Final report

Commercial application of supply chain integrity and shelf life systems

Project code: V.MFS.0447

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Abstract

The issue of product integrity has been subject to a large amount of attention by meat industry bodies, researchers and technology/service providers. The assumption in much of the work to date, is that the Australian meat industry is falling behind others in adoption of technologies and systems to enhance product integrity.

This project provides an independent assessment of the product integrity issue as it applies to the Australian red meat industry, largely through a commercial and operational lens. It explores the industry experiences and work to date on product integrity in red meat supply chains and highlights strategic issues for consideration, including detail around which products, as well as which markets and market channels, would benefit most from investment in integrity systems.

The project methodology has involved extensive research and analysis of prior work, together with engagement with industry stakeholders (covering meat industry businesses and technology/service providers), development of five case studies and a final report that synthesises the key findings.

The industry benefit that will arise from this work is that it provides a considered analysis of the key issues pertaining to product integrity systems that will elevate the industry knowledge base and be useful in informing future business and industry investment and strategies on product integrity.

Executive summary

Background

The purpose of this research project is to provide the Australian red meat industry with an enhanced understanding of the commercial applications of supply chain integrity and shelf life systems. The impetus for the study was a belief that the red meat industry was not leveraging the available technologies to the extent possible due to a lack of understanding of their potential applications. The target audiences for this report are red meat businesses, potential technology service providers to red meat businesses, MLA personnel and those trade officials or businesses involved in the export of red meat. The results of this study will be used to inform future investment in enhancing product integrity across the Australian meat industry.

Objectives

The objectives of the project are:

1. Explain the theoretical/academic background to understanding which products are worthy of supply chain protections (integrity and assurance systems) and how supply chain actors can be engaged in providing value to the consumer, combined with meat supply chain context and examples.
2. Document commercial case studies as examples of that understanding, showcasing existing traceability and shelf life systems and learnings from their implementation.

While the subject matter is complex, it is believed that this report achieves the objectives by providing detailed analysis and specific examples of the application of integrity systems and documenting five case studies which are appended to this final report.

Methodology

The methodology involved a literature scan, in-depth interviews with over 40 individuals concerned with the subject matter, profit pool and supply chain analysis and detailed reporting of the five case studies and key findings in appropriate commercial language.

Results/key findings

The industry views on the need for investment in enhanced supply chain integrity systems are at odds with those of researchers and technology/service providers, whose five core propositions in support of investment can be questioned. Meat industry business operators strongly associate supply chain integrity systems with 'traceability', which they believe is already more than adequate in the Australian meat industry and they feel that they cannot achieve a return on investment on enhanced integrity technologies.

Supply chain integrity technologies are highly complex and constantly evolving with implementation challenges for both meat businesses and providers. Despite these challenges, there *are* justifications beyond just product integrity and traceability for investment, including: improved supply chain management; reduced risk of fraud; extended shelf life; reduced operating and wastage costs; accommodating rising retailer expectations; and access to immediate market feedback. The message that comes through clearly in a number of the case studies appended to the report is that investment in product integrity technologies comes at a cost to the business and as a consequence, they need to gain benefits other than product integrity to justify investment. As highlighted in the

case studies, those businesses investing in integrity technology are building their businesses cases around the other benefits that flow from the technology such as improved supply chain efficiency resulting in cost reductions, the ability to gain working capital to finance inventory and improved profitability from B2B or B2C trading. There is also a strong argument for industry investment in systems that will protect the integrity of Brand Australia in export markets.

Benefits to industry

The industry benefit that will arise from this work is that it provides a considered analysis of the key issues pertaining to product integrity systems that will elevate the industry knowledge base and be useful in informing future business and industry investment and strategies on product integrity.

The learnings will also bridge the gap that currently exists between meat supply chain businesses and technology service providers on the commercial applications of emerging technologies relating to product integrity and supply chain management.

Future research and recommendations

Based on the results of the project, recommendations for future research or development include:

1. Validation of the fraud issue and preparation of an industry response
2. Study of the feasibility of implementing industry wide integrity enhancements
3. Further R&D in the area of cold chain integrity and its impact on shelf life
4. Bridging the gap between the red meat industry and technology/service providers
5. A detailed understanding of what integrity systems represent for consumers and what would stimulate their willingness to pay more for them.

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1. Background

MLA's Rural R&D for Profit Insights2Innovation project identified 'Food without Fear' as being an important global concern. Consumers in all markets have limited methods to judge the integrity of the products they consume. A report from FIAL estimates circa AUD 272 million p.a. of fraud is perpetrated on the industry in export markets (McLeod, 2017), which may or may not underestimate the extent of fraud since it is based on economic modelling with no sampling or testing in the marketplace to verify the estimate.

The food integrity space is changing quickly with both service providers and supply chain participants facing a steep learning curve. Supply chain participants are unclear about:

- How/why to implement a traceability system
- Who generates value from this traceability system and therefore if it is worthwhile
- How to determine which markets and products are suitable/worthwhile to include in a traceability system (versus including everything)
- What value a product integrity system can add to the business (how to define and put numbers around the intangible benefits) and what is the cost of doing nothing
- Many of the technologies being offered fail to provide cost-benefit analysis or case studies to justify the development and implementation of integrity systems through a supply chain. They may also only offer part of the solution that is required.

For an Australian meat processor/exporter/brand owner, the technological landscape of product integrity systems is confusing and convoluted, which reduces the incentive to implement systems that protect or enhance their product offering. For a supply chain integrity system to work effectively and mitigate the risk of intentional and unintentional compromises, the supply chain partners need to be appropriately incentivised to participate.

Technologies that improve shelf life outcomes also face similar challenges in adoption by industry. The level of interest and responsibility a processor/exporter takes in a product's quality after it leaves Australia can vary significantly. Some are very interested in improving outcomes along the entire supply chain, while others rely on insurance claims if there is a problem once the product leaves their custody.

There is a risk to brand reputation and potentially reduced margins for the entire industry from poor management of the red meat cold chain. Ultimately, the Australian meat industry needs to protect its global reputation and status to retain the margin premiums afforded by 'Brand Australia'. This in part, involves providing the level of assurance of product integrity that the consumer needs and expects.

This project aims to deepen the industry understanding of product and supply chain integrity issues and respond to the questions raised above through a process of research and analysis and exploration of what is working in a number of agrifood businesses who have already begun the integrity systems journey.

2. Objectives

The objectives of the project as briefed are:

1. Explain the theoretical/academic background to understanding which products are worthy of supply chain protections (integrity and assurance systems) and how supply chains can be engaged in providing value to the consumer, combined with meat supply chain context and examples.
2. Document commercial case studies as examples of that understanding, showcasing existing traceability and shelf life systems and learnings from their implementation.

While the subject matter is complex, it is believed that this report achieves the objectives by providing detailed analysis and specific examples of commercial application of supply chain integrity systems.

3. Methodology

The project methodology entailed eight distinct steps as outlined below.

Step 1| Project planning: A full briefing was conducted with the MLA team and relevant background research was discovered.

Step 2| Research and analysis: A literature search was undertaken via internet scanning and these documents, along with the relevant industry reports provided by MLA, were reviewed to capture useful learnings.

Step 3| Industry engagement: More than 40 interviews were conducted with players along the meat supply chain as well as other agrifood exporters and technology providers. The majority of these were conducted via telephone or video conference due to the COVID19 pandemic, which may have limited the depth of findings to some extent.

Step 4| Chain of responsibility mapping: Mapping of the supply chain to identify hazard break points, chain of command responsibility and current best practise was undertaken by drawing on the learnings from the industry engagement.

Step 5| Scoping of case studies: Research was undertaken to identify potential case studies via the literature scan, the engagement leads and through McKINNA *et al's* own networks across agribusiness.

Step 6| Development of case studies: Five case studies were compiled using information gathered from interviewing key players associated with the businesses or industry bodies involved (including technology providers and meat industry businesses) as well as reviewing background technical information specific to each approach.

Step 7| Reporting: The research findings reported with analysis and commentary.

Step 8| Knowledge transfer: Industry de-briefing conducted by participating in a debriefing session with the MLA team and conducting two industry webinars.

4. Results

The nature of the findings from the project research means that they are best presented as an analytical discussion rather than a definitive result. As such, the results are reported at length in a separate section of this document as a stand-alone paper at the heading: 'Analysis of product integrity and shelf life systems' (page 13).

The high-level themes to emerge from project V.MFS.0447 are as follows:

1. There is a significant misalignment between the views of the meat industry compared to technology providers and the research community, on the issue of product integrity, particularly with respect to:
    - The importance of product integrity as a purchase driver
    - The willingness of consumers to pay a premium for enhanced product integrity
    - The adequacy of industry's current product integrity systems and processes
    - Consumer demand for more traceability and information on provenance
    - The extent to which fraud is occurring and the damage being done to the industry.

2. The nature, extent and impact of fraud on the Australian red meat industry is not well understood. The widely referenced estimates need to be interpreted with some caution because of the basis of the calculations. There is a large disparity between the views of the industry compared with technology providers and researchers on the magnitude of the fraud problem. Meat businesses are confident in the robustness of the industry integrity systems and believe that when fraud does occur it is relatively minor, confined to a small number of customers and is only an issue within one or two markets, predominately China.

3. The focus by technology providers on the fraud mitigation features of their products is gaining limited traction with meat companies because fraud is not considered a priority issue. To be convinced to invest in integrity technologies, meat companies need to see a value proposition beyond product integrity *per se* which delivers a financial reward commensurate with the cost and complexity entailed. Meat businesses are confident in existing industry integrity systems and therefore, do not recognise the return on investment on the basis of enhanced integrity alone.

4. Product integrity is the cornerstone of Australia's competitive advantage in global markets. Consumer and customer confidence and trust in Australian red meat comes from its credence attributes which deliver a significant price premium over competitors. This price premium is largely captured in the trade brands of processor/exporters. As the key point of competitive advantage, Australia's reputation for product integrity needs to be strongly protected and continuously strengthened.

5. Shortcomings in cold chain integrity are imposing a financial burden on the Australian meat industry, which is largely hidden and treated as a sunk cost. The wastage and profit erosion caused by short shelf life is being borne by the industry, even though much of the cause of it is outside of its control or visibility. This profit leakage could be addressed by embarking on a

'whole of cold chain' and collaborative approach to addressing it which embraces active, real-time data management technologies, such as those being adopted by other perishable food sectors in collaboration with their supply chain partners as well as customers.

6. There are justifications beyond just traceability for investment in product integrity systems including: improved supply chain management, reduced risk of fraud, extended shelf life, reduced operating and wastage costs, accommodating rising retailer expectations and access to immediate market feedback. The message that comes through clearly in a number of the case studies appended to the report is that investment in product integrity technologies comes at a cost to the business and as a consequence, they need to gain benefits other than product integrity to justify investment. As highlighted in the case studies, those meat businesses who are investing in integrity technology are building their businesses cases around the other benefits that flow from the technology such as improved supply chain efficiency resulting in cost reductions, the ability to gain working capital to finance inventory, improved profitability from B2B or B2C trading. There is also a strong argument for industry investment in industry-wide systems that will protect the integrity of Brand Australia in export markets.

5. Key findings

Product integrity in the red meat industry has been the subject of a significant body of research, a common assertion being that it requires more attention and investment. This view is strongly endorsed by technology and service providers, many of whom are of the opinion that the Australian industry is lagging behind other exporting nations. The **five propositions** implicit in the case for more investment in are:

1. Product integrity is a major purchase driver
2. Consumers, and therefore customers, are prepared to pay a premium for enhanced integrity attributes
3. There are significant shortcomings in the product integrity systems of the Australian red meat industry
4. Consumers are demanding more traceability and information on provenance
5. There is widespread fraud of Australian meat in global markets, which is harming brand owners and the industry.

An evaluation of these propositions questions their validity as the claims do not always align with the industry experience and therefore, they warrant further investigation.

Most meat industry personnel instinctively equate the term 'product integrity system' with 'traceability system', but integrity systems are far broader than traceability alone, including:

1. Product authentication
2. Verification and tracking
3. Supply chain and inventory management
4. Trading and marketing platforms
5. Cold chain management systems.

Many of the technologies around product integrity systems that offer more than scientific product verification alone are largely based on cloud or blockchain platforms. The complexity around navigating the technologies on offer and applying the systems to the meat industry can be overwhelming for both the meat businesses as well as the service and technology providers. Key learnings in this regard are:

- The bar is continually being raised in relation to product integrity
- Enhanced product integrity in itself is unlikely to generate incremental value
- 'One size fits all' does not apply to supply chain technology solutions
- There is no 'plug in and play' option
- Technology is a journey not a destination
- Blockchain is not an integrity system - it is a platform.

The barriers to adoption of integrity systems by the Australian meat industry are:

1. The high level of confidence in current integrity systems
2. Cynicism about blockchain
3. The futility of attempting to stop fraud
4. Such systems add cost and complexity which cannot be recouped
5. The lack of an 'end to end' solution
6. Most systems cannot accommodate the complexity of meat businesses.

6. Conclusions and recommendations

1. There is a significant misalignment between the views of red meat businesses on the one hand, and technology providers and researchers on the other, regarding the needs and commercial application of emerging product integrity technologies.
2. The business case to invest in technologies to enhance product integrity and supply chain management are heavily based on five implicit propositions which need to be challenged.
3. There is a high level of consumer confidence and trust in the integrity of Australian meat in the domestic market, so integrity is an assumed attribute of red meat and not a high-level purchase driver. Product integrity however is a major purchase driver for most export markets, particularly in Asia. This trust is underpinned by the Australian provenance (Brand Australia). Consequently, there is little incentive for brand owners to invest in enhanced product integrity beyond which that required by customers and government regulators.
4. Product integrity is much more of an 'industry' issue rather than an individual 'brand owner' issue and there is a strong case for the Australian red meat industry to continue to invest to protect and enhance the integrity of its systems and processes.
5. Although red meat businesses are confident that their product integrity systems are robust, there is acknowledgement that customer and consumer expectations are continually growing.
6. There is a large amount of cynicism regarding blockchain within the red meat industry with most businesses rejecting it on the basis that it added cost and complexity with no clear value proposition.
7. One of the greatest barriers to the adoption of product integrity technologies is the cost and complexity it adds to the business which cannot be passed on to the end customer and must be absorbed as an overhead.

8. Meat businesses have found the search for technology solutions challenging and frustrating with many very expensive lessons being incurred because of the difficulty of finding a solution that meets the unique needs and priorities for their particular business. The common experience is that there no 'off the shelf' solutions making it necessary to patch together a range of technologies. Navigating the labyrinth of technologies is extremely challenging given the technical complexity.

9. Technology providers believe that the red meat industry trails behind other perishable food categories in terms of the adoption of cold chain integrity technologies and that the extent to which meat companies invest in cold chain integrity as a risk management tool is risk mitigation alone, whereas, other perishable food categories see benefits in factors such as waste reduction, immediate market feedback and shelf life management.

10. The cost impost of compromised cold chain is shared along the entire supply chain and treated as a hidden or unavoidable cost of doing business without consideration of the opportunity to reduce a significant amount of this wastage and recovering at least part of the cost burden. The fact is that compromised cold chain integrity is a much greater cost impost on the industry than traceability and fraud.

7. Related resources

A debrief meeting will be conducted with the project team and a podcast is being recorded to transfer knowledge to industry and technology/service providers.

The project analysis is presented in full in the following pages.

8. Appendix 1: Analysis of supply chain integrity and shelf life systems

This section of the document presents the full discussion and analysis on product, supply chain and shelf life integrity systems and the findings from the research and consultation conducted for MLA Project V.MFS.0447. It summarises the learnings from the project's two associated milestone reports in order to draw the analysis to a logical end point. The main content of the Milestone 3 report, which presents five case studies on commercial applications of product integrity systems, is tabled in the appendix.

This report attempts to review the complex subject of product integrity and supply chain management technology through a commercial lens to clearly outline what benefits integrity technologies can offer business operators in the red meat industry. The commercial perspective is important at this point in time because much of the current theory on product integrity does not appear to match the experiences of the business operators. There are divergent views between industry on one hand, and academics and technology/service providers on the other.

Navigating the labyrinth of product integrity systems on offer is challenging, especially in an environment when science, technology and the internet of things (IoT) are all evolving at such a rapid rate. There is a universe of technology and service providers out there (many of whom are in start-up phase), all marketing various solutions with varying capabilities. Although there are providers claiming to offer complete end-to-end solutions, the experience of those that have attempted to implement them, is that it is usually necessary to patch together a combination of individual technologies, each with their own applications and functionality.

Product and supply chain integrity and management systems are built in layers comprising various combinations of product authentication, verification, real time tracking and tracing, management of inventory and documentation, cold chain monitoring and on-line trading platforms. Because the needs and priorities of each meat industry business varies, each system needs to be customised to provide tailored functionality.

The overriding purpose of this project is to provide a balanced and objective assessment of the commercial application of product integrity systems in the meat industry, for the benefit of both meat businesses and technology/service providers. Currently, there is a disconnect between the key stakeholders. This lack of alignment of views on the product integrity issue stems from the fact that the technology and service providers are frustrated that mainstream Australian meat businesses have not embraced the emerging technologies and claim that they lag behind other categories, which is putting them at a commercial disadvantage. The red meat businesses believe that the technologies available do not add value and, to quote one business operator, *"solve problems that we do not have".*

The views of academics and technology/service providers have been well represented in the industry reporting and communications to date and yet in many instances they are at odds with the direct experience of meat industry businesses. Reviewing the industry reporting on the subject would give most readers the impression that there are significant shortcomings in the integrity systems of the Australian red meat industry, particularly with respect to product fraud and mislabelling. The reference material implies that fraudulent mislabelling of inferior meat as being of Australian origin in export markets, is a significant problem causing serious damage and that the industry needs to invest more to address the problem. In contrast, Australian meat businesses are generally very confident in the robustness of their current product integrity systems (in both

domestic and export markets) and believe that this is a point of competitive advantage for Australia in global markets. The general industry experience is, that although fraud does occur, it is relatively minor and tends to be confined to a small number of channels within two or three countries and as such, they believe that it is not doing great damage. Due to the fact that the vast majority of Australian meat (in volume terms) is marketed to long-standing customers through closed-loop supply chains, which are subject to rigorous inspection and third-party auditing, meat businesses are assured that there are high levels of controls and visibility across the supply chain. Although businesses acknowledge that the bar is always lifting in terms of product integrity and that they must continue to review their systems, they believe that these systems are of a high standard in global terms.

In order to understand the reasons behind these disparate viewpoints and to identify the point of mutual benefit between technology providers and industry, the authors have undertaken the analysis as follows:

- Examined the concept of product integrity
- Unpacked the nature of product integrity technologies from a layperson's perspective
- Described each of the major technology groups and their applications
- Documented the experiences of those who have used them
- Examined the barriers to adoption of technologies
- Summarised the findings and suggested priorities for future research and strategy.

9. Product integrity in context

The Oxford English Dictionary defines 'integrity' as *"the quality of being honest and having strong moral principles" (www.lexico.com, Oxford University).* In the context of a product, 'integrity' translates into assuring customers that they can be confident that what they are buying is precisely what it purports to be.

In the red meat industry, the term 'product integrity' is commonly used in the same sentence as 'traceability', which is the ability to trace and verify the integrity of a product at any point in the supply chain, given that in most meat supply chains, the product is outside of the direct control and visibility of the seller for a large part of the journey.

The term 'product integrity' is also frequently associated with 'credence factors', which are the attributes of a product that cannot be observed or experienced and for which the consumer is reliant on the honesty and integrity of the supplier to confirm. For red meat, credence factors include:

- Food safety (freedom from contaminants/chemicals/ bacteria)
- Production method (grain-fed/ grass-fed/organic/Halal slaughter)
- Environmental sustainability/carbon footprint
- Truth in labelling (ingredients/food allergies, religious or cultural beliefs)
- Provenance (product origin, terroir, the impact of natural environmental factors such a soil, air and climate on the product characteristics).

> **INSIGHT:**
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> **The interpretation of 'product integrity' is specific to each individual customer and consumer according to their own preferences and needs. The true test of a product's integrity is that the buyer has confidence that what they are purchasing is what it is purported to be.**

Product integrity in the red meat industry has been the subject of a significant body of research in Australia, with key reports sponsored by MLA, AMPC, CSIRO, FIAL, RIRDC/Agrifutures as well as others. A common assertion coming through much of the recent work is that product integrity is a major issue for the meat industry as whole as well as individual businesses and that it requires more attention. This view is strongly endorsed by technology and service providers, many of whom are of the opinion that the Australian red meat industry is lagging behind other exporting industries in terms of the adoption of product integrity technologies.

There are **five propositions** that are implicit in the case for more investment in product integrity systems made by researchers and the technology/service providers:

Proposition 1:   Product integrity is a major purchase driver

Proposition 2:   Consumers, and therefore customers, are prepared to pay a premium for enhanced integrity attributes

Proposition 3:   There are significant shortcomings in the product integrity systems of the Australian red meat industry

Proposition 4:   Consumers are demanding more traceability and information on provenance

Proposition 5:   There is widespread fraud of Australian meat in global markets, which is harming brand owners and the industry.

In order to provide context to this final report, the key points of each proposition are summarised here.

9.1 Proposition 1: Product integrity is a major purchase driver

A consistent premise of many of the research papers on product integrity and the prevailing view of high profile food industry experts and commentators is that integrity attributes are a major and growing purchase driver for consumers, both in export and domestic markets, and that consumers will pay a premium for assured credence factors. This observation may indeed apply to a certain cohort of consumers, but does not appear reflect the market situation.

Product integrity in export markets

The most relevant and comprehensive data set on red meat purchase drivers comes from MLA's Global Consumer Tracker (2018), which periodically tracks consumer perceptions of proteins, including beef and lamb. This research monitors consumer perceptions of proteins, including country of origin and competitors, across an array of Australia's export markets. The top five 'drivers of animal protein choice' varies across the 17 markets but predominantly includes the following:

1. The most superior meat
2. Family enjoyment

3.   Taste
4.   Consistency of quality
5.   Nutritional value
6.   Ease of preparation/convenience, ease of purchase
7.   Versatility
8.   Value for money
9.   Freshness.

While product integrity is not explicitly evaluated in the MLA research, there are four attributes that are explored with consumers and interpreted as a potential proxy:

1.   'The animal is well cared for'
2.   'Consistent quality standards'
3.   'Guaranteed safe to eat'
4.   'The industry is environmentally sustainable'.

In general, these attributes appear to be of a lower order in the ranking of purchase drivers and typically do not rank in the top five for consumers in export markets, with a small number of exceptions including Japan where 'guaranteed food safety' and 'care for the animal' are important to consumers and Qatar where, 'environmental sustainability' ranks in the top five factors.

The consultation for this project (V.MFS.0447 – Commercial application of supply chain integrity and shelf life systems) suggests that;

- Across most export markets, Australian red meat generally achieves a premium price for 'like for like' cuts relative to product from competitor countries. McKINNA *et al's* in-market research for MLA in a number of export markets some years ago, would also confirm this. This premium can be attributed to consumer and customer confidence in the integrity of the Australian product. Australian food products overall enjoy a reputation in Asian and Middle Eastern markets for so-called 'clean and green' credentials. Implicit in this over-used phrase is the confidence in the safety of the food, i.e. that the food is unadulterated, untainted by chemicals and pollutants, free from disease, and has been handled in a safe manner in the supply chain. Australian imagery in export markets is often characterised by sunny clear skies, green pastures, wild landscapes or pristine beaches with blue water. Based on many years of in-market trade research in Australia's key export markets, across several agrifood categories by McKINNA *et al,* it can be claimed that Australian food exporters generally enjoy a favourable reputation in international markets as being trustworthy and ethical trading partners.
- Essentially, confidence in buying Australian red meat is underpinned by trust in Australian systems and processes, including the government's regulatory process as well as the buyers' knowledge that the Australian red meat industry is comprehensively regulated and audited at every level of supply chain through a combination of industry integrity and biosecurity systems as well as retailer quality audits.

