%	-7%

Table 4 : Indicative Response to Selection

	Angus Breeding Index	Domestic Index	Heavy Grain Index	Heavy Grass Index
Calving Ease Direct	+0.9%	+1.1%	+0.7%	+0.9%
Calving Ease Dtrs	+1.1%	+1.3%	+0.9%	+1.2%
Birth Weight	-0.2 kg	-0.4 kg	-0.1 kg	-0.1 kg
Gestation Length	-0.8 days	-0.8 days	-0.6 days	-0.9 days
200 Day Growth	+3 kg	+3 kg	+2 kg	+4 kg
400 Day Weight	+6 kg	+6 kg	+5 kg	+7 kg
600 Day Weight	+8 kg	+6 kg	+6 kg	+9 kg
Mature Cow Weight	+5 kg	+1 kg	+4 kg	+5 kg
Milk	+2 kg	+2 kg	+2 kg	+2 kg
Scrotal Size	+0.4 cm	+0.3 cm	+0.3 cm	+0.3 cm
Days to Calving	-1.0 days	-0.8 days	-0.9 days	-0.8 days
Carcase Weight	+3 kg	+4 kg	+2 kg	+5 kg
Eye Muscle Area	+1.0 cm^2	+1.4 cm^2	+1.0 cm^2	+1.1 cm^2
Rib Fat	+0.1 mm	+0.1 mm	+0.1 mm	+0.2 mm
Rump Fat	+0.1 mm	+0.1 mm	+0.0 mm	+0.2 mm
Retail Beef Yield	+0.1%	+0.2%	+0.0%	+0.2%
Intramuscular Fat	+0.5%	+0.4%	+0.7%	+0.3%

Figure 20: Beef yield summaries and multi-trait indexes

Wholesale carcase value calculation		$/kg
Nov 2016 grid prices	$	5.40
Slaughter and boning cost	$	1.48
Gross margin	$	0.11
Wholesale value	$	6.99

Carcase composition impact on consumer value				
CCW		23.6		23
Fat Score		2		4
Retail kgs		13.08		10.34
Fat		4.68		6.89
Bone / waste		5.84		5.77
Retail value	$	173	$	144
SMY - CCW avg $/kg	$	7.33	$	6.26
SMY - Retail $/kg	**$**	**13.23**	**$**	**13.93**

Complexity of primal sales		Value	Share
High fabrication	$	13.23	70%
Low fabrication	$	6.99	30%
Average value of SMY/kg	**$**	**11.36**	

Photo Source: *MLA / Murdoch University*

Figure 21: Sheep saleable meat yield and value summaries

Yield increase calculation summaries - reference to multi-trait indexes			
Single trait rate of gain per generation for LMY			2%
Generation interval			4
Gain per year			0.5%

Factor limiting maximum LMY Increase		Potential LMY Increase in model	
		/year	/10 years
Measurement accuracy	30.00%	0.15%	1.50%
Magnitude of change	70.00%	**0.11%**	**1.05%**

Existing genetic improvement as part of Multi-trait Index	
LMYEQ/IMF	Carcase+
0.87%	1.91%

LMY increase/year		0.10%	0.20%	0.70%
Saleable meat yield value ($/kg)	$ 11.36			
ccw	22	$ 0.25	$ 0.50	$ 1.75
Annual volume	32,336,400	$ 8,078,248	$ 16,156,495	$ 56,547,733
Total			$ 8,078,248	$ 48,469,486

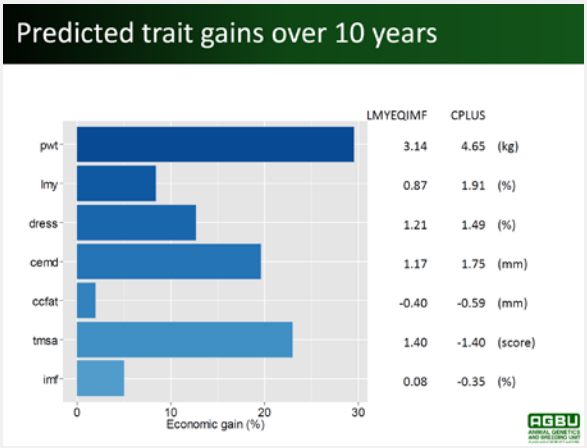


Figure 22: Sheep yield summaries and multi-trait indexes

Appendix 10: Sensitivity analysis

Beef Scenarios

Table 10: Sensitivity analysis for beef benefit scenarios - Maximum, 2020 potential and likely benefits ('000's)