The perceptions of the integrity of Australian red meat in export markets *do* align with the reality as the Australian red meat industry is underpinned by a number of interlinked platforms which collectively provide traceability, uniform product descriptions and a national grading language from the live animal on the farm through to the finished product. In blockchain language, this is 'the

source of truth'. Most of the more recently developed technologies draw on these foundations in various ways as their reliable information source. This industry integrity system is implicitly communicated to the consumer through the combination of trade brands and Australian country of origin provenance. Only a relatively small proportion of Australian meat is sold to the end consumer in export markets under the proprietary retail brands of meat exporters, as such, the brand value is inherent in 'Brand Australia'.

Australia has market access for red meat into many countries where its competitors do not, which could in part be attributed to the industry's product integrity credentials e.g. the USA had no market access to China for some years and the US industry believed that the absence of a national traceability system was one of the key blockers in rectifying this (as noted World Perspectives report, 2019), beyond geo-political trade issues and biosecurity blockers.

Product integrity in the domestic market

In the domestic market, the MLA Consumer Tracker (2018) indicates that the top five attributes of importance at the point of purchase for beef and lamb for Australian consumers are as follows:

Table 1: Top five considerations when purchasing for Australian consumers

BEEF:	LAMB:
1. Price per kilo	1. 100% natural
2. 100% natural	2. Price per kilo
3. Colour meat	3. Price per pack
4. Price per pack	4. Colour of meat
5. Quality grading or guarantee	5. Quality grading or guarantee

Source: MLA Consumer Tracker, 2018

Separate to the above data, Australian retailers interviewed in the consultation for this study were strongly of the opinion (based on their own extensive customer research), that 'value for money' and 'quality/consistency' are the dominant drivers of red meat purchase. They confirmed that there is already a high level of consumer trust in the integrity of Australian meat because of the confidence in both the retailer and proprietary brands, which is assumed in the purchase decision. Retailers verify this trust on their consumers' behalf by rigorous inspection and audit of their suppliers. In contrast, based many years of consumer research on fresh food products (including red meat), by McKINNA *et al,* it could be claimed that Australian consumers would be suspicious of imported meat from most parts of the world (except New Zealand) as it is assumed that most systems would be vastly inferior to those in Australia (note: this has not been verified by MLA research in recent years). Although there is a vocal minority of consumers who go to great lengths to scrutinise the food they eat, the retailers interviewed stressed that most Australians take the integrity of food supply chains for granted.

> **INSIGHT:**
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> **In export markets, trust in the integrity of Australian meat is encapsulated in the many attributes of 'Brand Australia'. This trust underpins the achievement of premium pricing for Australian meat in most export markets.**
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> **Product integrity factors do not figure as prime purchase drivers of red meat in Australia because integrity is already assumed.**

9.2 Proposition 2: Consumers, and therefore customers, are prepared to pay a premium for enhanced integrity attributes

Ultimately, any decision by meat businesses to invest in the enhancement of product integrity must deliver a commercial return on investment. This return flows from a willingness by consumers/customers to pay more for the product or because it drives an increase in market share or brand loyalty, which generates incremental profit. While technology/service providers put forward the above proposition as a key reason to invest, the consultation for this study would suggest that the commercial reality differs or is at least untested at scale.

Behavioural theory indicates that some consumers would pay more for enhanced integrity

Consumer behavioural models provide a framework to examine the extent to which consumers are prepared to pay for enhanced product integrity. Modern behavioural models are largely founded on Maslow's hierarchy of needs (Maslow, 1943), which famously prioritised the spectrum of needs that humans have to survive and ultimately be fulfilled. Herzberg's Hygiene Motivation Theory of the late 1950s (Herzberg 1959) applied this concept to the workplace, theorising that workers have lower level needs to avoid pain and deprivation and higher level needs to grow psychologically. As this body of work evolved, it was then applied to product attributes in the 1980s by Dr Noriaki Kano and colleagues (Kano *et al*, 1984). The central premise of Kano *et al* is that not all product attributes are valued equally by consumers. The Kano categories of product attributes are listed in the table below with examples of how they might apply to red meat products.

Table 2: Kano model as applied to meat industry

KANO CATEGORY	DESCRIPTION:	MEAT INDUSTRY EXAMPLES:
1. **Must be**	These requirements represent the base level of expected standards.	*Reasonable eating quality, safe, correctly labelled*
2. **Attractive (Delighter)**	Attractive requirements are those which are not necessarily expected but add to the satisfaction if present and 'delight' the consumer. The absence of these factors does not have any negative implications.	*Exceptional flavour, MSA assured tenderness*
3. **One dimensional**	These requirements may be explicitly demanded and expected by the customer.	*Organic, grass-fed, traceable, Halal*
4. **Indifferent**	These are the features that the customer is totally indifferent to, although they may have value to others in the supply chain.	*ISO accreditation of the abattoir*

5. *Reverse*	These are the project features that create dissatisfaction and when absent, result in high satisfaction.	*Limited variety of cuts on offer, dark colour, strong odour*

Source: Adapted from Kano et al (1984) by McKINNA et al

The 'attractive' attributes (sometimes translated as 'delighter' attributes) are the most critical attributes for building engagement with the consumer and underpinning brand value. Because these are the attributes that consumers will pay more for, they have most relevance to product integrity systems. The majority of product integrity attributes in red meat mostly fall into the 'must be' classification, particularly food safety. The five Kano categories of satisfaction can change in a consumer's mind over time due to environmental influences. For example, because the eating quality of meat has improved over recent decades due to grading methodologies such as MSA, tenderness is effectively changing from being an 'Attractive' attribute to a 'Must be' attribute in the domestic market. As the industry moves away from a commodity mindset to developing more sophisticated brands with unique value propositions, this will also shift a higher proportion of meat products from 'Must be' to 'Delighter' or 'One dimensional', according to the brand promise. The Kano model rankings are also linked to levels of affluence and disposable income.

An MLA study conducted by Melbourne University (Ashman, H., Warner, R. 2019) used an adaption of the Kano model to assess the value of new retail Smart Pack technologies for beef with consumers in Australia and China. The purpose of the study being to determine the cost/benefit of the technology investment. Using an on-line quantitative survey, the Melbourne University research probed the various integrity attributes of beef for both Australian and Chinese consumers, at the same time comparing the differences. One of the on-line survey findings was that consumers in China and Australia did indicate that they would be prepared to pay a premium for delighter attributes. The study estimated that the Chinese consumer would potentially pay a premium of $0.20 per pack for these, and the Australian consumer as much as $0.70. This finding must be interpreted with caution however, given that it is based on an on-line survey with a relatively small sample size and consumer behaviours claimed in market research are not always actualised in purchase behaviours (e.g. Joshi & Rahman, 2014). Testing around the actual propensity to pay via a qualitative study or an actual price trial in store would add value.

The study referenced above (Joshi & Rahman, 2014) tracked the research on so-called 'green purchase behaviour' globally over a period of 14 years reviewing 53 academic articles. It concluded that although consumers express a strong interest in buying goods with enhanced environmental credentials, in reality, there was little evidence to suggest that purchases of such products had increased in response to the claims. The market share of 'green' products remained at around 1 to 3% in developed markets. The research indicated that many studies reported a gap between attitudes and actual purchasing practices for organic foods and while a majority of consumers showed a positive attitude towards organic (67%), a relatively smaller number (4%) actually purchased organic foods.

In summary, more comprehensive consumer work needs to be completed around this hypothesis: *Consumers, and therefore customers, are prepared to pay a premium for enhanced integrity attributes* so that we have a more robust understanding. Both for our major export markets and domestically.

Marketing theory suggests that the need to differentiate will drive investment in integrity systems

Marketing experts continually advocate that product differentiation is necessary for competitive advantage and that de-commoditisation will deliver greater margins. In reality, this is not always the case in every industry. In the highly competitive global protein market, processors and brand owners are continually searching for material points of product differentiation for competitive advantage. Virtually all of the companies interviewed in the consultation for this project were reviewing, evaluating or commercially trialling a new generation of product integrity systems of some kind to varying levels of intensity, with trade brand differentiation being the key motivation.

The RIRDC report on product validation in agrifoods (GHD, 2016) notes that consumption trends are influenced by rising wealth and that de-commoditised products become more appealing to consumers in this context. The RIRDC report also notes that Australia's ability to offer differentiated products presents the potential for Australian exporters to lift product value and/or margins. However, differentiation is likely to be around attributes other than product integrity such as those relating to provenance, eating characteristics, convenience or emotional brand factors.

Despite the theory on de-commoditisation, the feedback from most stakeholders consulted was that very few, if any, of the product integrity enhancements they had trialled or considered had sparked a willingness from their customers to pay a premium for it.

The market feedback

Producer/exporter Latitude 28^0 has been one of the first businesses in the meat industry to apply a direct-to-consumer product verification system to their lamb and beef exports via blockchain. Because the Latitude 28^0 business model is based on engaging directly with Chinese consumers, a blockchain system was considered to be the obvious solution to countering the food scandals reported in China. The business tested the restaurant consumer's willingness to pay for the premium associated with blockchain verified authenticity by embedding an e-survey in the QR code on pack and running a competition with restaurant diners. The findings indicated that over 50% of restaurant consumers would be willing to pay a premium for the assured provenance verified by blockchain and 68% of survey participants would be willing to pay between 5 and 15% more for blockchain verification (Williamson, 2019). However, this finding again needs to be interpreted with caution given the survey methodology where diners were approached directly in the restaurant to participate by waitstaff who explained the blockchain concept to them (which culturally could make them feel obliged to offer a more positive response) and incentivised them with the prospect of winning a free meal (it is highly likely that they imagined a positive response would make them more likely to win the free meal). As explained earlier, commonly there are major differences in how consumers say they will behave in research compared with how they actually behave in the market.

The Flynn *et al* study for MLA suggested that 100% of the interviewed respondents in their study indicated that they would buy blockchain verified meat if the price was comparable (although diners in restaurants rarely see the product packaging that would enable them to verify the blockchain). The Flynn *et al* study drew this conclusion from one discussion group in China with food industry influencers. These findings should interpreted with caution as influencers do not necessarily reflect the views and behaviours of consumers and may have their own agendas. Flynn *et al* (2019) also asserted that because there is an underlying consumer mistrust in labelling in export markets, as consumers become more familiar with blockchain, it will drive demand for it. This finding is at odds

with the stakeholder consultation for this project where exporters are stating clearly that they cannot achieve a price premium for blockchain verification.

The Flynn *et al* (2019) report does note that there is some desensitisation to QR codes (used in most cases to verify the blockchain) because they are so ubiquitous in China. A number of meat businesses had trialled the use of QR codes and found that the level of uptake was low with reportedly only 2% of consumers scanning the code and that the number dropped off quickly unless there was an incentive such as a chance to win a prize or a promotional offer. One of the meat businesses consulted had introduced blockchain verified QR codes but dropped this because of poor uptake.

The scale of the opportunity is the issue

There is undoubtedly a growing niche of consumers in Australia and export markets for whom ethical product integrity issues such as substantiated environmental sustainability, authenticated provenance, organic production and animal welfare are of increased importance, particularly in more affluent post Gen X generations. It is widely claimed that the millennial generation, who are heavily influenced by social media and more predisposed to shop on-line, are more likely to place a higher weighting on ethical aspects of product integrity, particularly around animal welfare and environmental sustainability. A survey by market research company Retail Doctor (Lloyd-Wallis 2019) indicates 40% of millennials would not buy a product if it does not align with the credence values they aspire to. The research does not specify whether they would pay a premium for the credence values or simply avoid those products. The sentiment of the so-called 'ethical omnivore' cohort receives a large amount of attention in social and conventional media, to the point that many would think these views are mainstream. In reality, this is a small niche of affluent consumers who may well be willing to pay a premium for such factors, but the consultation with meat businesses and retailers for this study concluded that this is indeed an extremely small niche relative to the scale of meat consumed globally, and that it would be commercially unviable for mainstream meat businesses to service this cohort.

The available research assessing the propensity to pay more for enhanced product integrity in red meat is not sufficiently robust to counter the 'real world' experiences relayed in the feedback from the meat businesses consulted for this project. The industry stakeholders contend that the high level of confidence in processor trade brands and Australian country of origin provenance labelling provides adequate assurance to most consumers and customers of product integrity.

The logical conclusion to draw in relation to this proposition is that the level of demand from the very small proportion of consumers who are willing to pay a premium for enhanced product integrity in red meat is unlikely to provide an adequate commercial return on investment to large meat businesses to the extent that it justifies the significant capital investment, cost and increased complexity of operations. Smaller, more agile producers who are trading directly with niche markets comprising consumers willing to pay a premium, are able to fulfil the level of market demand. These boutique, vertically-integrated meat businesses are developing business models catering expressly to this cohort and servicing them via home delivery, farm gate or farmers market channels. For mainstream players, the product integrity component that is most important to consumers is implicit in the Australian product origin.

> **INSIGHT:**
>
> **There is no compelling evidence to suggest that mainstream consumer segments are prepared to pay a premium for enhanced product integrity. However, with increasing de-commoditisation and rising wealth, there is a cohort of niche consumers who may pay more for brands with differentiated attributes, but this market is likely to be much smaller than the claims being made.**
>
> **The premium paid for Australian meat in export markets is based on its Australian provenance, which underpins the integrity of Australian trade brands. There is little commercial incentive for most brand owners to invest in additional integrity over and above that captured in 'Brand Australia' unless they are marketing on a single point of difference such as 'organic' or some other quality attribute.**

9.3 Proposition 3: There are significant shortcomings in the product integrity systems of the Australian red meat industry

There is an implicit assertion inherent in the various industry research projects on product integrity claiming that it is a critical issue that needs to be addressed in the Australian red meat industry with some urgency. However, few studies support this call with a compelling evidence base.

Australia's systems and processes for product integrity and traceability are generally viewed as the centrepiece of the industry's competitive advantage in export markets. The Commonwealth Government's traceability study (2018) by the Traceability Working Group, quotes a global study (Charlebois et al 2014) that states *"Australia was considered to have strong livestock identification and traceability systems, however it was ranked 'average' across all commodities because the regimes were category specific and lacking an overarching framework.* Despite Australia's strong livestock identification system, the report ranked 11 European countries as superior to Australia on traceability systems for meat. The European Union traces meat back to the individually registered animals which is commercially feasible there given the smaller scale of operations. In the full report (Charlebois *et al*, 2014, p 1117), the point is made that Australia's ranking for electronic livestock systems is at the highest measure, 'progressive'.

The commissioning of many industry research papers on product integrity and traceability by the meat industry would in itself suggest that the current integrity systems in Australia require improvement, however, it must be remembered that it is the role of MLA and other industry bodies to continually review the adequacy of integrity systems and anticipate the industry's future needs.

The Australian red meat industry is comprehensively regulated and audited at every level of the supply chain through a combination of retailer quality and integrity frameworks, industry standards and government regulations. The Australian meat industry product integrity regime is underpinned by four pillars: the Livestock Production Assurance scheme (LPA); the National Vendor Declaration (NVD); the National Livestock Identifications System (NLIS); and the Property Identification Code (PIC).

Figure 1: Foundations of the industry product integrity system
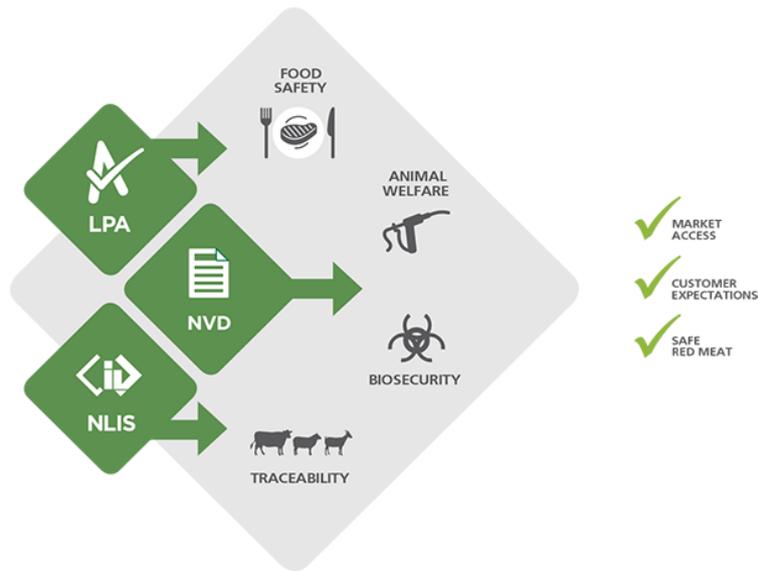
Source: Integrity Systems, MLA

While these pillars were intended to ensure food safety, animal welfare, biosecurity and reliable supply of safe red meat for Australian consumers, they also underpin the strength of Brand Australia in global meat markets by serving as robust integrity endorsements. Although these integrity systems are well-established, the industry cannot afford to become complacent, given that this is a critical element of Australia's competitive advantage and fundamental to the value proposition of Australian red meat.

Other add-on components of the national integrity systems in red meat include:

- The National Feedlot Accreditation scheme (an independently audited quality assurance program which covers virtually all lot-fed cattle)

- AUS-MEAT (an industry owned body which operates a uniform product description and quality assurance system). The uniform product description system is used as a universal language for meat trading at a trade level and has become particularly useful as a framework to enable on-line trading.

- Halal certification (a compulsory requirement for market access in most countries with large Muslim populations).

- Meat Standards Australia (a voluntary grading and branding system based around eating quality and fitness for purpose). A high percentage of Australian beef and to a lesser extent Australian lamb is MSA graded but not all MSA meat carries the brand.

- Livestock Transport Standards (a code of practice covering companies that transport livestock).

While some in the industry complain about the burden of compliance and the mandatory nature of the national integrity systems, collectively, these frameworks are the basis of Australia's competitive advantage in export markets because they have come to affirm customer trust in product integrity, particularly food safety. Unlike in other countries or industries where a national traceability system has been imposed on an industry by a negative event, the Australian red meat industry has been proactive in developing these foundations which have made Australia one of the largest and most successful meat exporters in the world. The report for the US beef industry by World Perspectives

(2018) estimates that approximately 61% of global beef exports come from countries with national traceability systems.

Despite the above initiatives and the high quality of Australian meat, consumer and customer expectations of product integrity is continually rising, and technologies are emerging to respond to this. In the consultation for this project, the providers of product integrity technology and services expressed the view that the red meat industry is trailing behind other food industries in the adoption of product integrity systems and processes. Therefore, it could be argued that customers, particularly supermarkets, are likely to raise their integrity and traceability requirements even further, driven by their experience with other supplier's adoption of emerging technologies. This means that the meat industry needs to continually monitor the latest technologies.

> **INSIGHT:**
>
> **The red meat compliance schemes imposed by government and customers ensure that product integrity in the meat industry is generally robust in Australia. However, as the technologies continue to advance and owning customer data becomes more important, global retailers will continue to tighten their specifications and blockchain-type systems may evolve into a mandatory extension of what is already a world class integrity system.**

9.4 Proposition 4: Consumers are demanding more traceability and information on provenance

There is an often-quoted market trend in the media and in conference presentations that increasingly consumers want to know where their food comes from. It is also a common topic of general discussion in the food industry's trade newsletters and forums. The claim is that consumers are seeking seamless traceability and whole-of-supply-chain transparency for the food they eat, particularly red meat. This assertion seems to be taken as being axiomatic and the trend widespread. The real test of this proposition, however, is the consumer's willingness to pay a premium for traceability, as has been questioned already in this document.

To a large extent, the view that the majority of consumers go to the trouble of checking the traceability and provenance of the meat they purchase, seems to be promulgated by proponents of farmers markets, artisan producers and movements such as 'Eat local', 'Slow Food' or 'Ethical Omnivore'. The sentiments are enthusiastically repeated in the promotional literature of the businesses selling product integrity technology and services.

As previously mentioned, the major Australian retailers interviewed for this study were strongly of the view that the vast majority of their customers have little interest in the mechanics of meat supply chains nor the explicit product origins because there is a high level of trust that the industry has tight systems and processes in place that are overseen by government regulations and audits. In fact, the retailers feel that most consumers would prefer *not* to know where their meat comes from. Undoubtedly, there is a segment of consumers for whom provenance is a major purchase driver, but according to the supermarket executives interviewed, the segment is small and not sufficient to justify higher levels of provenance branding. As noted, this smaller cohort is probably more likely to purchase meat through other channels.

A number of red meat brand owners have used or are currently using QR codes on pack that provide consumer visibility as to the region or the very farm from which the meat was supplied. This blockchain enabled tool is mostly used in on-line selling platforms. The experience of these parties is that only a small percentage (2% is commonly quoted) of consumers actually interrogate the QR code and in most cases, only once. For this reason, some of the parties had dropped the QR capability because it significantly added to cost and complexity with no resulting consumer or commercial benefit.

A study by Griffith University (authors not specified, 2019) commissioned by AMPC, aimed to assess the practicalities and benefits of implementing blockchain to provide full traceability to the primal level in the boning room. The ROI analysis conducted as part of the study was founded on the premise of achieving a price premium of 5 cents per kilo for the blockchain reassurance. The supporting analysis indicated a ROI of 1.85 cents per kilo could be achieved. Based on this conclusion, it would be difficult to mount a credible business case to industry for investment. Assuming that the average wholesale selling price of a primal is in the vicinity of $10 per kilo (a low estimate at the time of writing in 2020), this would represent a return of less than 1% per kilo. Given the cost of capital in a meat business is more than 12%, a ROI of this level would be uneconomic. Processors would also challenge the assumption of the 5 cents price premium achievable for blockchain verified traceability; the experience is that their customers will not pay anymore and would expect this as a condition of doing business if it was offered.

The Flynn *et al* (2019) report argues that investment in product integrity technologies to enhance traceability can create value for exporters in various ways through:

1. Increased sales through marketing the digital integrity system to improve brand perceptions
2. Improved consumer data
3. Assured social responsibility
4. Increased consumer confidence in the brand.

These claims are not strongly verified in the research and the improved consumer data can only be realised if consumers are incentivised to use the QR codes.

A final point on the issue of traceability/provenance is that expectations are increasing because of the capabilities of new technologies. The supermarket executives interviewed for this project indicated that they are continually seeking to review their traceability procedures because the potential for reputational damage to their brands with a food safety incident would be severe. The 2018 sabotage incident of needles appearing in strawberries brought the traceability issue into sharp focus in Australia, because it took several days to trace the cause. The Australian meat industry generally has a high level of traceability with the ability to trace back to the processing batch level within a short time. There is however, a blind spot in the visibility at the boning room where the link between the primal and the carcase is broken. This black spot does not seem to be an issue at this point in time, but this situation could change, as emerging technologies may in fact increase retailer expectations of achieving this.

INSIGHT:

Fully transparent traceability appears to be more of an issue for supermarkets and corporate food service brands than the vast majority of consumers. However, customer and consumer expectations are likely to grow with advancing technology and therefore, it is important that the Australian industry stays at the forefront to maintain the current level of competitive advantage.

9.5 Proposition 5: There is widespread fraud of Australian meat in global markets which is harming brand owners and the industry

Taking the literature scan conducted for this project at face value, fraud would appear to be a major issue for the Australian red meat industry, however the exporter experience of food fraud does not appear to be aligned with this view.

A report commissioned by FIAL attempted to assess the cost of food fraud to Australian exporters (McLeod, R. 2017). It estimated the value of loss to the red meat industry as being $272 million in 2016 /17 (ibid p 4). The estimate was based on a mathematical extrapolation that draws on very general data sources including percentages from international studies dating back to 1997 and 2007 (ibid, p28-29). Despite the author's earnest intentions to reach a useful conclusion, this figure is at best a highly educated guess and needs to be validated by the meat industry. To put this figure into perspective, it accounts for 1.4% of the gross value of the total industry.

Another study for RIRDC (2016) by GHD estimated the fraud situation in China and other unspecified Southeast Asian markets could account for as much as 6% of the value of the meat and live animal categories. The GHD study draws on the following quote as part of its evidence base:

 " . . . . it is estimated that about 750,000 tonnes of beef per year enters China through product substitution channels, with the illegal market estimated to account for about a third of beef sales in China each year (Alfred Chung, Executive Director, China Agribusiness Limited as quoted in Weekly Times Now, 2015)"

As re-quoted (GHD 2016)

These reports are continually being quoted by technology providers to justify claims about fraud being a major issue for Australian meets exporters.

The literature and promotional material from a number of technology companies highlights and attempts to quantify the extent of fraudulent claims of Australian provenance in red meat in a number of export markets, especially China. These claims conclude that fraud is a *"massive issue"* which should be of concern to the industry because it is a threat to industry brands as indicated in the following quotations.

 "Food safety and fraud concerns are massive issues, especially in places like China."
Beef Ledger Promotional Flyer

Global consultancy PWC are authors of the widely repeated industry claim dating back to 2015, that over 50% of the beef marketed in China as 'Australian' is in fact counterfeit. The PWC promotional

literature re-quotes a 2014 quotation from Professor John Spink, Director of the Food Fraud, Initiative Michigan State University:

"Food fraud costs the global food industry an estimated US$30 to $40 billion each year."
Professor John Spink
*As requoted by PWC (*https://www.pwccn.com/en/migration/pdf/fsis-food-fraud-nov2016.pdf*,*
2016)

The PWC reference that states that 50% of Australian beef in China is counterfeited is often repeated in industry communications and the promotional material of technology companies and although it is now somewhat dated, the figure persists and is widely requoted. The basis of the original research for the PWC claim appears to have come from a qualitative estimate as evidenced by this media quotation with one of the PWC researchers:

"Based on clients we have spoken to who are selling red meat into that market, based on distributors on the mainland and based on discussions with feed lotters serving the Chinese market, we have come up with that estimate — and it's probably a lowball estimate," he said.

Source: ABC News 2019 (abc.net.au)

Despite the strong and persistent claims of fraud, the majority of the meat companies consulted in this project repeatedly countered that, although counterfeiting of red meat probably does occur, they had little first-hand experience with fraudulent misrepresentation of their brands. The exceptions were two exporters interviewed who were exporting in retail packs who did report some brand fraud.

The confidence of the exporter position on fraud comes from the fact that there is little opportunity for product substitution or dilution because the vast majority of Australian product is sold to trusted customers, mostly through closed-loop supply chains, which are subject to rigorous inspection and audits. There is acknowledgement that the opportunity for fraud does exist in the fragmented supply chains where the product changes custody several times (e.g. product traded through wholesale markets or regional food service distributors or that sold through wet markets). Overall, this is seen to be a small proportion of the trade and exporters claim that if fraud is occurring in those channels, it is not particularly harmful to their business.

The market most commonly associated with meat fraud in both the literature and the industry consultation was China, but in the industry consultation, examples were cited of incidents in other markets including Vietnam and Indonesia. Fraud is almost unheard of in markets such as USA, Japan, Korea and Europe. It was noted in the consultation that fraudulent documentation, rather than product substitution can be an issue in the Middle East.

It must be noted that much has changed in the China market in the past five years. There has been a clamp down on corruption generally and trade through the grey channel is reported by many Australian exporting industries to be declining. The Chinese government has also tightened trademark protection in recent years. While it still remains challenging to register brands when entering the Chinese market, it is now becoming much easier to protect them. The Chinese courts have moved decisively on trade IP issues since the negotiations in their trade war with the USA and 75% of foreign entities challenging IP breaches in Chinese courts are now claimed to be winning their case (Tim Carroll, Australian China Health Accelerator, Global Table Presentation, 2019).

Brand fraud

Branding occurs at two levels in the meat industry, retail brands and trade brands. Retail brands are consumer-facing and predominantly exist on retail-ready packs. Trade brands only have visibility with trade customers.

Predominantly, Australian red meat is sold to the end customer in China under either the Chinese importer's or Chinese retailer's brands. Retailers prefer to sell under their own brands as a point of differentiation and to give them more market control and better margins. Only a minute proportion of Australian red meat is sold to the end consumer under Australian-owned and controlled, consumer-facing, proprietary brands. These products are largely sold in on-line or premium supermarket channels or to high end food service outlets where some brands may be listed on the menu. Australian brand owners are confident that there are few issues with their trade brands in export markets because they have total control and visibility of their supply chains at every point. The few experiences of fraud noted in the consultation for this project were with the Australian-owned consumer brands sold in China via local distributors, which would represent a relatively small market share.

One brand owner who routinely utilised a Google Alerts tool to identify if any of their brands were being advertised by on-line or retail outlets that they did not supply said that they only ever identified one incident in a food service outlet, which was soon rectified.

Although trade brand fraud is believed to be minor, when it does occur, it can cause collateral damage. An example was given of a case where a trade customer complained of overcharging on the basis that the Australian branded product was being sold to other customers at a discounted price. On investigation the brand owner found that his brand was being fraudulently mis-represented. This is of concern because it erodes confidence in their brand and the ability of exporters to attract a price premium.

Collateral damage to 'Brand Australia'

Of far greater concern to meat business is the actual or potential damage to the Australian provenance brand. Any erosion in customer and consumer confidence in the authenticity of the Australian provenance has the potential to dilute Australia's point of competitive advantage and ability to attract price premiums.

There is a high level of agreement in the industry of the critical importance of protecting the reputation of 'Brand Australia' but currently, fraud is mostly perceived an industry issue rather than a brand owner issue.

> **INSIGHT:**
>
> **The extent of provenance or brand fraud in red meat export markets is not verified conclusively. Because the claims of large scale breaches by technology companies do not align with the experiences of the majority of industry members, it will be important to validate the nature and extent of fraud in order to avoid unnecessary investment in mitigating a problem that may be overstated.**
>
> **In many export markets, integrity is not as secure as in the domestic market and the risk of an incident damaging Brand Australia is real, which then becomes an industry, rather than a brand owner issue.**

10. Untangling the technology web

10.1 Layers of integrity applications

The starting point for this project was to attempt to understand the range of integrity technologies on offer and their potential applications for the red meat industry. An MLA report which classified the large number of technologies on offer (Petty, 2020) lists 46 different technology providers offering products and services relating to supply chain integrity and there are almost certainly many others. In the course of researching this project, new products and services were appearing on the market regularly.

It is very difficult to classify the range of technologies in a simple and meaningful way because of the diversity in terms of the capability and functionality, but also because there is a high degree of crossover and interconnectedness. Elphick-Darling *et al* (2019) used the following six classifications of integrity systems in their catalogue of service provider product integrity systems:

1. Analysis for product authentication
2. Anti-counterfeit packaging
3. Anti-counterfeit labels
4. Labels for communication
5. Audit for integrity
6. Cloud / blockchain exchange of data.

RIRDC 2016 simplifies the classification of integrity technologies more succinctly into three categories:

1. Biological identification techniques (trace mineral markets, spectroscopic analysis, DNA)
2. Track and trace technologies (GS1 universal codes, GS1 Unique codes, RFID)
3. Anti-counterfeiting packaging and labelling (low tech, tamper-proof or embedded labelling).

The above classification has been based more on the capabilities or functionalities of the technologies and provides only a tentative understanding of their purpose. Reviewing the options from the perspective of their usefulness to red meat businesses, may be more helpful. In the absence of any 'off the shelf' holistic integrity technology solution for the meat industry, each business needs to build its own customised model. This invariably requires patching together a

number of components. Most customised systems are based on various combinations of the following five layers, depending on the required needs:

1.   Product authentication
2.   Verification and tracking
3.   Supply chain and inventory management
4.   Trading and marketing platforms
5.   Cold chain management systems.

Generally, integrity systems are built around blockchain or cloud computing platforms. The options are profiled in the following pages.

10.2 Product authentication

There are two scientifically proven technologies to verify product origin:

1.   DNA profiling

2.   Chemical Provenance Verification

DNA profiling

DNA profiling is a process of genetic tracing which can be used to verify the genetic basis of a living thing. In a meat tracing application it can scientifically prove that a cut of meat came from a particular animal to a high level of accuracy.

Some vertically integrated supply chain operators use DNA fingerprinting for the purposes of genetic improvement. It also has the capability of being able to track meat through the entire supply chain from a primal or retail pack back to a carcase. One of the meat businesses interviewed indicated that they had undertaken a trial using DNA tracing through the supply chain linked to a consumer facing QR code at the request of a major global retailer. Although this was operationally achievable, the program was put on hold because of low consumer uptake relative to the cost.

DNA tracing can be applied to verify the breed of a cut of meat, for example, in an instance where the Wagyu claim might be fraudulently used. DNA sampling was used in the early days of Meat Standards of Australia to protect against fraudulent misuse of the brand both in retail and food service channels. The original intention was that MSA would be a consumer facing-licensed brand (McKINNA *et al* was one of the joint developers of the original MSA concept). DNA tracing is no longer used by MSA because it has become essentially a trade level grading system, rather than a branding device, making it unnecessary to go to the cost of DNA sampling.

Chemical Provenance Verification

Chemical provenance verification provides forensic tracing of a product back to its geographic origins. Every natural product has a trace element fingerprint or isotope signature. All food products have a direct relationship with the environment in which they were produced, and it is reflected in the distribution of trace elements through absorption from the soil or water into the plant or feed intake. Trace element and stable isotope concentrations provide unique signatures that have been used to validate provenance claims and provide evidence-based support for case law.

This verification technique uses chemical analysis and isotope spectrometry to identify the key elemental markers of the product. The process provides a unique fingerprint that can prove the product's precise source of origin with granularity down to the paddock, pond, cage or shed. The trace elements are extremely stable and tamper proof. This means, for example, that a 100-year-old wine will still have most of the same trace elements as when it was produced that proves the terroir (provenance).

Chemical provenance verification works on the basis of comparing determined elemental distribution patterns against a database of reference patterns. The database is constructed by collecting reference samples from selected production locations.

There are two types of methodologies used, the most common one being Elemental Profiling and the more sophisticated Stable Isotope Ratio Analysis. The two analytical methods use different instruments, sampling methods and ultimately deliver different provenance determinations.

Stable Isotope Ratio Analysis is less costly and far more scalable but does not have the same level of granularity. Stable Isotope Ratio Analysis can determine provenance to a geographic level whilst Elemental Profiling, depending on the category, can determine provenance down to a farm of origin or even the precise paddock/shed/pond.

Another variation of the technology is trace labelling, whereby an artificial element is introduced (the equivalent of an invisible dye), which stays with the product and which cannot be tampered with.

The isotope methodologies are scientifically proven and have been successfully used to prosecute fraud cases in many different international jurisdictions. The technology is being used around the world to reduce the risk of:

- • product counterfeiting
- • product labelling
- • contamination
- • food terrorism.

Potential applications of tracing technologies to the red meat industry

Both the DNA and isotope tracing technologies are scientifically valid methods to conclusively prove the origins of a product. DNA tracing has potential application to brand owners who build their value proposition around specific genetic lines. The question is however whether it is worth the significant investment relative to the benefit. Those breeders who use DNA testing to trace favourable breed attributes back to a particular genetic line have already invested in the testing systems so could go to the next level of using it to detect brand fraud. This additional cost and effort could probably only be justified for super premium product. The bigger issue though is the cost of successfully prosecuting a fraud case, particularly in a foreign jurisdiction where the chance of success is very low.

DNA profiling has applications for breed associations to defend breed names such as Wagyu and Angus which are central to the value proposition for many trade brands and food service outlets. Without doubt, these breed names are being used fraudulently. Again, the question is whether it is worth the cost and effort to police and prosecute breed fraud when cases are detected.

DNA profiling has potential applications in tracing primals back to the carcase level, at present this is a black spot in the boning room. This has been successfully applied at a commercial level by at least one company. The question is whether customers will value this additional level of traceability to the point of being prepared to pay a premium for it. Industry experience to date is that this is not the case.

Isotope verification systems have application at an 'industry' rather than 'individual brand owner' level. The 'Product of Australia' provenance endorsement is a fundamental element in exporters achieving price premiums and where proprietary brands are traded, their value propositions are also heavily underpinned by the credibility of the Australian provenance. As such, systemic and ongoing fraudulent use of 'Brand Australia' on inferior red meat could erode customer and consumer confidence and compromise the ability to extract price premiums.

The reality is that the nature and extent of fraudulent misrepresentation of Australian red meat is not accurately known. Given the potential impact of fraud on the wider industry, it is important that the extent and source of it be quantified. Based on the experience of other industries, the elemental tracing technologies would appear to provide highly accurate and scientifically valid methodologies to quantify and define the problem.

Before going to the expense of introducing an on-going fraud detection system, it would be worthwhile for the industry to invest in a pilot trial to gain a better understanding of the nature and extent of brand fraud both at an industry and individual brand owner level. A pilot trial similar to those run by the farmed prawn and barramundi industries (see case studies in appendix) could be used to provide a preliminary snapshot to determine whether a more detailed investigation is justified. A tightly scoped study could be conducted (say one city in China) with a narrow range of beef cuts, working with two or three Australian exporters. It may also be worthwhile to include some proprietary branded product to assess whether brand fraud is more common on retail branded products from Australia. The trial would not only assess the level of fraud but more importantly identify where and how it is occurring.

10.3 Verification and tracking

There is a suite of integrity technologies and systems that protect, verify and trace meat products as they move through the supply chain. Variously, verification and tracking systems are designed to serve a number of purposes:

- To enhance the level of consumer and customer trust
- To reduce the risk of counterfeiting and fraudulent misuse of labelling
- To support supply chain management and documentation
- To track the product as it moves through the supply chain
- Facilitate faster and more efficient product recall
- Provide a means for the marketer to connect with their customers and tell their product stories and receive customer feedback.

10.3.1 Common components of verification and tracking systems

The range of verification and tracking technologies on offer have varying levels of functionally with many suppliers providing an integrated package. Product verification and tracing systems generally involve five components which are explained below:

1. Reliable and secure object identification
2. Data capture
3. Data storage
4. Data-processing
5. Data identification and presentation.

Reliable and secure object identification

All verification and tracing systems are based around a secure labelling method, which usually entails a unique digital code. The more sophisticated labelling involves verification technologies and devices such as encryption or anti-counterfeiting digital fingerprints affixed or embedded in the products in some form. The method of attaching the label to the product varies according to the category and product format but may include a sticker, label, a seal, laser engraving/ printing or smart tags which offer various levels of functionality.

With most verification and tracking systems, the brand owner is issued with an encrypted private key code which in turn can generate public key codes that are permanently affixed to each traceable unit, as listed in the register. Once the shipment is packed, all bundled codes related to the shipment are activated and the tracking begins.

The technology around smart tags is evolving rapidly, for example, there is a new generation of smart tags being developed which will be able to capture a wide range of data including location, temperature, custody, movement, shock and drop or presence of light and gas. Most of these high-tech solutions, often referred to as the 'Internet of Things' (IoT) because they connect to internet based platforms, were first developed for highly secure environments such as passports and currencies but are increasingly being adopted by agrifood businesses with high value products. Most of the systems are developed to GSI standard (a global standard for barcodes).

One of the companies at the forefront of smart tag technology offers a smart tag that can be embedded into the product in some way via the carton, label or packaging through a customised engineering solution. The system is powered by a proprietary, highly functional, low-cost microchip that will enable customers to capture and action time sensitive IoT data by unit, carton or pallet. Despite the small physical size of the device (6 x 6 mm), it can be leveraged with miniaturised sensors and other components and it does not risk being removed/displaced from its asset. This technology provider is developing reusable and reprogrammable IoT devices that can capture detailed information about the asset condition at every point in the supply chain. These tracking devices need to be approved by the airlines and the size of the device battery is a critical issue for airline approval.

The Rock lobster Industry is using a tamper proof smart tag which is attached onto the live lobster's horns by the fisher at the point of capture and which stays with the product literally to the table in fine dining restaurants. Fraudulent mislabelling is common for this highly prestigious seafood. The patent-pending smart tag is tamper evident and can be easily applied one-handed by a fisher, even in wild seas. It can withstand salt cold water for lengthy periods of time while the live lobster is in tanks and yet still present as a luxury item within a 5-star restaurant environment. The technology can be customised with the capability to monitor location, temperature and more (see case studies).

Data capture

Most of the tracking devices can capture data in transit which can then be translated through some form of data reading technology ranging from handheld scanners, cameras over conveyor belts, gantries or other devices or smart phones. Increasingly this data is uploaded to a blockchain or

cloud-based platform from the IoT device. Most data capture is through API (Application Programming Interface) software, a software interface that allows two applications to communicate.

Data storage

The myriad of technology devices are enabling data capture to move from paper-based systems to blockchain or cloud platforms. Blockchain is a secure distributed ledger system which is not modifiable once the data is uploaded. Cloud computing is a network of remote servers hosted on the Internet to store, manage and process data, rather than on a local server or computer. The cloud hosting enables much larger volumes of data to be stored.

Data processing

Many technology service providers offer customised software to process the data captured so it can be used to develop customised control points and artificial intelligence capabilities. Checks and balances and deviation tolerances and protocols are coded into the system to alert supply chain members with time sensitive information at critical control points. For example, some systems can automate product recall pathways and be programmed to respond to certain scenarios e.g. in the event of a cold chain disruption or shipping breakdown, alerting the product owners to find alternative solutions.

Data identification and presentation

Data identification and presentation enabled by the product integrity technologies can be customised on a 'fit for purpose' basis for improved information management. Customised dashboards can assemble and prioritise information to provide a high level of visibility of the measures of most importance to the business. Increasingly, developers are moving to smart phone-based data presentation systems which provide readily accessible data to customers, supply chain partners and consumers in their hand, wherever they are. Many B2C businesses are applying QR codes that can direct consumers to their website allowing them to tell their product story.

Many of these integrity systems have antifraud functionality, for example, the QR code can only be activated once, at which point it becomes disabled. Most QR codes are attached to a unique URL address which becomes void once scanned and cannot be used on another label. Some systems can provide data on the geographic location where the code was scanned.

These devices also provide a means of gaining customer feedback and market intelligence. For example, a Tasmanian cherry exporter marketing gift packs on-line found the market data enabled by this device to be extremely valuable. By learning where and when the gift pack was being opened and the QR code activated, they were able to target future marketing and prioritise geographic distribution programs.

The brand owner can selectively provide access to all or parts of the dashboards to other actors in the supply chain who can access it via computer or smart phone. This visibility encourages a spirit of transparency and shared responsibility.

10.3.2 Use of verification and tracking in the red meat industry

All Australian red meat products are identified by a unique barcode on the traceable unit (live animal to carcase, carcase to carton and in some cases, carton to retail pack). All cattle and sheep carry an RFID readable NLIS ear tag linked to a unique PIC (Property Identification Code). Movement of livestock at every stage must be recorded in the NVD (National Vendor Declaration) which also

includes basic data about the history of the animal. Many producers subscribe to Stockbook, a mobile application for real time collecting, viewing and managing data on all animals.

Data from the NLIS ear tag is scanned at the point of slaughter and then carcase tags are automatically generated. The data on these carcase tags is in turn transferred to carton labels, through manual or automatic scanning devices. The data can be downloaded to fulfil the various compliance documentation requirements.

The Australian meat industry integrity system provides traceability from the farm through to the customer, which is a major source of competitive advantage in export markets. The blackspot in the capability is in the boning room at the points from carcase to primal to carton, because each carton contains primal cuts from several carcases. Although the capacity does exist to trace back to the primal level, this is not being commercially used to any extent because of the cost and the fact that there is no apparent customer need or demand.

The use of blockchain or cloud based anti-fraud and traceability systems in the red meat industry to date has been minimal although there are a number of companies now developing systems as outlined in the following case study.

Application in Macka's Australian Angus Beef

Established in 1884 Macka's is a fourth-generation meat producer marketing premium, MSA graded Angus beef to high end customers in Australia and export markets. Macka's has experienced product fraud in China firsthand, which threatens to erode its brand credibility and dilute its premium pricing (see full case study in appendix). The fraud stems from the fact that Macka's is distributing products with clear provenance branding on the packaging through multiple distributors in China.

In response to the fraud issues, Macka's is currently piloting a blockchain-based, end-to-end, 'paddock to plate' product integrity system with a verification device. The system is being designed to provide three layers of protection by using encryption, tracking and blockchain technology. After investigating several systems to defend against the counterfeiting, Macka's chose to work with technology provider Aglive to develop the system (which is still in development) on a blockchain platform. Macka's has recently completed an air and sea freight trial shipment to Shanghai, in partnership with DB Schenker and Cathay Pacific, which has had support from MLA, (the results of this trial will be evaluated by Macquarie University and were yet to be released at the time of writing). The data inputted at each custodial change in the supply chain is loaded onto the blockchain platform and supply chain partners with the correct permissions can track progress through the supply chain on the Aglive monitoring dashboard. On receipt of the product, the end user can then use the free Aglive app on their smartphone to verify the authenticity, check that the ID has not been used by another party and confirm that there have been no anomalies in the supply chain.

KEY OUT TAKES: Verification and tracking

It is likely that customers, particularly global supermarket chains, will progressively raise their expectations and requirements with respect to verification of product integrity as the technology evolves and becomes more widely adopted. In time, these verification and tracking systems are likely to become standard practice and a condition of supply agreements with major supermarkets and corporate food service customers. As such, Australian red meat businesses will need to start doing some groundwork to better understand the technology and assess the systems which best meet their needs.

10.4   Supply chain and inventory management

Many of the companies interviewed for this project were researching product integrity technologies for the purposes of more than just ensuring traceability. Managing the increasingly complexity of export supply chains is requiring more technological horsepower than ever. Meat exporters need to process more data, more quickly and track a wider range of inventory across a broader global market with real time access to the information.

In simplified terms, supply chain management in the meat industry involves knowing where the product is at any point in time, in whose custody is it is in, its current temperature state and being assured that its authenticity, branding and labelling is not being compromised and that the documentation is current. Although this sounds relatively simple, supply chain management entails a higher level of risk when a multi-million-dollar inventory is being handled by third-party providers. Asset owners have limited control and visibility of their product as it moves through the journey to the customer.

Global supermarkets and food service providores are drivers of change contributing to much of the complexity in modern supply chains. As these customers move to long-term supply arrangements whereby they source from a limited number of preferred suppliers based on negotiated agreements to deliver a specified quality of product, to a mandated time schedule, within a delivery window of minutes, to a designated location, on a scheduled basis, with an agreed pricing formula that takes into account market price variation. The meat supply chain is also particularly long given that premium beef exports are grain fed for up to 350 days. This lead time, plus the seasonal variations inherent in agribusiness make scheduling and managing inventory extremely difficult. Supply chain inventories also require large amounts of working capital, which usually necessitates external finance.