@RISK Output Results

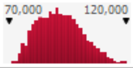
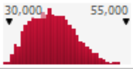
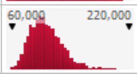
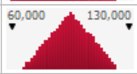
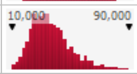
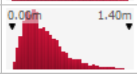
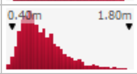
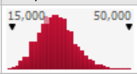
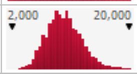
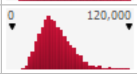
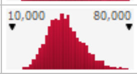
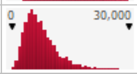
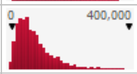
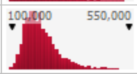
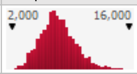
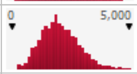
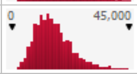
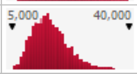
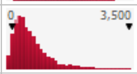
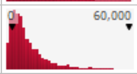
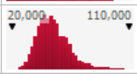
Status	Name	Worksheet	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	*S1 - Increasing lean meat yield but maintaining eating quality / Maximum Benefit*	Traits - Measurements Summary	AF2		$73,048	$92,274	$118,936	$79,477	$106,978	0
OK	*S2 - Increasing lean meat yield but maintaining pH / Maximum Benefit*	Traits - Measurements Summary	AF3		$30,071	$39,684	$53,015	$33,285	$47,036	0
OK	*S3 - Increasing feedlot quality but maintaining turn-off times / Maximum Benefit*	Traits - Measurements Summary	AF4		$65,438	$109,982	$200,099	$82,031	$143,466	0
OK	*S4 - Improving animal health / Maximum Benefit*	Traits - Measurements Summary	AF5		$68,896	$95,588	$121,191	$77,503	$113,532	0
OK	*S5 - Optimise livestock purchased to market specifications / Maximum Benefit*	Traits - Measurements Summary	AF6		$13,481	$37,856	$87,166	$21,628	$60,585	0
OK	*S6 - Fabrication of purchased livestock to optimise value / Maximum Benefit*	Traits - Measurements Summary	AF7		$67,589	$404,642	$1,313,826	$147,748	$808,172	0
OK	*Cumulative total of Benefit Scenarios / Maximum Benefit*	Traits - Measurements Summary	AF8		$404,525	$780,025	$1,739,559	$511,853	$1,192,172	0
Status	Name	Worksheet	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	*S1 - Increasing lean meat yield but maintaining eating quality / Total Pot. (2020)*	Traits - Measurements Summary	AG2		$15,409	$28,865	$49,766	$21,441	$37,255	0
OK	*S2 - Increasing lean meat yield but maintaining pH / Total Pot. (2020)*	Traits - Measurements Summary	AG3		$3,703	$10,258	$19,826	$6,553	$14,445	0
OK	*S3 - Increasing feedlot quality but maintaining turn-off times / Total Pot. (2020)*	Traits - Measurements Summary	AG4		$14,504	$46,497	$117,621	$26,310	$71,133	0
OK	*S4 - Improving animal health / Total Pot. (2020)*	Traits - Measurements Summary	AG5		$19,263	$42,332	$77,811	$28,638	$58,538	0
OK	*S5 - Optimise livestock purchased to market specifications / Total Pot. (2020)*	Traits - Measurements Summary	AG6		$1,234	$7,976	$26,733	$3,381	$14,766	0
OK	*S6 - Fabrication of purchased livestock to optimise value / Total Pot. (2020)*	Traits - Measurements Summary	AG7		$7,101	$84,882	$372,771	$25,699	$184,012	0
OK	*Cumulative total of Benefit Scenarios / Total Pot. (2020)*	Traits - Measurements Summary	AG8		$111,112	$220,808	$503,959	$150,922	$325,485	0
Status	Name	Worksheet	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	*S1 - Increasing lean meat yield but maintaining eating quality / Total Lik. (2020)*	Traits - Measurements Summary	AH2		$2,822	$7,685	$15,003	$4,822	$10,834	0
OK	*S2 - Increasing lean meat yield but maintaining pH / Total Lik. (2020)*	Traits - Measurements Summary	AH3		$447	$2,126	$4,962	$1,043	$3,370	0
OK	*S3 - Increasing feedlot quality but maintaining turn-off times / Total Lik. (2020)*	Traits - Measurements Summary	AH4		$3,806	$16,518	$43,355	$8,226	$27,597	0
OK	*S4 - Improving animal health / Total Lik. (2020)*	Traits - Measurements Summary	AH5		$6,896	$17,020	$35,212	$10,330	$25,527	0
OK	*S5 - Optimise livestock purchased to market specifications / Total Lik. (2020)*	Traits - Measurements Summary	AH6		$6	$648	$3,453	$131	$1,540	0
OK	*S6 - Fabrication of purchased livestock to optimise value / Total Lik. (2020)*	Traits - Measurements Summary	AH7		$80	$8,962	$51,133	$1,476	$23,177	0
OK	*Cumulative total of Benefit Scenarios / Total Lik. (2020)*	Traits - Measurements Summary	AH8		$28,359	$52,960	$104,635	$38,159	$71,502	0