The complexity of red meat export documentation adds to the challenge

Exporting any fresh agrifood commodity entails significant documentation, dealing with multiple parties, each with their own requirements and systems. In red meat exporting there are a large number of variables which need to be aligned, including but not limited to:

- Scheduling production
- Managing the large range of cut configurations and specifications (commonly product configurations are customised to a particular customer's specifications)
- Marketing and packing under a range of brands which are often customer-owned brands
- Selling to a large number of customers

- Customer specific product and shelf life labelling
- Dealing with the market access compliance documentation for multiple countries, each of which has distinctly different requirements (export documentation is critical, one small error on a form such as a misspelt word can result in the delay or loss of a shipment worth many thousands of dollars)
- Managing a range of product shelf life requirements and regulations for each market and customer
- Meeting the compliance requirements and documentation for endorsement bodies including organics, Halal, etc.
- Managing sea and air freight schedules, bookings and paperwork to minimise freight cost and transit time
- Invoicing under a wide range of trading terms
- Managing a customer data base with many foreign company and stakeholder names
- Dealing with a range of foreign currencies which fluctuate daily.

One small error or misalignment in any one of these variables can result in damaging and costly disruption.

Most supply chain management systems still require manual processes

Even in today's world of digitisation, most red meat supply chain management systems still require paper processes and manual data entry because the various inventory, supply chain and sales systems are not compatible. An increasing amount of data is being captured by digital devices, yet the market and business analysis that could be extracted from processing and cross-referencing this data is not leveraged.

Managing the paper trail associated with export supply chains is extremely labour intensive, even in some of the largest and more sophisticated meat exporters, requiring a costly back office staff.

The manual administration of this documentation also introduces the risk of human error, which can have major impacts.

There is a Lack of connectivity between systems

Most third-party providers have their own Enterprise Resource Planning (ERP) systems but unfortunately, when it comes to applying them to a blockchain or other common supply chain management platform, most systems are not compatible with each other. Even when companies are using the same system (e.g. SAP), they invariably use different account names, descriptors, currencies, languages and definitions for essentially what is the same product. The inability of these systems to seamlessly communicate with each other significantly increases the administrative workload and increases headcount because the data has to be uploaded and manipulated manually. Importantly, valuable data which could enhance product integrity and improve efficiency is lost because of the technological communication gap.

Financing inventory requires significant working capital

Meat exporters require a significant amount of working capital to fund the amount of inventory being held in the supply chain at any given time. The extended time delay between the farm and the end customer (which is particularly long for a grain-fed, exported product) adds to the cost. The

issue is that the value of the inventory grows exponentially at each point in the supply chain. For a large meat business, the value of inventory tied up within the supply chain at any point in time can amount to millions of dollars.

Meat inventory financial products tend to be very siloed with different financial institutions offering products specific to a particular point in the supply chain (e.g. on-farm versus product in the chiller). Financial products are available up until the point of processing and from when the product is loaded at the port/airport. The finance gap is from the point of processing to the point of shipping - at present no financial products exist for this part of the supply chain. Financiers have traditionally been reluctant to finance this stage of the inventory because it is difficult to account for the product when it is highly mobile and its value can be impacted by any number of unpredictable market or production factors. Financiers require robust reporting systems with immutable evidence of the nature, location, custody and value of inventory, which to date, has not existed to the level required to satisfy the financial industry. Integrity systems now offer the potential to deliver just that.

Blockchain as a tool for supply chain and inventory management

Argyle Foods Group, who featured in one of the case studies for this project (see appendix for full case study), is going to significant lengths to develop a supply chain management system customised to its needs. After an extensive search, Argyle elected to partner with KPMG and build a system around the KPMG Origins agnostic blockchain platform, which is a generic distributed ledger system applicable to most agrifood products. Apart from streamlining management of the supply chain, Argyle needed a system that could provide verified traceability so that it can guarantee the provenance of its product to its end customers, who are largely supermarket groups in Asia and the Middle East.

The KPMG traceability platform enables data sharing in a trusted environment with transparent governance and is being developed with the intention of being adaptable for any agrifood supply chain. The platform is a data ledger stored on blockchain that captures existing data from supply chain partners. Basically, it assists users to standardise, collate and share data.

This traceability solution reduces the amount of work required by each party by providing a standard for each supply chain partner to integrate their data with. The standardised data set is easily sharable. The blockchain traceability solution is able to collate multiple data points from different sources, which when combined, can be used to assess the integrity of the information (e.g. combining data from an ERP and IoT device to check that they both have a common location). The Argyle application of this system will start with the NVD and the NLIS, which with the integration of the 'Stockbook' livestock management tool, will provide a comprehensive profile of the history of the animal, including feed inputs and veterinary treatments. The Argyle solution will be designed to utilise existing standards such as NLIS, MSA and GS1, which is the global traceability standard required by major supermarkets.

Argyle management note that the challenge in developing the system has been to satisfactorily connect data along the supply chain due to a lack of standardisation. A blockchain system relies on a common language because each supply chain partner has their own company ERP system which uses unique language.

In Argyle's case, each product shipment will be tracked through the supply chain using a data capture IoT tracking device, which will capture a time, temperature, location, custody and cold chain

integrity score. All of this data will be uploaded to the blockchain traceability solution via the IoT device. This provides real time visibility of the location, custody and status of the product.

One of the distinguishing features of blockchain is the ability to independently verify the product status outside of the supply chain partners' own ERP systems and with minimal human intervention. The IoT tracking device provides a data set completely independent of the various ERP systems. It also provides the ability for customers and supply chain partners to independently check the status of the product in the supply chain. Importantly, a blockchain platform cannot verify data, it is totally reliant on the accuracy of the data provided and inaccurate data cannot be corrected once it is on the blockchain.

KMPG is currently collaborating with financiers to implement permissioned sharing of inventory data from the traceability platform that will enable financiers to create data-driven finance solutions by proving the value and the location of the inventory. For Argyle, this will enable increased access to working capital from the point of processing to shipment.

The Argyle system also has the potential to deliver improved shelf life outcomes. By applying an algorithm developed by MLA/UTAS that gives an accurate prediction of shelf life based on temperature history in transit, it is possible to accurately predict the shelf life of red meat (Lyons *et al*, 2020). With that knowledge applied to the system's data set, an improved inventory and shelf life management capability will be possible, which will reduce wastage and improve profitability.

Further to these operational benefits, the intention is to also introduce an AI scenario planning capability into the system which, as an example, could be used to find alternative pathways for a shipment in the event of a disruption in the supply chain, or indicate the optimal way to replenish stock after a food safety recall event. AI scenarios can be worked into the system to advise exporters on the implications of a wide range of possibilities.

The realm of possible applications for a supply chain integrity system such as the Argyle project extend far beyond traceability and are even broader than those outlined here. For example, blockchain can also build in additional functionality such as B2B or B2C trading platforms as outlined in the Two Hands case study (see appendix).

There are 'data' rather than 'technology' driven solutions for enhancing integrity

Meat exporter OBE Organic has taken a completely different approach to applying enhanced product integrity systems to its supply chain. Unlike Argyle, which needed an holistic supply chain verification and inventory management system, OBE Organic's focus was on integrating its internal data systems to improve management of the highly complex documentation trail inherent in exporting to a large number of customers across many markets, trading a range of organic and Halal certified products. Managing the documentation for dealing with multiple freight companies, the many different protocols and reporting requirements for each country, the complex shelf life regulations for each market, plus the added layer of complexity relating to the management of organic certification required many manual processes that increased the risk of human error. The lean back office team was becoming overwhelmed with the bureaucracy associated with all of the above.

With assistance from MLA, OBE Organic spent a large amount of time and resources working with a start-up technology company to design a tailored blockchain solution to addressing the complexity and risk associated with its documentation. After persevering for a number of years on this project, OBE Organic management reached the conclusion that blockchain was not addressing the core

problem and that the provider was designing an over-engineered solution to problems that the company did not really have. It appeared that this blockchain offering was primarily focused on product verification and mitigating fraud, which in reality, was not a problem with the customers OBE Organic was trading with. They felt that blockchain was more applicable to high-value designer goods and for large, well-resourced manufacturing companies and as such, it was far too complex for a smaller meat company which relied on being agile and responsive.

OBE Organic's other concern was that blockchain is heavily reliant on the honesty of individuals within its third-party partners over whom they had no control. Because of OBE Organic's highly fragmented supply chain, the majority of its product was handled by importers and distributors in each market over whom they had limited visibility. A further problem is that the various ERP operating systems used by its partners were not compatible with each other, meaning that the data would have still needed to be manually uploaded.

In addition to the need to streamline documentation processes, one of the biggest challenges for OBE Organic is managing its inventory and cash flow. It needs to know the location, custody and status of all products at every point in the supply chain. All meat exporters carry a high level of risk including commercial trading risks, cold chain breakdown, price volatility (both on the supply and demand side), exchange rate risk and more. OBE Organic's risk profile is amplified by the fact that it is a trading company that outsources all of its operational functions. This limits its ability to share in the total profit pool. Where an integrated business can take a margin at each link in the chain, thereby spreading risk, OBE is limited to the trading margin so accounting for inventory and managing cash flow is key.

After concluding that blockchain was not the ideal solution to its needs and conducting further research, OBE Organic developed a relationship with BSM Global (BSM is an acronym for Buy Sell Move), a software development and support service company that develops customised solutions for holistic export trade management. OBE Organic has been working with BSM for seven years to enhance its export trading management platform. OBE Organic is using the BSM system for order management, documentation and compliance, managing shipping bookings, tracking of shipments, invoicing and exchange rate management.

BSM works with its clients to develop customised software systems to integrate data from existing sources. The company develops tailored, cloud-based software systems that captures and manages data from a range of sources to provide a high level of visibility and functionality across the entire supply chain. The BSM system is akin to a 'big data' network whereby data is centralised and used to add functionality and depth of analysis, whilst at the same time providing a means to cross-check information from multiple sources. For example, by integrating with a shipping company's software, the BSM system can provide real time tracing of containers, cost and make freight bookings, manage documentation such as bills of landing, check currency fluctuations and more. There is also the option to integrate real time data logger devices. The BSM system makes all this data accessible on a user-friendly dashboard for easy analysis and tracking.

As required, the BSM system can develop solutions to manage the entire export trading process including but not limited to:

- Manage customer database
- Demand planning
- Order creation
- Create contracts

- Shipment planning, schedules and rates
- Export documentation
- Logistics planning
- Compliance
- Shipping documentation flow
- Customer communication
- Tariff rates
- Reconciliation and freight management
- Product tracing
- Customer order status reports.

The BSM system is reliant on the cooperation of the supply chain partners such as processors, shipping and transport companies, etc. Most of the major shipping companies are willing to be a part of the system because it benefits them as well.

One of the biggest challenges reported by OBE Organic, has been to integrate the various ERP systems being used by supply chain partners. There is a vast amount of highly valuable information from supply chain partners that was not accessible with a paper-based system. This challenge is a work in progress.

Unlike blockchain systems the BSM system does not provide product verification or authenticity of provenance, which is not a significant issue for OBE Organic. However, by being able to verify the location and custody of the product by cross-referencing the various data sources, it does provide a means to flag irregularities.

The BSM system could readily be integrated into a blockchain system but both BSM and OBE Organic do not believe that this would add any value, at least at this point in time. (See appendix for full case study)

KEY OUT TAKES: Supply chain & inventory management

The comparison of the Argyle Food Group and the OBE Organics journey towards enhanced integrity highlights the fact that meat businesses need to find a customised solution that fits their individual needs and priorities and that there is no 'one size fits all' solution. Business managers will be rewarded for spending time and resources to find the optimum combination of technologies, devices and systems to construct a 'fit for purpose' system.

Integrity technologies and systems have the potential to provide some powerful benefits to supply chain and inventory management including:

1. **Far more comprehensive and timely management information**
2. **Improved risk management due to a far greater level of real time visibility of inventory**
3. **Higher levels of confidence around provenance and product authenticity**
4. **The ability to reduce administrative head count by automating systems**
5. **Reduced risk of human error which can have dire and costly consequences**
6. **The ability to have timely access to working capital by providing a secure document trail which satisfies financiers.**

10.5   Blockchain and cloud computing

Most supply chain integrity and management technologies use either blockchain or cloud computing as platforms to store and manage data. Both are Internet-based platforms but with quite different functionality and purpose.

Blockchain described

Blockchain is an immutable, digital ledger comprising a series of files linked together by encrypted codes which are duplicated and distributed across the entire network of computers in the supply chain. It is a system for recording information in a way that makes it difficult or impossible to change, hack or cheat. Blockchain is purely a platform to securely store, compile and manage data, it cannot generate data and is totally reliant on input from other devices and systems. In this respect, the often used descriptor of blockchain as *'a single source of truth'* is misleading as it relies on data from several sources and does not verify the data inputted. Essentially, blockchain platforms allow digital information to be distributed but not copied, which means that each individual piece of data can have only one owner and can only be updated by consensus by all participants in the system.

Cloud computing described

Cloud computing is a remote, shared storage device where data and programs are stored over the Internet instead of on individual computers or local servers. Cloud services provide scalability and can be used on an 'as required' basis and with payment on a usage basis. Authorised parties can get access to cloud-based applications, increasingly through smart phone applications.

The security of cloud computing is a little different from any other computing or data environment. However cyber security specialists generally believe that the cloud is more secure than local

computer servers because it is managed by data specialists, operates under strict protocols certified by independent specialists and third-party auditors and operates an elaborate system of firewalls.

10.5.1 Applications of blockchain in the red meat industry

A number of red meat businesses are working on the development of blockchain-based systems to manage supply chains and product integrity systems for various purposes. Many more indicate that they have assessed blockchain to varying degrees and have decided that it was not appropriate to their business at this point in time. The consultation for the project indicates that there is a high degree of cynicism around blockchain in the industry, which may to some extent be attributed to a lack of understanding of its purpose and functionality.

Blockchain offers three core functions that could be of value to meat businesses:

  1.   Product verification through tracking each point in the supply chain
  2.   Supply chain management and inventory monitoring
  3.   B2B and B2C trading platforms.

The functions of blockchain for product verification and supply chain and inventory management have been discussed already in this document.

Two of the meat businesses profiled in the case studies, Macka's and the Argyle Food Group are developing blockchain systems that integrate all of the above three functions to create a holistic operating system. Another business, Latitude 28^0 has been working with the support of MLA to develop a B2C marketing platform targeting high-end consumers in tier 1 cities in China using a B2C blockchain on-line marketing model.

10.5.2 Two Hands blockchain marketing platform

Two Hands is a recent start-up company specialising in servicing food service supply chains in China with premium seafood and other proteins. Two Hands, is partnering with Aglive and other IoT providers to develop a secure blockchain platform focused on the high-end hotels and restaurant channels. Aglive is a specialist agrifood supply chain software provider which develops customised blockchain systems.

The Two Hands marketplace is a blockchain-based trading and marketing platform which facilitates a direct relationship between the seller and the buyer. The commercial arrangements such as pricing and trading terms are by arrangement between the buyer and seller and the supply chain risks remain with the seller. Two Hands' revenue stream comes from charging a commission, deducted from the payment by the customer for facilitating the trade. Similar to specialist marketing platforms such as AirBNB, the Two Hands platform is totally transparent to all actors. The other key point of difference in the Two Hands platform is that it takes a number of steps out of the supply chain, increasing the producer's share of the total profit pool. The product is only touched by two hands as the company collects the product on arrival at the airport in China and delivers it directly to the five-star restaurants. Two Hands estimates supply chain cost savings of around 20%. The technology also has the capability of managing the complex array of documentation that comes with export trading, further reducing administrative costs.

Although the Two hands model is a B2B marketing platform it has the potential to also provide a direct connection with end consumers. For example, with lobster, a product verification smart tag is attached to the lobster's horns at sea which carries a QR code that can be scanned with a smart

phone at the restaurant table taking the diners directly to the seller's website. This allows the seller to tell a story about their product and its provenance. It also offers a market research opportunity by providing instant market feedback. The URL address is immediately made void once scanned the first time so that the tag cannot be fraudulently applied to another inferior product.

Macka's is soon to trial marketing its premium Angus beef on the Two Hands platform. The shipment will be monitored throughout the journey using a tracking device from technology company SensaData, who customise integrity systems to capture detailed information about the asset condition at every point in the supply chain including location, temperature, presence of gases, shock and drop, light and pressure. These are small (6 x 6 mm) reusable and reprogrammable IoT devices that are embedded into the product in the carton or package through a customised engineering solution.

Trading on the Two Hands blockchain marketing platform will provide a number of advantages to Macka's beyond fraud mitigation (see appendix for full case studies).

10.5.3 The potential benefits of blockchain trading platforms

Blockchain B2B and B2C marketing platforms have the potential to open up another market channel for premium, high value retail or food service red meat products. The potential benefits include:

- **Enhanced product integrity through improved visibility and transparency**: this can add incremental value to customers such as global retailers or hotels, which is likely to lock in loyalty. The improved verification reduces the risk of reputational damage to all Australian meat.
- **Reduced supply chain costs**: shipping directly from the supplier to the customer reduces the number of product movements and the associated administrative costs.
- **Increased share of profit pool**: with traditional supply chain structure, up to 50% of the profit pool is distributed to supply chain intermediaries (see profit pool analysis later in this report), whereas with a blockchain trading platform, some links in the chain are eliminated.
- **Reduced exposure to product damage in transit**: a direct to customer model reduces the handling and therefore the exposure to product damage and compromised supply chain environments.
- **Improved cold chain integrity:** the integration of cold chain monitoring IoT devices with the blockchain platform allows supply chain partners to identify anomalies and deviation from ideal conditions, which together with the application of artificial intelligence, can mitigate risk and identify and rectify areas of weakness.
- **Increased transparency**: every party, right through to the end customer, can have visibility of the product on the platform. Permitted supply chain parties can know what the product is, where it is and what state it is in.
- **Stronger customer relationships:** this stems from the blockchain enabling a direct, two-way communication channel. With the use of QR codes, blockchain provides a powerful marketing platform for the brand owner to tell their story, enhancing the consumer experience and building brand loyalty.
- **Market research and customer feedback**: market signals can be immediate and frank, directly from the diner's table and the producer is less reliant on market signals that may have been diluted or manipulated by distributors

- **Reduced chance of corruption:** The visibility of this system reduces the opportunity for corrupt practises such as kickbacks and disproportionate gifts within hotel and restaurant kitchens, a practise which the owners of international hotel brands are keen to stamp out.
- **Prompt payments and the virtual elimination of bad debts**: depending on the trading terms, with blockchain the invoice is paid once the customer scans the agreed documentation. With high value products such as premium red meat, this has considerable implications for cash flow and working capital.

There are of course disadvantages with a blockchain marketing platform such as the Two Hands model for exporting, including reduced responsiveness due to the loss of the warehousing function or reduced economics of scale, so this model is not appropriate for most meat businesses.

10.5.4 The challenges of developing blockchain systems

Notwithstanding the potential benefits of using a blockchain platform to trade direct to customers, the implementation of a blockchain system is complex, can be costly and requires a large commitment. Many of the red meat processors consulted have looked at blockchain to various degrees and most have either decided to not proceed or have put their plans on hold because of the cost and complexity relative to the benefit. A comment many concurred with was that *"blockchain solves problems we don't have"* in reference to the fact that it is largely viewed as a traceability or anti-fraud mechanism.

Blockchain platforms have been more commonly applied to more homogenous categories, which have far simpler, ambient temperature supply chains and less market complexity (e.g. designer apparel, electronic goods), which are far less complex than meat.

10.6 Cold chain integrity and its implications

Investment in new technology solutions for the purpose of enhancing the integrity of cold chains does not appear to be high on the agenda for most red meat businesses. Cold chain integrity is after all taken as a given because it is a core function of running a meat business. In contrast, other perishable food industries regard cold chain management as a first order issue. For most, the focus has shifted from 'food safety', to 'shelf life management' and 'reduced wastage'. Yet the burden of wastage as a result of compromised cold chain integrity is arguably proportionately greater for businesses in the meat industry, given the heavy exposure to export markets where the risk of cold chain breakdown is significantly greater and the consequences more dire, due to the high product cost.

There is a hidden cost of sub-standard cold chain management systems (e.g. wastage, price markdowns, compromised shelf life and more), which is not being factored by many meat business operators.

10.6.1 Varying perspectives of the supply chain actors

The research for this project has highlighted a significant disconnect between the views of red meat processors, supermarkets and cold chain integrity technology and service providers on the issue of cold chain management. These views are profiled in the following paragraphs.

The processor perspective

Processors are confident that their systems and processes are sound, being subject to multiple third-party audits by customers and government agencies. To the extent that they do monitor supply chains, it is largely, to support claims and assign liability in the event of a breakdown. Common practice is to use passive data loggers as a risk management device in the event of a breakdown to transfer and prove liability against other parties, usually the transportation and shipping companies. Loggers seem to be used on most but not all shipments. These data loggers are only recovered and downloaded in the event of an incident, because of the cost and effort of recovering the unit.

The industry consultation for this project indicates that the prevailing view is that most of the breakdowns are due to mishandling in transit or at the customer end, beyond when it is in their control or responsibility. This is legally the case for FOB (FCA) trading terms where the custody changes when the product is delivered to the point specified in the contract. Cold chain integrity is problematic in many export markets due to poor infrastructure, climate extremes and lack of skills, systems or processes in cold chain management. Cold chain integrity breaches are more frequent in the developing markets that are transitioning from frozen to chilled meat formats. Exporters indicate that chilled meat handling practices in some markets is quite primitive with product exposed to ambient temperature for extended periods, refrigeration not being set at the optimum temperature and poor inventory management.

Exporters also report regular issues with use-by dates with many customers believing that the product should remain in good condition until the expiry date, regardless of how the cold chain is managed. As a precaution, exporters indicated that they are deliberately putting a shorter expiry date on their export products. This practise is creating tension with customers who are demanding extended shelf life coding. It is also problematic in some markets where a minimum shelf life is a mandated protocol on entry.

Although it may well be true that exporters are not at fault, ultimately the exporter carries much of the burden of cold chain breakdown and shortened shelf ultimately impacts on the profitability at all levels of the supply chain.

The supermarket perspective

The retailers consulted in this study confirmed that management of shelf life is a first-order performance indicator for supermarkets because of its capacity to impact their own brand image, but also because of its major impact on profitability. The value proposition of retailer brands, particularly premium supermarkets, is built around fresh food departments because this is a critical point of differentiation between brands. For example, the Woolworths tag line, 'the fresh food people' expresses this focus on freshness and many supermarkets apply variants of this proposition as a brand differentiator. A food safety incident can do irreparable damage to a supermarket brand, from which it can take several years to recover, illustrating why supermarkets take food safety so seriously.

An increasingly important driver of supermarket interest in shelf life is because inventory management is a key profit driver. Globally, supermarkets are investing heavily to improve shelf life through refrigeration systems, inventory control, supply chain management and staff training, to reduce wastage. Profitability is significantly eroded when supermarkets need to discount product as it approaches the end of short shelf life. Red meat packs with short use-by dates are very difficult to sell because of shopper concern about food safety; consumers closely observe the use-date of

perishable products and commonly throw out food at home which is close to or over the date. This can impact their willingness to buy as much on the next shopping trip.

Industry research shows that a high percentage of meat is thrown out by consumers when it actually in prime eating condition because of the use-by date or because it looks dark or has a lot of drip in the tray. This presents an unsolved challenge to the industry.

The service provider perspective

Cold chain technology and service providers are of the view that the red meat industry is significantly behind other perishable food categories in terms of adopting active real time cold chain system to improve the efficiency of cold chain management, shelf life and reduction of wastage which is a major cost burden on the industry. In their view, perishable food categories such as dairy and produce are much more advanced in cold chain management and have shifted their focus from food safety to waste reduction, shelf life improvement and efficiency improvement. According to the technology providers, only a small number of red meat businesses are using the real time monitoring technologies and then only for pilot trials.

It is the opinion of cold chain technology providers that meat businesses do not see the value of technology products and services in improving supply chain efficiency and integrity and ultimately, customer satisfaction.

There has been a complete pivot in the relationship between perishable food companies and cold chain providers in other industries, from adversarial to collaborative on the basis that cold chain management is a shared responsibility. A central element to this collaboration is proactive information sharing and transparency enabled by real time, active data loggers which clearly indicate when there is a compromise and which party has custody at the time. Trials conducted in other categories which have been profiled in the case studies appended to this report clearly show that there are compromises occurring at every level.

10.6.2 The shift in focus from food safety to shelf life and wastage

Cold chain management has taken on greater importance for perishable food companies because of the sheer cost of inefficiency. The cost of food wastage is also driving perishable food companies and their cold chain suppliers to move from a 'risk management mindset' to a proactive and collaborative 'process improvement mindset'. The driving force of this change in mindset is the realisation that ultimately, the cost of wastage is worn by the supplier, even if it occurs in the retailer's custody.

For highly perishable food categories, a breakdown in the cold chain imposes significant food safety risks. However, what is becoming more important is the wastage issue, because a small cold chain compromise that does not jeopardise food safety, can still impact shelf life, necessitating wastage and price discounting when product gets close to the use-by date. This latter factor is being heavily driven by the major supermarkets where the continual need for price discounting is eroding profit margins, the cost of which they are passing on to suppliers. For perishable foods, supermarkets typically factor an additional margin of around 10% to cover mark downs and wastage which dilutes their profit.

10.6.3 The critical importance of a 'whole of chain' view to cold chain integrity

By definition, cold chain involves several links where the custody of the product changes. These changes in custody usually coincide with a change of transport mode where there is a risk of temperature being compromised (e.g. when a container refrigeration unit is unplugged in transit).

The focus for cold chain management systems now is one of a 'whole of chain' view that proactively and positively engages each link in the supply chain and motivates all actors to assume responsibility while the product is in their custody. Central to this is the importance of providing full visibility of the temperature state to all parties through accessible, real time data sharing.

Any cold chain compromise at any point has a cumulative effect. Furthermore, if a breakdown occurs at any point it cannot be safely rectified. Recognising the shared responsibility of cold chain integrity, the major suppliers of refrigeration services and products and leading perishable food companies have formed the Australian Food Cold Chain Council (AFCCC), which serves to advocate and drive innovation and compliance to reduce waste and improve food safety in Australian food cold chains. Effectively, this has stimulated a change of philosophy regarding cold chain management from an adversarial to a partnership approach. The intent of the AFCCC is to embrace all stakeholders in the cold chain, sharing responsibility for the outcomes in recognition of the fact that although custody and responsibility changes several times, the final outcome is a reflection of their collective behaviours. The AFCCC has also fostered an industry-wide culture of continuous improvement. Central to continuous improvement is the critical importance of sharing information and providing all parties with complete and open visibility.

10.6.4 The link between temperature and shelf life

There is scientific evidence of the direct relationship between temperature management and shelf life indicating that any deviation from the ideal temperature range at any point in the cold chain significantly reduces shelf life. In the case of the red meat industry, this claim has been proven in the research by University of Tasmania and MLA (Kaur *et al,* 2018), which scientifically verifies that optimum cold chain handling can significantly extend shelf life. Increasingly, meat exporters are applying the algorithm identified in this study to set use-by dates.

10.6.5 Emerging cold chain management technologies

The capabilities of the active data loggers are continually evolving beyond time, temperature, location and custody. Cold chain monitoring and management technology is advancing rapidly. The emerging generation of data logging technologies will be capable of monitoring more than temperature to include humidity, shock and movement, light, atmosphere including CO_2 levels (important for a shipment of full carcases) or the presence of other gasses. This can be done in real time and can record and alert the time and place of opening the container. These systems will be able to be customised for each commodity.

Such data can then be interrogated to identify critical control breakdown points and the knowledge gained can be applied to improve cold chain integrity as well as other aspects of supply chain management. The latest devices also offer the potential to employ artificial intelligence to actively instruct actors in the cold chain if something goes wrong. The technology can also be used to monitor the performance of distribution partners.

The enhanced information will provide stakeholders with a comprehensive picture of the product as it moves through the cold chain. As these technologies advance, their cost is coming down. Essentially, there will be *'nowhere to hide'* for any player in the new age of cold chain management, demanding best practise from all.

10.6.6 Current cold chain practices in the red meat industry

Sea freight

Exporters take due care to ensure the cold chain integrity up to the point of delivery to the customer or their agent, as per the trading terms. With FCA trading terms (FOB in previous incoterms lexicon) being common, the ownership, and therefore the chain of responsibility for the exporter, ends at the point of delivery to the customer's freight forwarder at the port or airport.

Standard practice on exports is to include a passive temperature data logger in each container, which cold chain service providers are concerned provides a poor level of coverage because of the large amount of variation that exists within a container.

Airfreight

Complaints and claims relating to cold chain breakdowns are said to be far more common with air-freighted, chilled product, where meat is exposed to ambient temperatures for extended periods in transit or when the plane is not at cruising altitude.

The cold chain for air freight is more complex and with more hazard points because the product is shipped in cartons or carcase bags to the freight forwarder for packing into air containers. The types of containers used and the source of cooling and insulation varies from refrigerated containers, insulated containers, ice packs and dry ice (when allowed by airlines). At best this reduces the temperature variation but generally the temperature is above the ideal for much of the journey.

Air containers can be exposed to ambient air for extended periods before and after the flight during loading, particularly if there is a stopover or transhipment. Most airlines have a two hour deadlines before flight cut off time for delivery (for budget carriers the cut off time is 4 hours) and similarly, there is an extended time lag at the destination for unloading.

Air cargo holds are not refrigerated and rely on the low temperatures during the time when the aircraft reaches cruising altitude to maintain low temperatures. The captain has only very limited ability to control the temperature of the cargo hold and needs to accommodate the mix of cargo which may include everything from frozen foods to live animals.

Table 3: Cold chain hazard points of vulnerability

Sea freight	Air freight
- Temperature of the product at the point of loading - Temperature of the container just prior loading - Temperature of the container on transit to the port - Time that the container is unplugged from the refrigeration unit at the point of loading - Efficiency of the ship's refrigeration unit	- Temperature of the stock when leaving the exporters premises - Temperature of the transport vehicle to the airport - Choice of air container (refrigerated/insulated/dry ice/gel packs) - Temperature environment at the point of loading the container

• Time that the container is unplugged from the refrigeration unit at the point of unloading • Temperature of the container on transit from the port to warehouse • Temperature controls at the point of unpacking the container • The temperature environment at all points beyond this to the retailer or restaurant	• Time lag and temperature in transit, loading onto the plane, and when the plane reaches cruise altitude • Temperature of the cargo hold • Time on the ground if there is a transhipment • Time and temperature on the ground at destination • Temperature environment at all points beyond this to retailer or restaurant
The processor/ exporter has no direct control over any of these hazard points beyond the point where the container leaves their loading dock at which point it is in the hands of the logistic providers. Unless real time data loggers are used, they have no visibility and therefore ability to take action to rectify any problems during the journey. With passive data loggers the data cannot be extracted until the end of the journey when the damage has already been done.	There are many more cold chain hazard points with air freight compared to sea freight because the product is exposed to ambient temperature for extended periods as indicated above

10.6.7 The hidden cost and impact of compromised supply chain integrity

Substandard cold chain management is a significant and largely hidden burden on the red meat industry. There are a number of dimensions to this including:

1. Wastage and price markdowns
2. Insurance cost
3. Transport cost
4. Potential impact on market access
5. Supply chain inefficiency

Wastage and price markdowns

The true impact of poor supply chain practices appears to be underestimated by the red meat industry. The red meat industry tends to consider wastage in terms of claims made by customers as a sunk cost and, given that common practice is to insure against this risk, that cost is therefore counted as the insurance premium. What is not usually factored, is the allowance made by supermarkets and major food service customers for wastage and price markdowns at the end of a product's shelf life. For perishable foods, including red meat, supermarkets typically factor an additional margin into their trading terms (usually in the vicinity of 7 to 15%) to cover price mark downs. Ultimately this cost of doing business erodes the profit pool which is shared at every level of the supply chain.

Red meat companies accept trading terms as an unavoidable and something over which they have no control. There is not yet a recognition by the industry that there is an opportunity to address the issue. Given the size of the Australian meat industry, collectively this cost burden is very high. A report commissioned by DAWE and Refrigerants Australia (Expert Group, 2020, p5) estimates that 3.5% of annual red meat production is wasted in the supply chain due to cold chain breakdown. This wastage amounts to 155,000 tonnes, with an estimated wholesale value of $670 million. To put this

into context in terms of this product integrity study, this figure is substantially greater than most of the estimates of the cost of fraud.

The potential exists for the red meat industry to recoup a significant part of this cost through getting on board with the new collaborative culture and adopting a 'whole of chain' approach to cold chain management.

Insurance cost

Poor shelf life management is resulting in escalating insurance premiums which, again, given the volume of meat traded, collectively amounts to millions of dollars per year.

Common practice when there is a customer claim is to pass this on to the insurer rather than attempting to investigate the cause and make try to gain compensation from the defaulting party. Exporters report that it is becoming extremely difficult the prosecute a claim against shipping and airline companies and freight forwarders because of the difficulty in proving fault. Increasingly logistics businesses are becoming more risk averse with more restrictive clauses in their contracts meaning that the burden of risk is falling back onto the exporter. This situation has got to the point where third-party logistics providers are absolving themselves of risk, except for when there is a blatant breach. The rising cost to logistics companies has been reflected in increasing industry insurance premiums, which must ultimately be factored into the profit and loss equation for all actors in the chain.

Transport cost

Improved shelf life has the potential to substantially reduce transport costs to some markets by making sea freight a feasible alternative to airfreight. This is particularly the case for distant markets such as the US with extended shipping times, where an additional 7- 10 day can make the difference between the feasibility of sea freight over air freight.

The new active, real-time cold chain management technologies coupled with the application of shelf life algorithms can greatly enhance the ability to confidently extend and manage shelf life. These technologies provide comprehensive data which allows far more accurate calculation of shelf life, providing confidence to the customer.

Potential impact on market access

Some markets, such as the Middle East countries, stipulate a minimum shelf life as a condition of market access. In some cases, Australian exporters find it difficult to meet these shelf life regulations with sea freight. Real time temperature management technologies have the potential to provide scientific evidence to support a case to extend shelf life to the extent of gaining market access and saving freight costs.

Supply chain inefficiency

A by-product of the 'real time' monitoring technologies is their potential to improve supply chain efficiency by providing an accurate understanding of the location, temperature state and custody of the product at any point in the supply chain. Knowing where the product is, who has custody of it, its temperature and other attributes, will enable better planning and management of inventories and logistics capacity. Improved efficiency has positive flow impacts on cost. The improved visibility of inventory also enables better management of cash flow.

10.6.8 Shelf life management is a major issue in emerging markets

Cold chain integrity is problematic in many export markets due to poor infrastructure, climate extremes and lack of skills, systems or processes in cold chain management. Cold chain integrity breaches are said to be more frequent in the developing markets that are transitioning from frozen to chilled meat formats. Exporters indicate that chilled meat handling practices in some markets is quite primitive with product exposed to ambient temperature for extended periods, refrigeration not being set at the optimum temperature and poor inventory management. Exporters also report a regular issue with use-by dates with many customers expecting that the product should remain in good condition until the expiry date, regardless of how the cold chain is managed. As a precaution, exporters indicated that they are deliberately putting a shorter expiry date on their export products to avoid risk. This practise is creating tension with customers who are demanding extended coding.

The shelf life issue will escalate in importance as some of these emerging markets gradually transition from frozen to chilled product.

10.6.9 Barriers to adoption of cold chain integrity technologies

Compared to other perishable food categories, the red meat industry has to date, been far less inclined to embrace the new and enhanced cold chain management technologies. This may to some extent, be due to the fact that food poisoning is a lesser risk in red meat because the odour makes the meat inedible well before it poses a risk. Furthermore, for this reason supermarkets to date have put their focus on other high-risk factors. Supermarkets are able to pass the cost of shelf life price discounting back to suppliers through trading terms.

To date the meat industry has not recognised the other cost reduction and efficiency gains from enhanced cold chain management.

The major barriers to the adoption of smart cold chain technology by the red meat industry is said to be cost and the fact that they are satisfied with current systems. However, according to the providers of the integrity technologies, this situation is anticipated to change as customers become more aware of the capabilities and value of these technologies. They anticipate that in future, customers may stipulate the adoption of the smart devices as a condition of future supply agreements. Furthermore, the functionality of these technologies is expanding, and cost is continuing to come down through innovation, which would improve the business case for adoption.

KEY OUT TAKES: Cold chain integrity and shelf life

The conclusion to draw from the above commentary is that poor cold chain practices right through to the end of the supply chain are diluting meat industry profit margins by a large amount each year, which is absorbed as a sunk cost. Although much of the breakdown is occurring when the product is in another party's custody (where the exporter has limited control), ultimately, it is the seller who wears most of the reputational risk. The financial loss is also apportioned down along the supply chain, based on relative market power.

The impact of compromised cold chain integrity is a substantially higher cost impost than most of the estimates of fraud in the industry. The relative slowness of the red meat industry to adopt emerging cold chain monitoring technologies also comes with a large opportunity cost including the following benefits:

- It accurately identifies the points of breakdown, which can the focus the area of investigation
- The information is visible immediately as the problem occurs, allowing swift action while there is still time
- The data trail provides a scientifically valid basis for accurately and confidently predicting and managing shelf life with the flow-on benefits that come with extended shelf life
- Real time data capabilities are a powerful tool for facilitating collaborative 'whole of chain' continuous improvement.

There would appear to be a compelling business case for MLA to invest in projects or commercial demonstration trials to build awareness of the benefits of emerging cold chain technologies and the potentially large paybacks.

11. The commercial reality of investing in product integrity

The bar is continually being raised in relation to product integrity

There is a strong expectation among meat businesses that there will be increasing pressure on them to continually invest in upgrading their product integrity systems and processes. This pressure is most likely to come from customers rather than consumers - in particular, the global supermarkets and major food service brands will be across every opportunity to continuously improve. The impetus for 'lifting the bar' will certainly be technology driven because as the functionality of technologies advance so to do customers' expectations.

The recent food safety incident of needles in Australian strawberries, exposed the vulnerability of supermarkets to shortcomings in their traceability systems. Best practice in traceability is digital tracing to the carton level within minutes. Although the traceability systems for red meat are generally good and few have experienced large scale problems to date, they fall short of the rising standards of international supermarkets because most are still paper-based. Supermarkets demand a response to a traceability issued within minutes.

Enhanced product integrity is in itself unlikely to generate incremental value for the brand owner

The analysis presented throughout this report strongly indicates, that although consumers and customers are likely to favour a product with stronger integrity credentials, only a small percentage are willing to pay significantly more for it because, in the domestic market, consumers have a high level of trust in the integrity of Australian red meat and take this as 'a given'.

In most export markets, Australian red meat achieves a significant premium over and above identical products from other supplier countries because buyers have confidence in the Australian provenance. The extent to which individual brand owners achieve an incremental premium over and above that generated by the Australian origin, is predominantly due to attributes other than integrity such as quality, service levels, etc.

Higher product integrity levels generated by investment in integrity systems such as blockchain may provide brand owners with a competitive advantage, but the experience is that this advantage manifests in ways other than price premiums, e.g. improved customer loyalty.

It is expected by most red meat exporters that some customers will progressively require higher levels of product integrity and traceability as a condition of their supply agreements, but the belief is that they will not pay for the improved integrity.

The message that comes through clearly in a number of case studies appended to the report is that investment in product integrity technologies comes at a cost to the business and as a consequence, businesses need to gain benefits other than product integrity to justify their investment. Those businesses investing in integrity technology are building their businesses cases around the other benefits that flow from the technology such as improved supply chain efficiency resulting in cost reductions, the ability to gain working capital to finance and inventory, improved profitability from B2B or B2C trading or the flow on benefits from extended shelf life. The clear message here is that red meat businesses must be able to identify a tangible additional benefit to justify their investment or otherwise the introduction of the enhanced technologies will simply dilute profitability.

Because trust in the integrity of Australian red meat is a pivotal element of the Australian competitive advantage in international markets, which in turn underpins the value of individual brands, there is a strong business case for industry level investment in maintaining or improving product integrity in line with the rising customer expectations.

'One size fit's all' does not apply to supply chain technology solutions

It is apparent from these case studies that the needs and priorities of red meat companies with respect to technology solutions vary greatly between businesses depending on their product range customer base /markets, business model and resources available. The motivations for investment in technologies vary greatly, requiring quite different mixes of functionality and application of technologies in multiple ways to solve distinctly different problems.

The experience of all companies consulted is it is necessary to do the research to develop a customised solution, which often requires piecing together a number of components from multiple providers. This involves a large amount of time, effort and cost. A suite of technologies that work for one meat business will probably not be suitable for another.

There is no 'plug in and play' option

There is no such thing as an end-to-end, 'off the shelf' solution to product integrity for red meat businesses. The first challenge is to determine the right combination of components, which in itself is a complex task as there are countless service providers offering different answers, often overpromising on what they can deliver and commonly underestimating the complexity of red meat supply chains.

The interviews with meat businesses suggest that the motivations for investment in technologies vary greatly, requiring quite different mixes of functionality. The biggest challenge, as emphasised in the case studies, is to connect the components, which usually have their own operating systems and languages which are usually not compatible with each other. Most of the case studies profiled for this research were in development and still grappling with this compatibility problem.

It is apparent from developing the case studies for this project that a considerable amount of groundwork needs to be done to adapt whatever technology platform is selected, not just to customise it to deliver the solution required, but also to harmonise the various data sets. In some cases, businesses have found it necessary to develop their own technologies to fill gaps.

A further important lesson flowing from the case studies is the critical importance of designing the right 'fit for purpose' system from the outset because wrong choices can be very costly. The search for the right combination of technologies can be frustrating. There is a myriad of technologies on offer, each offering a range of functionality, from a large number of providers, all of whom make strong claims around the features and benefits of their particular systems. Evaluating these technologies is extremely challenging as they tend to be technically complex. Very few have been developed specifically for the meat industry. Most are generic systems which were conceived for other industries with far less complex product mixes and supply chains.

As some businesses have found, making the wrong decisions on such technologies can be very costly and a number interviewed had abandoned the system after a considerable investment of time and resources because it did not satisfactorily deliver to their needs. The other risk is that it such systems can be very costly to modify once they are in place.

Technology is a journey not a destination

The adoption of any technology is an on-going journey, and this is no less the case for technologies applying to integrity systems for red meat supply chains. Technology, almost by definition, is a dynamic phenomenon, forever evolving, with each new iteration providing increased capability and functionality beyond the previous version and usually at a lower cost. The bar is continually being raised in terms of customer and consumer expectations of levels of verification or authenticity, visibility and cost reduction because of the improved functionality of the technology. In this situation, the failure to keep up with the rapidly emerging technologies means that the meat industry is falling further behind.

Blockchain is not an integrity system - it is a platform

There appears to be a widely held misconception that blockchain provides a complete, end-to-end verification and supply chain management solution in its own right, which is not the case. Blockchain is a distributed ledger platform that holds and transfers information in a secure way and does not generate or verify data. It is a repository of information collected through other means. Blockchain

platforms require connection with other devices and technologies. The three case studies applying blockchain examined in this study (appended to this report) are each using it in a very different way for a very different motivation, linking to a very different set of IoT devices.

Proponents of blockchain promote the platforms as providing 'a single source of 'truth'. This is only the case if all of the information loaded into the blockchain is correct and verified by some other means. The claim of a 'single source of truth' is only true to the extent that once the data is in the system it cannot be altered.

12.   Supply chain mapping

The purpose of this section of the report is to map out a number of representative supply chains for red meat in order to identify the critical hazard points in terms of the potential for integrity breakdown; the typical chain of responsibility; the chain of communication; and the likely impact.

A number of supply chains were mapped in the process of researching this project, not all of which are presented here. This background work showed that there is high degree of commonality across many supply chains, meaning that there is little point in profiling them all. The examples profiled here have been selected to illustrate a range of product integrity scenarios, including:

1. Chilled beef to domestic supermarkets
2. Chilled beef to Japan
3. Chilled beef to China
4. Chilled beef to Indonesia
5. Chilled lamb to the USA

Each sample supply chain provides details of the traceability and integrity factors including:

- the unit of traceability
- the identification devices
- the country of origin branding
- the product branding.

The chain of responsibility and the assignment of risk in each supply chain is specific to the negotiated trading terms. The commentary focuses on highlighting the key differences and nuances for each supply chain mapped

12.1 Supply chain structure in the Australian meat industry

Foundation integrity systems common to all supply chains

The product integrity systems at the beginning of every meat supply chain in Australia are common to both domestic and export markets. The building blocks of the Australian product integrity system are the National Livestock Identification System (NLIS), the National Vendors Declaration (NVD) and the Property Identification Code (PIC) as discussed previously. These elements provide the cornerstone on which other category specific accreditation schemes are added such as those specific to feed lots, Halal certification or organic. AUS-MEAT and MSA are voluntary systems (although AUS-MEAT accreditation is mandatory for export abattoirs and boning rooms), but commonly referenced in quality assurance and accreditation schemes.

All meat processing and value-adding plants are registered and inspected by State Government food regulatory agencies that scrutinise all food safety aspects of operations. In addition, export works

are subject to certification and inspection from the Federal Government Department of Agriculture, Water and Environment (DAWE). All export meat products carry an export certification label with an associated paper trail. In addition, some importing countries have their own inspection and audit document trails and some of them have inspectors based in Australia.

All of the above systems are subject to third-party audits, which gives them a high degree of credibility, particularly in export markets. The systems are harmonised and collectively build upon each other, providing a seamless and highly credible integrity system.

Trading terms

Understanding the impact of trading terms on the supply chain maps is important. Trading terms determine the chain of custody and responsibility along the supply chain. The burden of commercial liability and risk for both domestic and export trades is specific to the trading terms negotiated.

The trading terms in the domestic market are subject to negotiation and mostly bound by common-law contracts. Trade with the major supermarkets and corporate food service companies and providores tends to be based around long-term supply agreements that stipulate in detail quality standards, codes of practice, delivery requirements, payment terms and dispute resolution mechanisms. Commonly, the service agreements include discounts for prompt payment terms and build in an allowance for wastage.

Incoterms, the trading language for international traders, instruct each party in an international transaction with respect to the carriage of goods from the buyer to the seller, confirming who is responsible for export and import clearance. They also explain the division of costs and risk between parties and are used a basis for payment. Incoterms are defined by the International Chamber of Commerce (ICC) and are updated periodically to reflect changes in trading practices. In effect, these terms form the basis of international treaties and agreements and are recognised in courts of law or trade arbitration panels in the jurisdictions of most trading partners. There are two sets of Incoterms one which covers all forms of transport and another specific to ocean freight.