Table 11: Sensitivity analysis for beef benefit scenarios - 2030 potential and 2030 likely benefits ('000's)

@RISK Output Results

Status	Name	Worksheet	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	*S1 - Increasing lean meat yield but maintaining eating quality / Total Pot. (2030)*	Traits - Measurements Summary	AI2	25,000 70,000	$25,119	$41,382	$67,567	$31,620	$52,319	0
OK	*S2 - Increasing lean meat yield but maintaining pH / Total Pot. (2030)*	Traits - Measurements Summary	AI3	5,000 35,000	$9,737	$18,496	$30,290	$13,369	$24,476	0
OK	*S3 - Increasing feedlot quality but maintaining turn-off times / Total Pot. (2030)*	Traits - Measurements Summary	AI4	0 120,000	$14,504	$46,497	$117,621	$26,310	$71,133	0
OK	*S4 - Improving animal health / Total Pot. (2030)*	Traits - Measurements Summary	AI5	10,000 80,000	$19,263	$42,332	$77,811	$28,638	$58,538	0
OK	*S5 - Optimise livestock purchased to market specifications / Total Pot. (2030)*	Traits - Measurements Summary	AI6	0 60,000	$6,199	$21,226	$57,651	$11,605	$34,929	0
OK	*S6 - Fabrication of purchased livestock to optimise value / Total Pot. (2030)*	Traits - Measurements Summary	AI7	0 900,000	$34,679	$226,404	$839,913	$82,470	$452,844	0
OK	*Cumulative total of Benefit Scenarios / Total Pot. (2030)*	Traits - Measurements Summary	AI8	0.10m 1.10m	$172,650	$396,336	$1,039,047	$242,870	$632,941	0
Status	Name	Worksheet	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	*S1 - Increasing lean meat yield but maintaining eating quality / Total Lik. (2030)*	Traits - Measurements Summary	AJ2	10,000 35,000	$11,582	$20,700	$33,451	$15,152	$26,661	0
OK	*S2 - Increasing lean meat yield but maintaining pH / Total Lik. (2030)*	Traits - Measurements Summary	AJ3	4,000 18,000	$5,242	$9,518	$16,535	$6,771	$12,761	0
OK	*S3 - Increasing feedlot quality but maintaining turn-off times / Total Lik. (2030)*	Traits - Measurements Summary	AJ4	0 70,000	$8,337	$25,987	$64,331	$14,118	$41,464	0
OK	*S4 - Improving animal health / Total Lik. (2030)*	Traits - Measurements Summary	AJ5	10,000 55,000	$12,521	$27,516	$50,577	$18,615	$38,050	0
OK	*S5 - Optimise livestock purchased to market specifications / Total Lik. (2030)*	Traits - Measurements Summary	AJ6	0 35,000	$3,719	$12,736	$34,591	$6,963	$20,957	0
OK	*S6 - Fabrication of purchased livestock to optimise value / Total Lik. (2030)*	Traits - Measurements Summary	AJ7	0 550,000	$20,807	$135,842	$503,948	$49,482	$271,706	0
OK	*Cumulative total of Benefit Scenarios / Total Lik. (2030)*	Traits - Measurements Summary	AJ8	100,000 700,000	$101,048	$232,299	$621,456	$139,576	$374,227	0

Sheep Scenarios

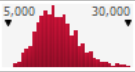
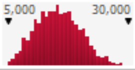
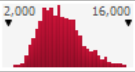
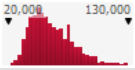
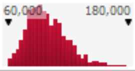
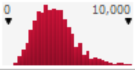
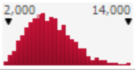
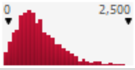
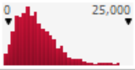
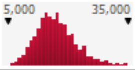
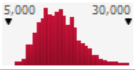
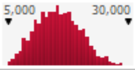
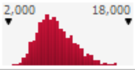
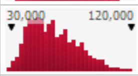
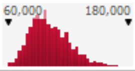
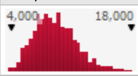
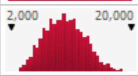
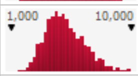
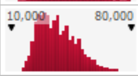
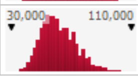
Table 12: Sensitivity analysis for sheep benefit scenarios - maximum benefits ('000's)