The trading terms referred to in the Incoterms range in the level responsibility from EXW (Ex-Works) where the buyer assumes the full costs and risks including loading from the point of destination, through to DDP (Delivered Duty Paid), where the seller bears responsibility to the point of unloading in the destination country. The Incoterms are usually overlaid with specific terms or clauses in trading agreements.

Although Incoterms define the legal chain of responsibility along the supply chain during the physical movement of the product, they do not ensure the integrity of the product in terms of quality, provenance, authenticity or adherence to best practice cold chain management. In this respect, the relationship is reliant on trust and a track record of performance. Notably, sellers believe they have completed their obligations once the agreed trading conditions have been reached even though the impact of any breach runs the risk of causing reputational damage to the seller (or the industry at large), right up to the customer's experience.

12.2 Supply chain 1: Chilled beef to domestic supermarkets

Figure 2 below outlines a supply chain map based on the Australian domestic supermarket trade for consumer-ready packed, chilled beef. It is based on prime quality beef, 70-day grain fed, which is the basis for most supermarket prime cuts. Virtually all of the supermarkets have predominantly gone to

a case-ready system whereby product is sliced off premises by third party suppliers and packed and labelled in shelf-ready packs. Supermarkets account for close to 70% of red meat sales in Australia.

The standard practice for Australian supermarkets with prime quality beef is to take control of the supply chain from the farm right through to the store through closed-loop supply chains. Supermarkets develop programs with a small number of suppliers with whom they have long term service agreements.

In most cases, supermarkets source cattle by contracting feedlotters to supply finished cattle to their specifications/standards. The product is service killed and then sent to a slicing and retail packaging plant. All of the above functions are outsourced to third party providers on a fee-for-service basis and are subject to audit trails. Supermarkets do this for two reasons:

1. To give a high level of control over the supply chain
2. To reduce supply chain cost.

In addition, they also source carton beef to supplement their supplies directly from processors. Because of the need to balance supply with demand (some cuts are more popular sellers than others), and also because of the need to offer attractive price specials, which generate high volumes of sales, they also buy stock through saleyards as required. Most of the meat sold in supermarkets is under one of the retailer's own brands or proprietary brands, over which that supermarket usually has exclusive rights.

Supermarket: Product integrity and verification

Because supermarkets control the entire supply chain with tightly managed third-party suppliers who are monitored through stringent audit trails, there is little room for compromise in product integrity. Effectively, supermarkets own and have full visibility of the product through the entire supply chain.

Supermarket: Traceability

The product is traced from the farm through to the boning room using a RFID ear tag on the live animal then a carcase tag applied on the slaughter floor. Carcases are then processed and primal cuts from a number of carcases go into a single carton, which is then given a carton label that designates the batch. At this point, the traceability from the carcase to the primal is lost in most cases. Cartons can be traced back to the kill shift at the abattoir, but not to the individual carcase. There are some emerging technologies which allow traceability from primal back to carcase, but it appears that none of these are being commercially used at this point because of their cost and the complexity that they add to the process.

Common practice is for processors to work in a system where similar types of cattle (often only from small number of properties) are processed in one shift. This means that it is usually possible to trace a carcase back to the farm level, or at least narrow the source down to a small number of farms or smaller group of carcases, depending on the circumstances.

Supermarkets are striving to improve their traceability systems in light of recent food safety incidents in some agrifood categories. Their ideal is to be able to trace back to the source with a high level of granularity within minutes through a digitised system.

Beyond the boning room, supermarket retail packs carry a unique bar code label that links back to the carton, which in turn links back to the batch level, but not the carcase.

Some of the larger global supermarket chains have reportedly introduced blockchain to streamline their traceability systems and there is an expectation from processors that it is inevitable that Australian supermarkets will follow this trend at some point in time.

Figure 2: Supply chain for chilled beef to domestic supermarkets/consumer ready

BREEDING		PROCESSING			SUPERMARKET SUPPLY CHAIN		CONSUMER
Cattle Producer	Feedlot	Slaughter	Chill	Pack	Value-added processing	Retail delivery	Retail display
Steers and heifers sold to feedlotters direct or purchased by feedlotters from saleyards.	Steers and heifers on feed for 70 days, 300k to 450kg				Vacuum packed primals, value-added. Bulk crated fresh deliveries, sorted and valued.	From value-adder to retail store or to central supermarket DC	Packaged meat display, consumer ready.
	Consistent carcase weight, age, meat and fat colour, minimal marbling	\<td colspan>Service kill - with credits for items not retained by supermarkets			Value-adding: primal cuts sliced for steaks, diced. Beef primals and trimmings minced. Sausages. Marinating. Corning. Kebabs.		Retailers with fresh meat cutting - vacuum packed primals sliced and prepared for customers
					Branded package types; modified atmosphere, skin pack, vacuum packed.		
ADDITIONAL / ALTERNATIVE SUPPLY CHAIN							
		Primal cuts purchased from processor/exporter to top up requirements and add diversity to product range (e.g. heavier marbled, grain-fed, organic).			Prepared and branded by value adder.	From value adder to retail store or to central supermarket distribution centre	Packaged meat display, consumer ready.

UNIT OF TRACEABILITY

	BREEDING	PROCESSING	SUPERMARKET SUPPLY CHAIN
UNIT	Live animal	Carcase / primal / crate	Cartons/crates to retail packs
DEVICE	RFID Ear Tag PIC	Carcase tag / label	Carton barcode · Retail barcode
ORIGIN	Australian		
BRAND		Processor trade brand	Retailer or processor brand

AUSTRALIAN INTEGRITY SYSTEM

LPA
NLIS
NFAS
HALAL
AUS-MEAT
MSA
DAWE
TEMP CTR

Source: McKINNA et al

12.3 Supply chain 2: Chilled beef to Japan

The Japan supply chain example profiles 200-day grain-fed, full sets of beef that are sea freighted to Japan and sold to supermarkets and food service outlets.

In Japan, 200-day grain-fed beef is considered to be a midmarket category, which is popular in Japanese supermarkets and mid-tier food service restaurants. The premium segment is dominated by 300 to 400 day imported and local beef, which is mainly sold through premium outlets and the highest levels of food service outlets.

Compared to Australia, the Japanese supply chain is complex and convoluted with additional links in the chain including the trading house, which acts as the import agent, primary wholesalers and often several links of distributors. Trading houses are large conglomerates (known as Zaibatsu or Keiretsu) which are essentially agents that manage the import process, documentation and customs clearance, as well as logistics from the port. They also provide finance, acting as intermediary between the exporter and the primary wholesaler.

Commonly the imported meat is handled by several layers of wholesaler/distributors who value-add the product on behalf of the supermarkets. In some cases, some Japanese supermarkets have their own central processing facilities. Most of the retail-ready processing occurs in Japan, because the Japanese consumers, unlike their Chinese counterparts, have a high level of confidence and trust in local processing. There is also trust in Australian product by the Japanese consumer, but they prefer to have the product value-added in Japan.

Food service outlets either prepare their own products from primals or buy from a plate-ready wholesaler or value-adder who slices the meat and delivers it to the restaurant on a daily basis.

Japan: Product integrity and traceability
Product integrity is robust at the Australian end of the supply chain because the product is in the hands of the processor until the container is sealed. This verification is endorsed by the processors trademark and a number of critical markers of product integrity including the DAWE export certificate. Furthermore, each carton contains a GS1 barcode which provides traceability back to the batch level.

The potential point of vulnerability in terms of product integrity in this supply chain is with a wholesaler or value-adding partner who could theoretically have the opportunity to substitute the product. However, in practice, the risk of substitution is very low because the value-adding process is subject to third-party audit by the supermarkets and also the Japanese Ministry of Agriculture Forestry and Fisheries (MAFF).

Japan: Branding
The majority of beef in Japanese supermarkets is sold under the reseller brand but with strong Australian country of origin branding. Country of origin branding is compulsory in Japan and subject to inspection by the Japanese MAFF. Regardless of the regulations, Japanese supermarkets are keen to promote Australian country of origin because of the high level of trust by the Japanese consumer.

Figure 3: Supply chain for grain-fed chilled beef to Japan/200 day chilled, full set

	BREEDING		PROCESSING					EXPORT/IMPORT					WHOLESALE		RETAIL			CONSUMER
	Cattle Breeder	Feedlot	Slaughter	Chill	Boning	Pack	Cold Storage	Export consign-ment	Export documenta tion	Export transport	Importer customs clearance	Transport importer's cold store	Further processing	Transport delivery	S/market depot	S/market store	S/market display	Consumer purchase
	Angus feeder steers breed and grow to 300kg	Angus feeder steers on feed for 200 days	Slaughter floor	Side/quarter chiller	Boning room	Packing room	Carton chiller	Cartons secured in container	Consignment export documentation including packing list, health certificate	Container trucked to wharf, on board ship and shipped to destination port	Customs clearance, truck transport arranged by importer	Container receival and cartons discharged to chiller	Cartons sorted by cut for customer (retail/ food service). Cartons opened, product further processed, branded and repacked. New barcode	Load consignment, deliver and unload at retailer depot	Cartons held in central chiller ready for distribution to individual supermarkets or directly delivered to individual supermarkets	Cartons opened, vacuum packed primals, sliced and prepared for retail display. Retail ready items placed on display	Cartons held in chiller awaiting use	Customer selects retail pack from supermarket shelf. Pack scanned on sale.

UNIT OF TRACEABILITY

UNIT	Live animal		Carcase		Side/quarter	Primal	Carton	Sealed container					Branded units					
DEVICE	RFID Ear Tag PIC		Carcase barcode label		Barcode label	Branded bag & label	Carton label	Consignment label and barcode					Barcode					
ORIGIN	Australian																	
BRAND								Processor trade brand					Japanese supermarket brand					

AUSTRALIAN INTEGRITY SYSTEM

LPA																		
NLIS																		
NFAS																		
HALAL																		
AUS-MEAT																		
MSA																		
DAWE																		
TEMP CTR																		

Source: McKINNA et al

12.4 Supply chain 3: Chilled beef to China

China has been profiled as a sample supply chain because the analysis suggests that this is the market where product integrity is the greatest issue. The example mapped here is frozen forequarter cuts, which are mostly sold through wholesale channels and wet markets.

As is characteristic of China, the wet market supply chain for red meat can be quite fragmented with product passing through several points of custody, making it vulnerable to substitution and fraudulent mislabelling. This is why the global and on-line retailers work with closed-loop supply chains.

The product is labelled as being of Australian origin on arrival and the processor brand is strongly featured up to the point of sale where the product is sold in a loose form. The Australian origin is indicated on the price ticketing as a selling feature.

The experience of exporters working in China and the MLA in-country managers is that the wet markets and food service distributors are the most common channels of product fraud. For the low value product used in the following example, the extent to which fraud does occur it is not particularly damaging. The potential damage is far greater with higher value cuts which can flow through the same supply chains.

The processor trade brand plays a pivotal role in communicating the integrity of the product and its quality characteristics. Wholesalers and supermarkets become loyal to a particular processor brand and, to varying degrees, are prepared to pay a premium for their preferred trade brand. Fraudulent passing off as a particular trade brand can therefore be damaging to the exporters and in the longer-term undermines Australia's premium pricing.

Figure 4: Supply chain for chilled beef to wet markets in China/frozen forequarter cuts, individually packed and full container frozen knuckles

BREEDING	PROCESSING				EXPORT/IMPORT			PREPARATION			RETAIL	CONSUMER
Cattle producer	Slaughter	Boning	Freeze	Pack	Non-pack Exporter	Export Ship	Customs	Wholesaler	Distributors	Transport	Wet market	Consumer purchase
Grass-fed bullock					Sales, export docs	Road transport to Brisbane-consigned to ship	Customers clearance, collected and transported to wholesaler	Consignment receival, cartons sorted by wholesaler for sale to a number of distributors	Distributor sorts cartons for multiple customers. Delivery schedule is arranged	Load consignment, deliver and unload at butcher in wet market	Cartons defrosted and cuts displayed. Customer asks for cut to be diced	Meal prepared in home

UNIT OF TRACABILITY

	Cattle producer	Slaughter	Boning	Freeze	Pack	Non-pack Exporter	Export Ship	Customs	Wholesaler	Distributors	Transport	Wet market	Consumer purchase
UNIT	Live animal	Carcase	Sides	Bag/Carton		Sealed container				Bag/Carton			Cuts
DEVICE	RFID Ear Tag PIC	Carcase label barcode	Barcode			Consignment label and barcode				Barcode			
ORIGIN	Australian								Local fresh beef				
BRAND		Australian processor brand											

AUSTRALIAN INTEGRITY SYSTEM

	Cattle producer	Slaughter	Boning	Freeze	Pack	Non-pack Exporter	Export Ship	Customs	Wholesaler	Distributors	Transport	Wet market	Consumer purchase
LPA	■												
NLIS	■	■											
NFAS													
HALAL		■	■	■	■								
AUS-MEAT		■	■	■	■								
MSA	■	■	■	■	■								
DAWE		■	■	■	■	■	■	■	■				
TEMP CTR		■	■	■	■	■	■	■	■	■	■		

Source: McKINNA et al

12.5 Supply chain 4: Chilled beef to Indonesia

Air freight trade to Indonesia entails delivery of the product by the processor to the buyer's nominated freight forwarder, on pallets in a refrigerated vehicle. The freight forwarder at the airport packs the product into the air container of the exporter's chosen airline. The container is then delivered to the airline's terminal handling agent for loading. On arrival in Indonesia, the shipment is picked up at the airport, usually by the importer. From that point on, the product is in cartons, meaning that the cold chain integrity is in the hands of the importer and the exporter relies on a level of trust that it will be handled correctly. There is an opportunity during this link in the chain for the label to be switched but this is difficult. The country of origin label and the establishment number are critical information which is difficult to forge.

The product is delivered to the end user in the original carton. The food service customer prepares the product in their own kitchens. The Australian origin brand stays with the product right through to the customer, commonly in higher end steak restaurants the menu lists Australian 200-day air flown beef and sometimes the processors brand. The air flown tag is often used designate premium and freshness.

The following example covers grain-fed, chilled beef sold into Indonesian food service outlets.

Figure 5: Supply chain for chilled beef to Indonesia/grain-fed chilled loin cuts, airfreighted to Jakarta

	BREEDING		PROCESSING – SERVICE KILL				EXPORT/IMPORT					PREPARATION			CONSUMER
	Cattle Breeder	Feedlot	Slaughter	Chill	Boning	Pack	Exporter	Export transport	Importer Jakarta	Importer warehouse	Importer truck	Steakhouse chain depot	Steakhouse	Preparation	Consumer purchase
	Angus feeder steers breed and grow to 300kg	Angus feeder steers on feed for 270 days.					Sales, export documentation, airfreight	Road transport to Brisbane - consigned to airline	Customs clearance, collected and transported by distributor	Consignment receival, cartons sorted by customer. Delivery schedule arranged.	Load consignment, deliver and unload at restaurant	Consignment unpacked and cartons ready held in chiller ready to be sent to individual restaurants	Consignment placed in chiller ready for use	Carton opened by restaurant. Loin primals may be aged for a period then primals cut into steaks as needed. (Carton breakdown, vacuum packed primals sorted, value-added)	Customer selects a steak from menu or Chilled cut purchased

UNIT OF TRACEABILITY

UNIT	Live animal		Carcase		Primals		Carton/ primal					Crates/ primals	Primals		Individual cuts
DEVICE	RFID Ear Tag PIC		Carcase label		Barcode label		Consignment label and barcode					Primal labels	Retailer price ticket		
ORIGIN	Australian														
BRAND			Processor trade brand										Australian processor brand		

AUSTRALIAN INTEGRITY SYSTEM

LPA	■														
NLIS	■	■	■												
NFAS		■													
HALAL			■	■	■	■									
AUS-MEAT			■	■	■	■									
MSA	■	■	■	■	■	■									
DAWE			■	■	■	■	■	■	■	■	■				
TEMP CTR			■	■	■	■	■	■	■	■	■	■			

Source: McKINNA et al

12.6 Supply chain 5: Chilled lamb to USA

The following map outlines the supply chain for chilled lamb shipped by sea to a west coast USA supermarket customer.

The situation for US supermarkets is identical to Australian supermarkets as described previously. The supply chain to the point of delivery to the importer's warehouse is identical to the other sea freight supply chains. The importer then delivers to the supermarket's retail ready partner who slices, packs and delivers to the supermarket warehouse. The product is clearly branded as Australian all the way through the supply chain including on the retail pack. Australian chilled lamb achieves a price premium over local and New Zealand lamb in US supermarkets because of its eating quality.

There is little chance of product integrity breaches in this supply chain as the product is in the custody of trusted partners for the entire journey and subject to various third party audits.

Figure 6: Supply chain for chilled lamb to USA/west coast, various cuts

	BREEDING		PROCESSING				EXPORT/IMPORT				WHOLESALE		RETAIL			CONSUMER
	Lamb producer	Buyer	Slaughter	Chill	Boning	Pack	Exporter	Shipping	Customs clearance USA	Transport importer's cold store	Value-adding	Transport delivery	S/market depot	S/market store	S/market display	Consumer purchase
	Second cross lamb from southern Aust. 25 kg carcase weight	Purchase direct or from sale yard					Chilled reefer container. Sales, export docs. Road transport to Melbourne	Sea freight	Exporter office, USA. Customs clearance, truck transport arranged by importer	Container receival, cartons sorted by cut/customer. Delivery scheduled	Preparation for retail	Load consignment, deliver and unload at retailer depo	Cartons cross-checked and distributed	Cartons opened. Some processed for display	Retail packs on display	Prepared in home

UNIT OF TRACEABILITY

UNIT	Live animal		Carcase		Bone in and boneless cuts	Cartons	Sealed container				Carton of branded units – may change at supermarket					
DEVICE	RFID Ear Tag PIC		Carcase label		Barcode label	Branded bag & label	Consignment label and barcode				Barcode					
ORIGIN	Australian															
BRAND							Australian processor brand								Product of Australia	

AUSTRALIAN INTEGRITY SYSTEM

LPA	██															
NLIS	██	██	██													
NFAS																
HALAL			██	██	██	██										
AUS-MEAT			██	██	██	██										
MSA																
DAWE			██	██	██	██	██	██	██	██						
TEMP CTR			██	██	██	██	██	██	██	██	██	██	██	██	██	██

Source: McKINNA et al

12.7 Product integrity through the supply chain

The integrity of Australian red meat supply chains is robust up until the point where the product is delivered to the port or airport. Integrity to this point is underpinned by the interwoven regime of government inspections (both by Australian governments and the governments of some importing countries) together with overlapping third-party audit trails required by customers.

Beyond the point of shipment, the integrity of the product is in the hands of third-party supply chain partners and customers. In the vast majority of cases, trading terms dictate that the custody of the product changes on unloading at the Australian port, beyond which the exporter loses control and visibility over the products. Beyond this point, exporters are highly confident in the integrity of their product in the vast majority of cases, because it is sold to long-standing, corporate customers and handled through closed-loop supply chains, which are also mostly subject to third-party audits. The invisible area for product integrity in export markets occurs with the meat that is sold through wholesale markets and regional food service distribution channels where there is minimal opportunity to prevent fraud through the many layers of various agents and distributors.

12.8 Profit pool analysis

Profit pool analysis is commonly used by consultants to analyse supply chain revenue and profit distribution. It was developed by Orit Gadiesh and James Gilbert of Bain & Co to demonstrate to businesses the concept of concentrating on profit rather than revenue (Gadesh and Gilbert, 1998).

In the context of this project, profit pool analysis is a useful way to understand how the revenue and profit is distributed along the red meat supply chain. It is vital to stress at the outset, that when applied to the meat industry, the profit pool must be taken as nothing more than highly indicative because of the large amount of variability that occurs from season to season and agricultural risk in general. The revenue and profit split varies between literally every transaction due to the daily volatility in livestock pricing, selling prices, input costs, exchange rates and so on. This has required making some simplifying assumptions in the analysis presented here.

Structure of the profit pool model

The example used here is for chilled, 100-day grain fed Angus striploin, delivered to a Beijing supermarket. The chart has been developed by collecting data from multiple sources including public information and confidential discussions with various parties in the industry.

The horizontal axis of the chart indicates the revenue split across each link in the supply chain as a proportion of what the final consumer pays. The calculations at each link are on a price per kilo basis. The supply chain has been broken into the key functions to demonstrate the revenue split across various activities in the supply chain although in reality, major meat businesses are vertically integrated and are involved with a number of links. For example, the processing stage presented here is calculated on a service kill basis. The freight and logistics components have been added to the respective links according to who incurs the cost. The width of each box reflects the degree to which they value-add the product and their pricing power.

Determining the value of each piece of the carcase involves a very complex calculation for which most businesses have a spreadsheet calculator tool. We have used such a tool provided in confidence by a processor for the purposes of undertaking this analysis.

The vertical axis indicates the gross margin percentage which is calculated as the net selling price less the variable costs, but not including overhead costs. The area of the cube is the total gross profit dollars.

Figure 7: Beef profit pool analysis
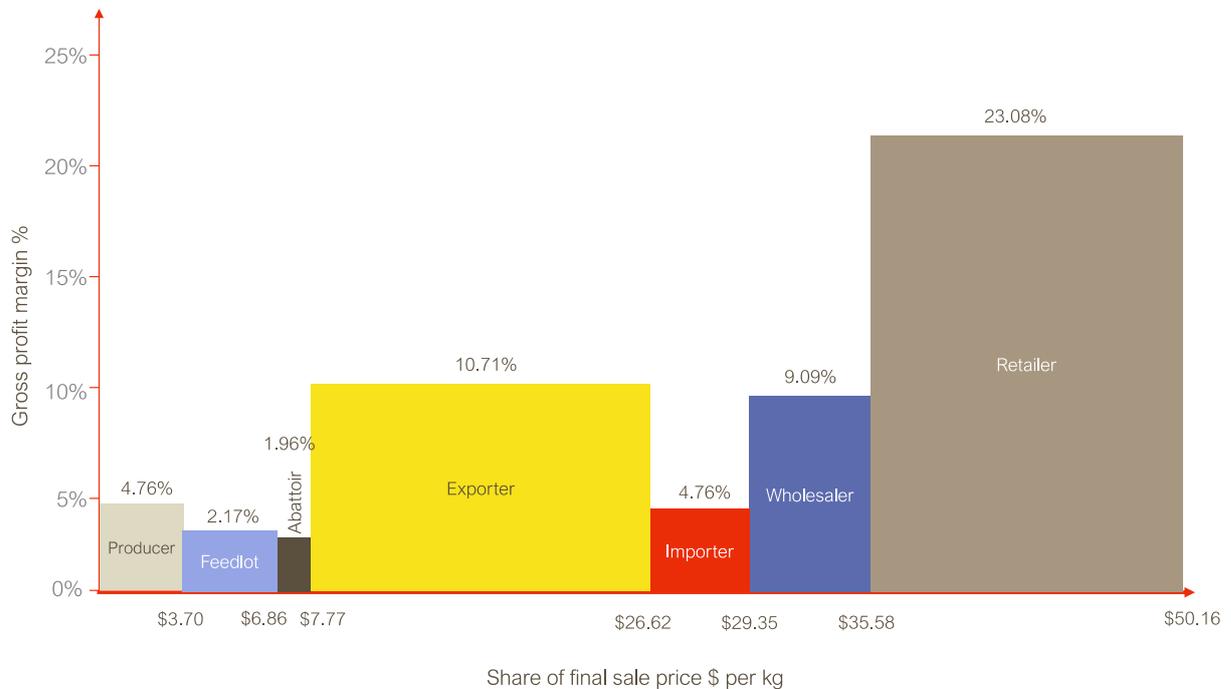
Source: McKINNA et al

Interpreting the profit pool

The first point to note on Fig. 7 is that the value of the product increases exponentially at each stage through the supply chain, for example, the producer gets $3.70 per kilo on a live weight basis then sells to the end consumer for A$50.15. This is because value is added at each stage plus a profit margin. **Note:** On the diagram above, $3.70, $6.86 and $7.77 are liveweight prices, then the price converts to price per kilo from $26.62.