@RISK Output Results

Status	Name	Worksheet	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	*S1 - Increasing lean meat yield but maintaining IMF / Maximum Benefit*	Traits - Measurements Summary	AF2	15,000 50,000	$18,010	$29,471	$47,605	$21,061	$39,154	0
OK	*S4 - Improving animal health / Maximum Benefit*	Traits - Measurements Summary	AF4	48,000 62,000	$48,633	$55,938	$61,280	$50,820	$60,023	$0
OK	*S5 - Optimise livestock purchased to market specifications / Maximum Benefit*	Traits - Measurements Summary	AF6	6,000 28,000	$7,884	$15,533	$26,254	$10,702	$20,924	0
OK	*S6 - Fabrication of purchased livestock to optimise value / Maximum Benefit*	Traits - Measurements Summary	AF7	60,000 200,000	$75,603	$114,494	$183,076	$80,269	$162,984	0
OK	*Cumulative total of Benefit Scenarios / Maximum Benefit*	Traits - Measurements Summary	AF8	160,000 300,000	$165,242	$215,436	$296,401	$179,469	$264,872	0

Table 13: Sensitivity analysis for sheep benefit scenarios - 2020 and 2030 potential and likely benefits ('000's)

@RISK Output Results

Status	Name	Worksheet	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	*S1 - Increasing lean meat yield but maintaining IMF / Total Pot. (2020)*	Traits - Measurements Summary	AG2		$7,182	$15,607	$29,713	$10,031	$22,262	0
OK	*S4 - Improving animal health / Total Pot. (2020)*	Traits - Measurements Summary	AG4		$5,958	$15,694	$28,224	$9,123	$22,491	$0
OK	*S5 - Optimise livestock purchased to market specifications / Total Pot. (2020)*	Traits - Measurements Summary	AG6		$3,196	$8,285	$15,348	$5,218	$12,232	0
OK	*S6 - Fabrication of purchased livestock to optimise value / Total Pot. (2020)*	Traits - Measurements Summary	AG7		$26,526	$61,148	$126,085	$38,719	$91,868	0
OK	*Cumulative total of Benefit Scenarios / Total Pot. (2020)*	Traits - Measurements Summary	AG8		$65,060	$100,733	$174,689	$75,801	$131,444	0
Status	Name	Worksheet	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	*S1 - Increasing lean meat yield but maintaining IMF / Total Lik. (2020)*	Traits - Measurements Summary	AH2		$878	$3,994	$9,978	$1,934	$6,555	0
OK	*S4 - Improving animal health / Total Lik. (2020)*	Traits - Measurements Summary	AH4		$2,146	$6,308	$13,922	$3,450	$9,704	$0
OK	*S5 - Optimise livestock purchased to market specifications / Total Lik. (2020)*	Traits - Measurements Summary	AH6		$23	$675	$2,361	$155	$1,374	0
OK	*S6 - Fabrication of purchased livestock to optimise value / Total Lik. (2020)*	Traits - Measurements Summary	AH7		$226	$6,421	$22,679	$1,720	$12,927	0
OK	*Cumulative total of Benefit Scenarios / Total Lik. (2020)*	Traits - Measurements Summary	AH8		$6,929	$17,399	$33,907	$10,905	$24,938	0
Status	Name	Worksheet	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	*S1 - Increasing lean meat yield but maintaining IMF / Total Pot. (2030)*	Traits - Measurements Summary	AI2		$7,333	$15,962	$29,445	$10,425	$22,574	0
OK	*S4 - Improving animal health / Total Pot. (2030)*	Traits - Measurements Summary	AI4		$5,958	$15,694	$28,224	$9,123	$22,491	$0
OK	*S5 - Optimise livestock purchased to market specifications / Total Pot. (2030)*	Traits - Measurements Summary	AI6		$3,156	$8,550	$16,153	$5,393	$12,402	0
OK	*S6 - Fabrication of purchased livestock to optimise value / Total Pot. (2030)*	Traits - Measurements Summary	AI7		$30,983	$63,072	$118,371	$40,880	$93,082	0
OK	*Cumulative total of Benefit Scenarios / Total Pot. (2030)*	Traits - Measurements Summary	AI8		$64,754	$103,278	$166,901	$78,533	$133,623	0
Status	Name	Worksheet	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	*S1 - Increasing lean meat yield but maintaining IMF / Total Lik. (2030)*	Traits - Measurements Summary	AJ2		$4,335	$9,364	$17,730	$6,065	$13,232	0
OK	*S4 - Improving animal health / Total Lik. (2030)*	Traits - Measurements Summary	AJ4		$3,873	$10,201	$18,346	$5,930	$14,619	$0
OK	*S5 - Optimise livestock purchased to market specifications / Total Lik. (2030)*	Traits - Measurements Summary	AJ6		$1,894	$5,130	$9,692	$3,236	$7,441	0
OK	*S6 - Fabrication of purchased livestock to optimise value / Total Lik. (2030)*	Traits - Measurements Summary	AJ7		$18,590	$37,843	$71,023	$24,528	$55,849	0
OK	*Cumulative total of Benefit Scenarios / Total Lik. (2030)*	Traits - Measurements Summary	AJ8		$38,883	$62,539	$101,228	$47,635	$80,940	0