The first three stages of the supply chain (i.e. the producer, feedlot and abattoir) get a minor part of the profit pool and by far the lowest gross margin. This reflects the highly competitive and commoditised nature of primary production. Profitability at the early links of the supply chain is driven by volume.

The exporter, who is the trade brand owner, gains a relatively large share of the profit pool both in terms of revenue dollars and gross margin. The sharp increase in the value at the exporter link from $7.77 to $26.62 reflects the separation of the striploin from the other cuts. Up until the point of boning, the price reflects the average across the whole carcase. It includes the considerable cost of boning, slicing and packaging.

The relatively high gross margin at retail reflects the willingness of the Chinese consumer to pay a premium for their confidence in the safety and integrity of Australian meat. To a large extent this

needs to be viewed as the brand premium dividend, which is enabled by a combination of the processor trade brand and 'Brand Australia' flowing on from the collective product integrity systems and processes. On a risk adjusted basis, the profit share for China would be a lot less. It must be noted the level of premium is likely to be much less in most other markets, although China is the market which places the highest level of value on product integrity. It should also be noted that this profit pool analysis reflects the elevated level of risk associated with exporting to China.

Although the wholesaler gets a relatively small share of the revenue in the total profit pool, their gross margin is relatively high, which reflects the value of their distribution networks and customer base.

The retailer receives by far the largest gross margin in the profit pool, which is partially a reflection of market power. Affluent consumers in China are increasingly shopping in supermarkets because of convenience and the safe and clean shopping environment. The vast majority of supermarket beef is sold under the supermarket's own brands. Supermarkets achieve a brand premium because of the trust and loyalty that a shopper has for their brands. Only a very small share of meat sells under Australian-owned consumer brands in retail channels.

For the purposes of this analysis the links in the supply chain have been split into individual components. However, the most common model is an integrated processor/ exporter/ brand owner model, sometimes it also has an associated feed lot operation. It is the processor/exporter's trade brand that generates the premium margin. Some of the larger companies also own or are aligned with importers and/wholesalers in the importing country. There is also an increasing trend towards business models with integrated breeder, feed lotter, exporter and trade brand owner with the processing component outsourced.

The significance of profit pool analysis in the context of product integrity

The profit pool analysis highlights the important role of brands in generating profit. Exporter trade brands achieve a premium in export markets largely because of trust in the integrity of the product. A large component of this premium is generated by the 'Brand Australia' franchise underpinned by customer and consumer confidence in the integrity delivered by the Australian systems and processes. The brand dividend is difficult to calculate but is significant. The benefits of it are mostly captured by the trade brand. Exporter brand owners gain an additional premium, but this is largely attributable to quality and customer service aspects beyond product integrity *per se*. Although the industry bemoans the burden of the customer and government regulatory requirements, this analysis indicates that they generate a significant premium for the industry, particularly the exporter/brand owner.

Figure 8: Beef profit pool analysis margin premiums
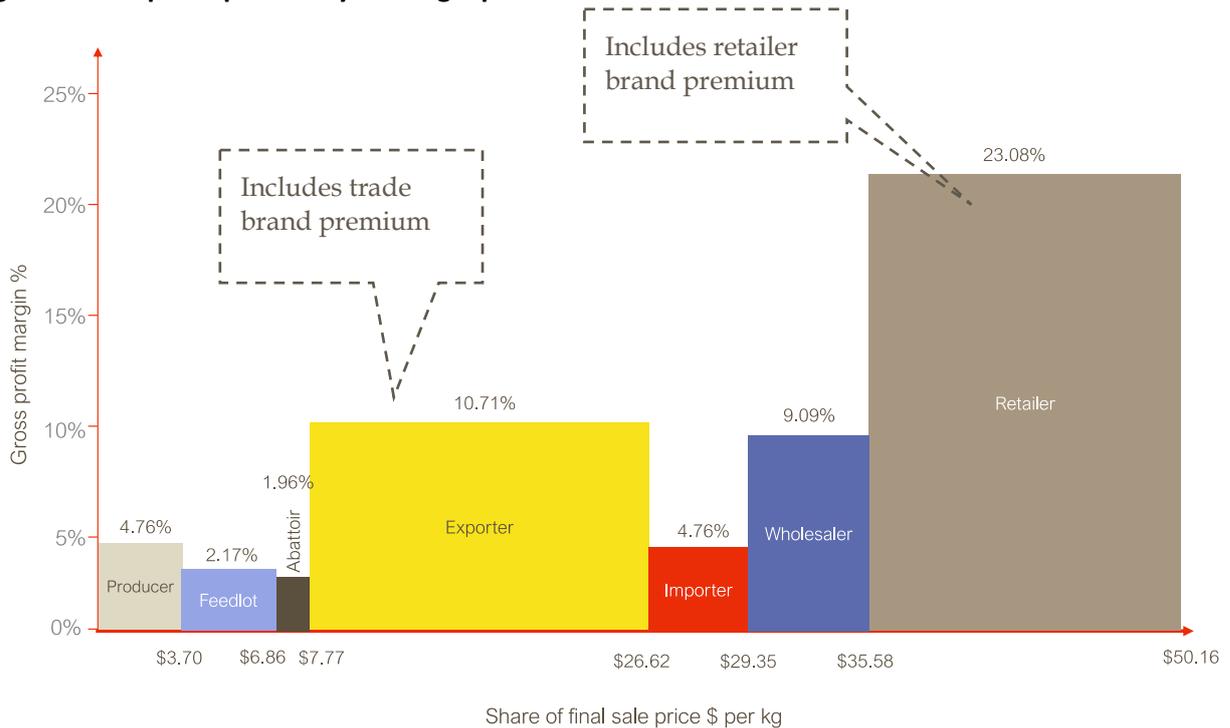
Source: McKINNA *et al*

The profit pool analysis also illustrates the opportunity to build incremental profit by utilising blockchain platforms for B2B and B2C marketing models. Direct to customer models allow the exporter to reduce supply chain cost and capture the gross margin dollars currently going to importers, wholesalers and retailers (in the case of a B2C model), as illustrated in some of the case studies and elaborated on in the section on blockchain.

13. Barriers to adoption of integrity systems

There is an apparent stand-off between meat businesses and technology companies with regard to the adoption of product integrity and supply chain technologies. Virtually all of the meat supply chain companies consulted had assessed, or were in the process of assessing, various technology solutions to enhance supply chain integrity. Some businesses had advanced 'proof of concept' trials, some of which were still underway at the time of consultation. However, throughout the consultation, it was difficult to find examples of any full-scale commercial adoption of step change technologies around integrity, verification and traceability within most meat businesses. Most of the technology adoption was by integrated breeder/marketers and start-up companies rather than by processors. From their viewpoint, the technology and service providers observe that the red meat industry does not appreciate the contribution that these technologies offer. The reasons for the gap in perspectives and the reluctance of red meat businesses to embrace the rapidly advancing product integrity and supply chain technologies are various, as noted already throughout in this report, but the key points are consolidated here.

There is a high level of confidence in the integrity of current systems and processes.

Meat businesses strongly hold the view that the Australian industry generally has robust, best practice product integrity standards and this is a key part of Australia's competitive advantage. Management of product integrity is accepted as one of the core functions of operating a meat business. Because of this context, many in the meat industry regard the term 'product integrity' to be synonymous with traceability and fraud mitigation. Although there is an acknowledgement that fraudulent mislabelling occurs, it is believed to be minor, largely confined to China, and is thought to be having only a minor impact. This level of confidence is based on the fact that, in volume terms, the vast majority of red meat, both in domestic and overseas markets, moves through closed-loop supply chains, via trusted supply chain partners, therefore there is a high degree of control and visibility over product integrity in every link through to the end customer.

Businesses do acknowledge that the bar is always rising in relation to integrity systems, driven by customers' expectations which in turn are being driven by the advancing functionality of supply chain integrity technology. As a consequence, most businesses are continually reviewing their systems.

There is industry cynicism about blockchain

Meat industry businesses do not see a compelling reason to consider using blockchain systems. This stems from the fact that blockchain is predominantly seen as a fraud management system. Some acknowledge that blockchain may have potential applications in niche or fragmented supply chains (e.g. to verify high value Wagyu provenance), but that it would probably be compromised by its dependence on the integrity of supply chain partners (who ultimately control the data entry) to do the right thing, which defeats the whole intent of blockchain. Most believe that it is inevitable that blockchain will be imposed on them soon by their major customers, which as one processor said, *"they will be dragged into kicking and screaming".*

The potential benefits and applications that blockchain can deliver do not appear to be widely recognised within the industry. There is acknowledgement that blockchain based systems could be helpful in achieving harmonisation of the myriad of customer and government compliance requirements that generate excessive duplication and costly paperwork, which is an ongoing burden to businesses.

The futility of attempting to stop fraud is a disincentive to act

Brand owners are resigned to the fact that fraud is inevitable and virtually impossible to stop. This Is borne out by the experience of businesses in other industries who have gone to great lengths to prevent fraudulent mislabelling and whose efforts have been thwarted by agile fraudsters who have quickly found ways to get around even very sophisticated systems.

The other question is, what does a business do if it discovers fraud? Attempting to prosecute a trademark infringement in a foreign jurisdiction is costly and has a very high chance of failure. Even though China is tightening scrutiny around brand fraud, it is still a very challenging process.

The only practical way to manage fraud is to refuse to deal with some countries, channels or with untested customers, which limits business opportunities.

The message here to technology companies is that there is a need to market a broader value proposition of their products besides product integrity *per se*.

Technologies add cost and complexity which cannot be recouped

The clear message from the industry feedback is that there is little incentive to invest in technology to improve product integrity over and above that which currently exists, as it would simply erode profitability. There is a high level of confidence in the status quo and although customers would value the enhanced integrity delivered by these technologies, they are not prepared to pay for them - it is expected and assumed by customers that industry will adopt the latest improvements at their cost. Across all of the interviews conducted for this study, there was not one meat industry respondent who indicated that they were achieving a premium for their investment in product integrity systems over and above the premium enabled by Brand Australia. Brand Australia ultimately serves to endorse their individual proprietary brands.

One reason given for red meat companies to invest in any product integrity activity beyond that already regulated, would be to build customer loyalty in their brand in order to secure repeat business, rather than for the purposes of extracting additional price premiums. The other reason is cost. The focus of most meat businesses on reducing cost is relentless. Labour, energy and compliance costs are continually rising and, given the competitiveness and volatility of the industry, these costs cannot be passed on.

The overwhelming conclusion is that the cost benefit equation for investment in these technologies it is simply not there at this point in time.

The lack of an end-to-end solution makes it all too hard for most

A commonly held view expressed by stakeholders is that most of the product integrity technologies provide piecemeal or band aid solutions, focused on one problem only. Most options on offer are seen to be overcomplicated and costly with none offering an end-to-end, seamlessly integrated solution. The ideal technological solution from an industry perspective would be a platform that managed the entire supply chain including transactional capabilities. To date, most meat businesses have not been able to find a such a solution. To develop one would require piecing together a series of technologies from several providers. The challenge here is in successfully connecting these various components, which tend to have their own operating systems, most of which have been found to be incompatible. Furthermore, the needs and priorities from these technologies varies considerably from business to business making an 'off the shelf' option, if there was one, impossible to apply to all. Some technology companies claim to offer end-to-end solutions, but the experience is that these still require customisation. Most meat businesses find this prospect of building their own systems far too daunting and cannot reconcile the cost relative to the potential benefits.

Most technology systems cannot accommodate the complexity of meat businesses

The meat businesses believe that part of the problem is that technology companies do not understand the extremely complex and fragmented nature of meat supply chains and that the various technologies have been designed for simpler, non-perishable supply chains, with very high value products such as designer handbags, diamonds or wine.

A common experience of those who have tried to implement blockchain-based platforms is that they require much more development work than expected to adapt the system to meet their business' needs. This invariably resulted in considerable cost and time blow outs.

14. Project insights

Borrowing a phrase from the former Vice President of the United States, Al Gore, there are a number of 'inconvenient truths' associated with the application of supply chain and product integrity technologies. These soon became apparent in the resulting insights from the project, which include the following:

1. The interpretation of the whole notion of product integrity is specific to each individual customer and consumer, depending on their own preferences, needs and priorities. The test of product integrity is that the buyer is confident that what they are purchasing is what is purported to be.

2. There is a fundamental misalignment between the perspectives of meat businesses, the research literature and technology providers on the subject of product integrity and its adoption to supply chain management, particularly with respect to product fraud and traceability. The reality is that the precise nature, extent and impact of fraud is not quantified nor well understood.

3. The business case to invest in technologies to enhance product integrity and supply chain management are heavily based on five implicit propositions which need to be challenged as they lie at the heart of the disconnect between the various actors in the supply chain:
   1. *Product integrity is a major purchase driver*
   2. *Consumers, and therefore customers, are prepared to pay a premium for enhanced integrity attributes*
   3. *There are significant shortcomings in the product integrity systems of the Australian red meat industry*
   4. *Consumers are demanding more traceability and information on provenance*
   5. *There is widespread fraud of Australian meat in global markets, which is harming brand owners and the industry.*

4. There is a high level of consumer confidence and trust in the integrity of Australian meat in the domestic market, so it is an assumed 'given', and not a first order purchase driver. Product integrity however is a major purchase driver for most export markets, particularly in Asia. Trust and confidence in the integrity of Australian red meat is the centrepiece of the Australian competitive advantage and it supports significant price premium in most markets. Customer trust is projected through the exporter's trade brands whose credibility in turn is heavily underpinned by the Australian provenance (Brand Australia). However, there is no compelling evidence to suggest that brand owners gain incremental premiums over and above those enabled by the Brand Australia factor. Any additional premiums gained by individual brand owners are predominantly due to quality or service attributes rather than due to higher levels demonstrable product integrity. Consequently, there is little incentive for brand owners to invest in enhanced product integrity beyond which that required by customers and government regulators.

5. The logical conclusion from this body of analysis is that product integrity is much more of an 'industry' issue rather than an individual 'brand owner' issue and there is a strong case for

the Australian red meat industry to continue to invest to protect and enhance the integrity of its systems and processes.

6. Although red meat businesses are confident that their product integrity systems are robust, there is acknowledgement that customer and consumer expectations are growing, largely driven by technology and that they need to continually reassess and review their systems.

7. There is a large amount of cynicism regarding blockchain within the red meat industry; most major meat businesses have, to varying degrees, investigated the potential application of blockchain and rejected it on the basis that it added cost and complexity with no clear value proposition. This position is heavily based on the view that blockchain is predominantly a fraud management system.

8. One of the greatest barriers to the adoption of product integrity technologies is the cost and complexity it adds to the business which cannot be passed on to the end customer and must be absorbed as an overhead. In order to justify the investment, there therefore needs to be a value proposition over and above product integrity *per se*. The focus by technology providers on marketing the product integrity features of their technologies is therefore not gaining traction with meat businesses.

9. Most red meat businesses are continually reviewing technologies searching for opportunities to improve supply chain efficiency because of escalating costs, which are eroding profitability. Commonly, meat businesses have invested time and resources in search of technologies to streamline the management of the supply chain and compliance management. A major cost area is managing the complex and ever-increasing compliance burden imposed by regulators and customers. Meat businesses have found the search for technology solutions challenging and frustrating because of the difficulty of finding a solution that meets the unique needs and priorities for their particular business.

10. Technology providers believe that the red meat industry trails behind other perishable food categories in terms of the adoption of cold chain integrity technologies and that the extent to which meat companies invest in cold chain integrity as a risk management tool is risk mitigation, whereas, other perishable food categories see benefits in waste reduction and shelf life management. Furthermore, other industries have pivoted the relationship between supply chain links from adversarial to a collaborative, working with suppliers to provide 'whole of chain' visibility using the rapidly developing data logging technologies. The collaborative enables sharing of real time data and generates a culture of shared responsibility and accountability. Compromised cold chain performance and its impact on product shelf life comes at a significant cost to the meat industry. This cost impost is shared along the entire supply chain and treated as a hidden or unavoidable cost of doing business without consideration of the opportunity to reduce a significant amount of this wastage and recovering at least part of the cost burden. The fact is that compromised cold chain integrity is a much greater cost impost on the industry than traceability and fraud.

15. Future research priorities

This project has identified a number of areas that justify further investment by MLA relating to product integrity and supply chain management technologies. These are outlined below:

Validation of the fraud issue and preparation of an industry response

Given its potential significance to Australia's red meat industry, the fraud issue warrants further investigation. In reality there is no robust understanding of the nature, extent and impact of fraud on brand owners across the industry at large. Because product integrity is the centrepiece of Australia's competitive advantage in global markets, improved understanding of this issue is important. Other industries such as those in seafood have employed isotope tracing technologies to track incidents of 'passing off', as a basis for developing fraud mitigation strategies. There is a strong case for the Australian meat industry to invest in similar work. Rather than embarking on a comprehensive and costly global research project, it may be more practical to start by conducting a highly targeted pilot trial on one particular market (logically China) within one particular product category to assess whether further work is needed.

Study of the feasibility of implementing industry-wide integrity enhancements

It is critical that Australia's leadership in product integrity be maintained. The Australian red meat industry faces increased competition from the rapidly improving product integrity in competitor countries. Furthermore, the escalation of technological capability is continually lifting consumer and customer expectations. The ideal situation would be to build on the solid foundations of the NVD, NLIS and PIC systems to create a seamless, whole of supply chain, paddock to plate industry traceability system. Although the Australian traceability system is robust from the farm to the abattoir, the link is usually broken in the boning room between the carcase and the primal. To date, this has not been a problem, but as major customers raise the bar in terms of expectations, it is likely to become an issue that will need to be addressed. The opportunity exists to adopt an industrywide, whole-of-chain traceability system utilising smart tag and verification tracing technologies. This system could be used to harmonise all of the regulatory and compliance frameworks. Such a system would provide a platform on which individual brand owners could attach further functionality and a customer value proposition. This would enhance Australia's competitive advantage. The feasibility of such a scheme warrants further investigation, starting with the development of a business case taking into account the industry views on the subject.

Further R&D in the area of cold chain integrity and its impact on shelf life

Shortcomings in cold chain integrity is costing the industry a large amount of money each year. Most customers routinely factor in a fixed percentage in their trading terms to cover the wastage factor (10% is commonly used). The cost of wastage appears to be greater than fraud, therefore justifying priority examination. The starting point for this enquiry would be a number of trials using active real-time data logging technologies to track performance and identify critical breakdown points. This work should cover both the domestic and key export markets (both air and sea freight). A more detailed understanding of the issue will provide a foundation for the development of 'whole of cold chain' collaboration management models. There is also an apparent need for MLA to invest in programs to build awareness of the issue of cold chain management and its link to shelf life

outcomes. The industry could also be encouraged to become part of the Australian Food Cold Chain Council.

Bridging the gap between the red meat industry and technology/service providers

MLA could sponsor an annual forum or other event on the issue of product integrity and supply chain technologies, bringing together the key stakeholders from meat businesses, the research community and technology providers. The event could profile emerging technologies and share learnings from the experiences of other industries. It is critical the Australian red meat industry stays at the forefront of product integrity, supply and cold chain management best practise.

A detailed understanding of what integrity systems represent for consumers and what would stimulate them to pay more for them

Industry knowledge of the consumer perspectives on integrity systems is a gap that could be filled with focused qualitative research. The knowledge gap here includes understanding what the components of integrity are in the eyes of the consumer in terms of understanding how they think (or don't think) of them; care (or don't care); and how consumers express product integrity in their own language. Identifying which parts of this information are important in product purchase decisions will be valuable information for brand managers. Pinpointing the exact factors that consumers will pay a premium for and which factors are expected, would enhance the product experience and therefore willingness to pay more for that.

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18.   Stakeholder organisations and businesses consulted

In addition to thanking the stakeholders consulted from the companies listed below, who generously shared their knowledge and experiences, the authors would also like to acknowledge the valuable contribution from meat industry consultant, Allister Lugsdin.

AACO
AgLive
Sustainability specialist   Teys
Argyle Foods Group   The Avolution
Australian Country Choice   Thomas Foods
Australian Food Cold Chain Council   Trust Codes
Australian Organic Meat Group   Two Hands
Australian Packaging Institute   V&V Walsh
Barossa Fine Foods   Woolworths Supermarkets
BeefLedger
Bindaree Beef
BSM Global
Coles Group
Consolidated Food Co.
Curtin University
Emydex Technology
Escavox
Eurofins Food Testing Pty Ltd
FIAL
Foods Connected
Harvey Beef
Hilton Group
JBS
Latitude 28^0 Produce
Macka's
Mangoes Australia
Melbourne University
MLA
Natasha Wing QA & Auditing
NH Foods Aust
OBE Organic
Oritain
Result Group
Sealed Air
SensaData
Sensitech
Source Certain
Stockyard Beef

19.   Appendix 2: Case studies

The five case studies in the following pages were formerly presented as the Milestone 2 report of project V.MFS.0447.

All stakeholders who shared their experiences have approved the content presented here. The authors would like to gratefully acknowledge their generosity in giving their valuable time and openly sharing their experiences for the benefit of the red meat industry.

Australian Farmed Barramundi Association
Aglive
Argyle Food Group
Australian Organic Meat Group
BSM Global
Escavox
KPMG
Macka's
Mangoes Australia
OBE Organic
SensaData
Source Certain
The Avolution
Two Hands

Case study 1: A verified blockchain trading and marketing platform

About this case study

The purpose of this case study is to describe the application of blockchain (Distributed Ledger Technology) used with associated Internet of Things (IoT) technological devices (including all manner of smart tags, loggers, monitors and more) to provide a holistic transactional, product integrity and marketing solutions platform.

The integrity system	A verified blockchain trading and marketing platform
The applications	• Marketing platform • Transaction management • Product integrity tracking
The problems being solved	• Fraud and corruption • Supply chain complexity • Inability to market to end users
The parties	**Digital Supply Chain:** • Aglive, an end-to-end Supply Chain Traceability Solution • Two Hands, a blockchain enabled marketplace • SensaData, an IoT device that measures the status of the item/ product **Physical supply chain:** • Macka's Australian Black Angus Beef

This case study profiles emerging solutions provided by Aglive, a 'paddock to plate' tracking platform, and SensaData, a smart tag technology provider. The Aglive and SensaData technologies have been applied in two different supply chains: a marketing platform called 'Two Hands', which is a start-up ecommerce marketplace servicing the premium food service channel in China; and Black Angus Beef producer Macka's, which has recently completed a trial shipment to China with Aglive. That trial has been supported by MLA and is being independently verified by Macquarie University. There is a high degree of natural alignment between the various parties, with Macka's also being about to launch a premium food service range of black angus beef on the Two Hands marketplace platform.

Both Two Hands and Aglive are still working with a number of technologies to find the optimum solutions for this product integrity initiative and the program is still in development. Two Hands has independently successfully tracked lobster into Shanghai and market research suggest that buyers are enthusiastic about the platform's potential to eliminate fraud and streamline the supply chain. Although the early results look very promising, the businesses involved are still proving their systems. Both Two Hands and SensaData are start-up companies still in the capital raising stages of their development, while Aglive is an established technology business, which has worked with MLA over a number of years to deliver the first on-farm solution to manage traceability of livestock from birth to the meat processor with eNVD and other eCertificates.

This case study has been chosen because it provides valuable learnings for the Australian red meat industry on the potential applications of blockchain. In particular, the potential to use blockchain for B2B transactions could open up a completely new, streamlined supply chain with significant financial benefits for the beef exporter.

To the limited extent that blockchain has been used by the Australian meat industry, it has been largely for product integrity and traceability purposes. A number of meat businesses have already trialled blockchain or are looking at potential applications, but there are very few that have commercially adopted a system.

Based on the engagement, there appears to be a general view across the meat industry that blockchain adds complexity and cost without adding any tangible benefits. Because most premium quality red meat flows through closed-loop supply chains where businesses have long term relationships with corporate customers and trusted supply chain partners, they have a high degree of control and visibility over the supply chain, obviating the need for blockchain solutions. Another common industry view is that the integrity of blockchain is heavily reliant on third parties inputting data, which exposes the platform to serious compromise and defeats its very purpose, leading to the perception that the technology is *"solving problems that we don't have".*

All three technology partners involved in this case study work hand-in-hand to transfer products from Paddock-to-Plate, with everyone playing a crucial role to ensure that data is traced through the end-to-end supply chain.

Figure 1: Supply chain partner integration model
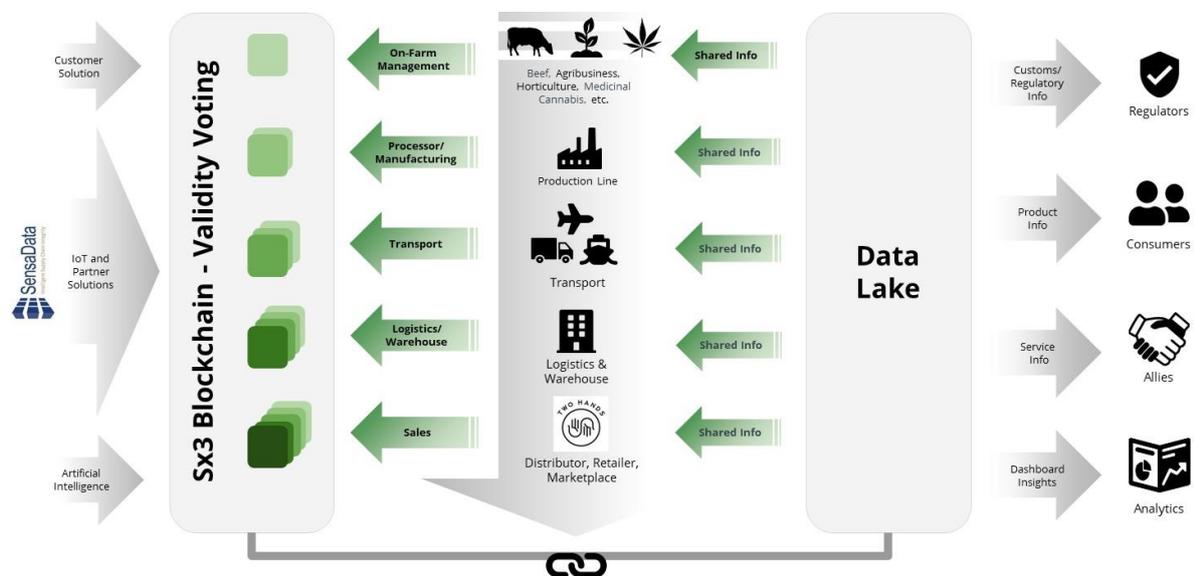
Source: SensaData

Macka's Australian Angus Beef

Established in 1884 Macka's is a fourth-generation meat producer that markets premium, MSA graded Angus beef for high end customers in Australia and overseas. Macka's offer includes grass-fed, free range grain-finished; and grain-fed options ranging from 100 to 200 days. The business runs a breeding herd of 3,000 cattle across 15,000 acres on eight stations throughout NSW. Macka's is about to launch its premium food service product on the Two Hands platform targeting high end restaurants in Shanghai.

The impetus to invest in a product integrity system

Macka's has experienced a high level of product fraud in China firsthand, which threatens to erode its brand credibility and dilute its premium pricing. The source of the fraud stems from the fact that Macka's is distributing products with clear provenance branding on the packaging through traders in China. The branding and packaging has been copied and fraudulently branded inferior product is being passed off as Macka's, selling at discounted prices relative to the genuine product. This was eroding customer confidence in the brand, but more importantly, it was beginning to impact Macka's premium price as buyers thought they were being overcharged for the Australian brand when cheaper product was appearing elsewhere on the market. After investigating several systems to defend against the counterfeiting, Macka's chose to work with Aglive to develop an integrated product integrity and tracking system, which is still in development. Macka's has recently completed an air and sea freight trial shipment to Shanghai, in partnership with DB Schenker and Cathay Pacific, which has had support from MLA. The results of this trial will be evaluated by Macquarie University and are yet to be released.

The proposed system

The proposal is to have an end-to-end, 'paddock to plate', blockchain product integrity system with a verification device. The system is being designed to provide three layers of protection by using encryption, tracking and blockchain technology.

Each traceable unit carries a 40-digit alphanumeric cryptographic code which is tracked at every stage in the supply chain through a smart tag. The device includes RFID remote sensors linked to satellite tracking. The system is enabled through blockchain which makes product fraud impossible because the data can never be altered or erased. The data can be audited or verified at any stage - with a distributed ledger, computers of separately owned entities across the supply chain constantly validate and update the data on a shared ledger.

The genesis of the tracking data is the National Vendor Declaration system where the RFID ear tag is scanned at each point from farm to feedlot and then on transportation through to the processor. The data is captured in digital form and uploaded to the cloud. The farm level data will include Livestock Producer Assurance (LPA), Electronic National Vendor Declaration (eNVD), Meat Standards of Australia (MSA) certification and National Feedlot Assurance (NFAS) declarations. At the point of processing, the Aglive system integrates with the

processor's systems, which are cross-verified through other systems. Product is identified at each point though RFID labels.

Aglive is working with a number of providers to develop a smart tag tracking system. For the purposes of the trial, the Ceres Tag system was used, which uploads data via satellite and can track GPS location and the health and welfare of the animal.

For the trial, Macka's employed an IoT device used by DB Schenker, which provided relatively basic monitoring of location and temperature. There other more sophisticated systems such as those produced by SensaData, but these are facing some hurdles with aircraft compatibility.

In Macka's system, the brand owner is issued with an encrypted private key code which in turn can generate public key codes that are permanently affixed to each traceable unit, as listed in the register. Once the shipment is packed, all bundled codes related to the shipment are activated and the tracking begins. Each custodial change is tracked and recorded and displayed on the Aglive monitoring dashboard. Each supply chain member can be granted access to the dashboard to view this data. On receipt of the product, the end user can then use the free Aglive app on their smartphone to verify the authenticity, check that the ID has not been used by another party and confirm that there have been no anomalies in the supply chain.

A report to MLA on the trial shipment was being developed at the time of writing the case study.

Figure 2: Aglive cold chain performance dashboards

Figure 3: QR code and verification information
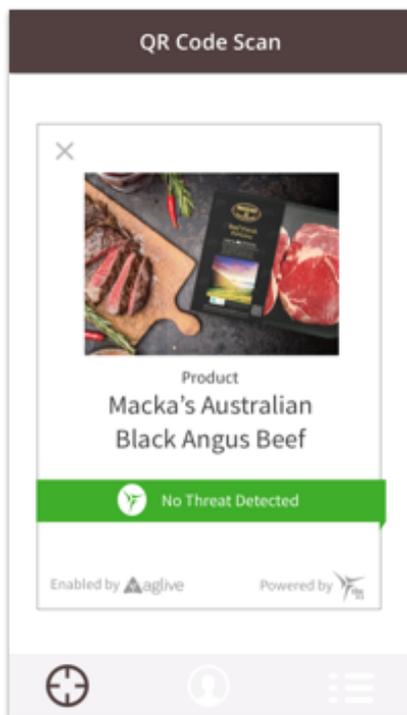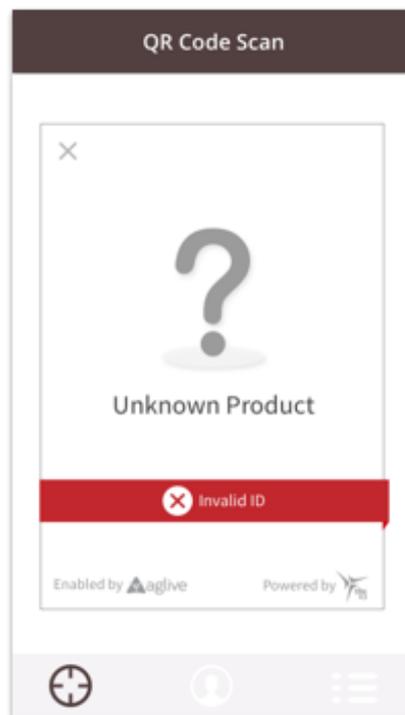
Two Hands Food service trading platform

Two Hands is a start-up agritech company that grew out of a seafood trading business exporting lobster and abalone to high-end restaurants in Mainland China. Two Hands was founded with the express purpose of reinventing the food service supply chain by creating a B2B platform. Two Hands is effectively a trading platform for high value protein foods into the premium food service channel in China where product integrity is protected using blockchain and IoT devices in tandem.

The problem/opportunity

The decision to move to blockchain platforms was motivated by two factors:

1. The complex, multi-link supply chain for seafood in China which was adding risk and taking an inordinate share of the profit pool from the producer.
2. The corrupt nature of the food service supply chain in China, particularly for seafood.

Prior to forming Two Hands, the seafood exporting business was receiving constant feedback from procurement managers in the international hotels that they had no confidence in the seafood supply chain in China and felt they were at the mercy of the highly unreliable distributors and traders based in the wholesale seafood market. This was of concern because of potential reputational damage to their prestige global tourism brands.

Complex supply chain

The seafood supply chain in China is highly convoluted with multiple links including fishers, exporters, import agents, wholesalers and different levels of distributors, which greatly erodes profitability as each of these links takes a margin with the result that the fishers sometimes get less than 50% of the price the end customer pays. The rising costs of fishing is putting pressure on fisher profitability and so capturing more of the margin in the profit pool has become more critical. There are also many issues with slow payment and bad debts plus false claims are a common occurrence.

Corruption in the supply chain

According to seafood industry journalist Mark Godfrey (2018), the Chinese seafood industry has become inextricably linked with criminality. Crime and corruption occurs at many levels including smuggling/grey channel imports, fraudulent labelling, flushing fresh water into the fish tanks (which significantly adds to the weight of the live fish and reduces the shelf life and eating quality), use of toxic chemicals (such as formaldehyde) to improve the appearance of the product, overcharging customers and bribery of buyers. This corruption is a particular issue for Southern Rock lobster, which is highly prized for wedding banquets because of its spiritual symbolism in the Phoenix and Dragon legend (the lobster represents the dragon), its particularly vibrant lucky red colour when cooked, superior eating quality and its provenance from the pristine waters of Southern Australia. Passing off inferior product from other sources is very damaging to the Southern Rock Lobster brand, with the potential to erode category pricing because consumers will be less inclined to pay a premium if they have a poor eating experience or are not confident about the provenance.

Because the lobster is usually portioned in the kitchen and served without its shell , it makes it very easy to mislabel and mislead diners in a banquet by simply placing the retained head of a Southern Rock lobster served earlier on top of a plate of inferior fish.

With the rampant corruption that exists in the seafood supply chain, particularly in seafood wholesale markets, procurement managers of high end hotels cannot trust the authenticity of the products they are buying, which is compromising their own brand image, given their discerning client base and high menu prices.

The 'end to end' digital supply chain model

Two Hands is a start-up company (currently calling for investors) established with the express purpose of reinventing the high value protein supply chain into premium food service channels in China. The business offering is the provision of a secure, transparent trading platform where all parties involved in the transaction have complete visibility, secured by a blockchain platform that provides a single source of truth.

The trading platform targets five-star international hotels such as the Waldorf Astoria and the Ritz Carlton as well as high-end independent restaurants in China (commencing in Shanghai). Although the business is launching with live Southern Rock Lobster and abalone, the intention is to expand into a full range of gourmet protein products including beef and lamb, which is being driven by customer demand.

The Two Hands business value proposition is based on three essential elements:

1. A transactional platform whereby farmers and fishers can deal directly with the end customer, establishing their own pricing and trading terms with guaranteed shorter payment schedules.
2. A multi-data point verification system enabled by IoT devices that confirm the authenticity of the product and track its status at any point in the supply chain.
3. An electronic marketing platform that allows producers to tell their stories to both the hotel/restaurant buyers and the end consumer.

Because Two Hands is a trading and marketing platform, it enables a direct relationship between the seller and the buyer, with all of the benefits as well as the commercial and supply chain risks remaining with the seller (although the platform is designed to minimise the risk). The Two Hands marketplace provides a vehicle to allow producers to communicate directly with the end customer via a marketing platform on which they can tell their stories in their own way and receive direct product feedback from customers. Two Hands' revenue stream comes from charging a 5% commission, deducted from the payment by the customer. The platform is totally transparent to all actors.

Two Hands is partnering with Aglive and SensaData and a number of other suppliers to develop this integrity system. Aglive is an established blockchain-enabled data capture and storage company specialising in customised agrifood supply chain data solutions. The Aglive solution collates data from every link of the supply chain (importantly, by utilising existing supply chain data collection systems) and digitises the data. The robust integrity of the system stems from the fact that the data is collected from several independent sources

throughout the supply chain through IoT devices, without human intervention. This data is then securely recorded within the blockchain platform.

Start-up company, SensaData is also a key part of this integrity system. SensaData contributes its Smart-r-tag which is a reusable tagging system that compiles a comprehensive data set about the product via the cloud. The tag captures live information about the status of the asset at all points in the supply chain that can accessed while the product is in transit (downloadable within telephone range).

Lobster supply chain model

Unlike red meat, lobster does not change form from catch to final delivery, but it presents its own challenges as a live product with a short shipping window.
At the point of capture, the fisher locks a tamper proof smart tag onto the live lobster's horns. This smart tag, which has been customised by Two Hands, records the weight and quality of each fish. The smart tag is the critical identifier, which stays with the product literally to the table in fine dining restaurants. The patent-pending smart tag is tamper evident and can be easily applied one-handed by a fisher, even in wild seas. It can withstand salt cold water for lengthy periods of time while the live lobster is in tanks and yet still present on a luxury item within a 5-star restaurant environment, where it performs rapidly and accurately when scanned by the diner. The tag includes a unique QR code and RFID capability. Each QR code is linked to a unique URL. The carton that the lobster travels in also has a unique QR code.

At the point of capture, the data on the QR code is scanned and uploaded to the digital marketplace together with pricing. Food service buyers can view the marketplace, make offers and place orders. Orders are then aggregated and packed for shipment. After clearing customs in China, the product is transported directly to the customer by Two Hands staff, thereby greatly reducing the amount of handling and associated costs, but most importantly eliminating any opportunity for fraudulent intervention. Throughout the entire process, both seller and customer can go to the Two Hands marketplace website and track the status of the order.

The Two Hands system offers a potentially powerful marketing tool whereby diners can read the QR code with a smart phone at the table. The scan takes them directly to the seller's website, which provides an opportunity for the seller to tell a story about their product and its provenance. The URL address is immediately made void after it is scanned once so that the tag cannot be applied to another product.

Figure 4: the Two Hands consumer experience

The supply chain tracking in this integrity system comes from a combination of in-house and off-the-shelf, industry-specific software and hardware that gathers information on the fisher, port and region together with product species, weight, quality and colour. The data is uploaded via the IoT devices without human intervention, into the blockchain using cloud technology. Software and sticker smart tags developed in-house record the change of custody through the supply chain.

The SensaData Smart-r-Tag

The Macka's Australian Angus Beef shipments will be monitored throughout the journey using a device currently in advanced stages of development by SensaData. The technology can be customised with the capability to monitor location, temperature, presence of gases, shock and drop, light and pressure. These tracking devices need to be approved by the airlines and the size of the device battery is a critical issue for airline approval.

These are reusable and reprogrammable IoT devices that can capture detailed information about the asset condition at every point in the supply chain. The smart tag is embedded into the product such in the carton or package through a customized engineering solution. The system is powered by a proprietary highly functional, low-cost microchip that will enable Enterprise customers to capture and action time sensitive IoT data by unit, carton or pallet. Its small physical size (6 x 6 mm) can be leveraged with miniaturised sensors and other components for physical deployment into the packaging of items, ensuring that the tracking system is not removed/displaced from its target asset.

Figure 5: SensaData Smart-r-Tag and monitoring sample
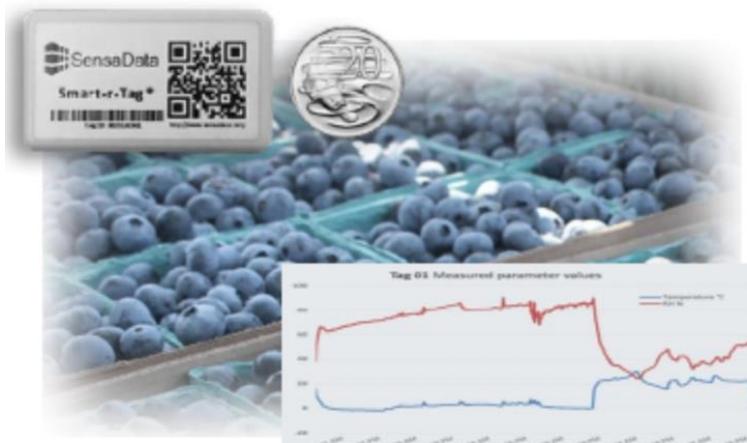
The data held on the device is transmitted in real time via mobile phone signals whenever the shipment is in range of available backhaul networks. Where required, the system can interface with WiFi and other network types such as LoRa, NB IoT, etc.

The data is then used to develop a customised dashboard and database which can be accessed by anyone in the supply chain who has been given permission. SensaData will also offer a full diagnostic and analytical service and report on issues along the supply chain. The intention is that the customer would also have full visibility at any point of the supply chain.

Because of the internet fire wall in China, which restricts access to websites outside of China, it is necessary to have a company established in China and then to gain approval to have a licence to host a website. Cloud information storage, such as AWS and Alicloud, cannot communicate directly into parties in Mainland China but this issue is currently being resolved.

The challenges in implementing verified blockchain systems

The challenges in the implementation of integrity systems such as the two profiled in this case study, stem from the complexity of red meat supply chains with their many links, the large and diverse range of meat cuts, variation in product quality as well as the large number of potential markets, each with their own import requirements and regulations. Most of the blockchain technologies to date have been applied to more homogenous categories, which have far simpler, ambient temperature supply chains and less market complexity (e.g. designer apparel).

There is no off-the-shelf solution for a 'paddock to plate' product verification and tracking system, meaning that these systems are having to be built from the ground up by piecing together and adapting a suite of technologies. All three solution providers had to invest substantial amounts to develop their own technologies because there was nothing available that would solve the problems specific to the individual industries that they serve.

The challenge in setting up verified blockchain systems is complicated by the fact there are a large number of technology providers offering solutions that all promise seamless product

integrity and traceability. Commonly, most systems have significant gaps or shortcomings and in many cases, providers who come from other sectors lack appreciation of the complexity of fresh food supply chains (this point was reported by many of those interviewed for these case studies). A common challenge for the two progressive businesses in this study was in finding user-friendly interfaces, given that many of the parties involved in the supply chain have low levels of computer literacy and often basic English language skills as well as being in challenging production contexts (in this example it was on a remote fishing vessel in rough seas).

The other imperative for both these businesses was the need to minimise cost and not introduce new levels of complexity for supply chain partners. Even the off-the-shelf systems can require investment in new hardware and software, which can demand additional staff or skills training. The advantage of the Aglive system is that it integrates seamlessly with existing systems and data sources.

Case study 1: Learnings for the red meat industry

This case study on verified blockchain integrity systems provides a number of valuable learnings for the Australian red meat industry, which are outlined below.

1. There are multiple benefits

Although not yet fully commercially substantiated, a verified blockchain trading platform for red meat has a number of potential benefits:

1. It has the potential to reduce supply chain costs. In the Two Hands food service model, which includes a marketing platform, there is a reduction in the number of product movements and the associated administrative costs. The Two Hands model operates with a fixed percentage trading commission. By employing IoT technologies, the costs of operating the system are minimised. Two Hands claims supply chain cost savings of as much as 20%. The technology used also has the capability of managing the complex array of documentation that comes with export trading, further reducing administrative costs.

    The Two Hands marketplace model significantly increases the share of profit pool. With the current food service supply chain structure, up to 50% of the profit pool can be lost to producers as the intermediaries all take a cut of the profit in the export supply chain and the opportunity for corruption in hotel kitchens prevails.

    The reduced number of product movements in the Two Hands model reduces the exposure to product damage and compromised supply chain environments.

    The transparency of the supply chain is greatly enhanced because every party, right through to the end customer, can have visibility of the platform. Supply chain parties can know what the product is, where it is and what state it is in. This adds significant value to the customer in markets like China, which is likely to build loyalty.

    Relationship building is critical to building sustainable export markets. This integrity system enhances the capacity of the producer to identify the individuals involved in the purchase decision (because they need to be granted access to the tracking system) and make contact with them to develop direct business relationships that are not blocked by middlemen.

Global hotel operators are well aware of the kick-back incentive gifts or payments in food service kitchens and elsewhere in the supply chain. The visibility of this system reduces the opportunity for corrupt practises.

Verified blockchain systems have the potential to be used as a powerful tool to manage cold chain integrity because with the use of IoT devices, supply chain partners can identify anomalies and deviation from ideal conditions, which together with the application of artificial intelligence can provide a powerful diagnostic tool kit. This tool can be used to mitigate risk and identify areas of weakness in the system for improvement. This has potential flow-on effects such as reduced claims in the first instance, as well as reduced insurance premiums.

The platform will facilitate prompt payments and the virtual elimination of bad debts. With blockchain, depending on the trading terms, the invoice is paid once the customer scans the agreed documentation. With high value products such as premium red meat, this has considerable implications for cash flow and working capital.

Verified blockchain platforms that include QR or other codes provide a powerful marketing platform for the brand owner to tell their story, enhancing the consumer experience and building brand loyalty.

The potential to conduct direct and highly cost effective market research through the system is exciting. Because the chef and procurement managers have access to the dashboard, it may be possible to capture feedback from them directly. The producer is not relying on market signals that may have been diluted or manipulated by distributors. The consumer is interacting with the product at the restaurant table via the QR code, so immediate consumer feedback could also be captured and collated.

The credence factors generated by the enhanced product integrity such as visibility and transparency, add incremental value to the customer which is likely to enhance customer loyalty.

The improved product integrity reduces the potential reputational damage to all Australian meat, which could erode the premium pricing that is being achieved.

2. Some reasons meat businesses are reluctant to adopt block chain platforms can be refuted

A number of meat businesses interviewed as part of this project have, to varying degrees, examined or trialled blockchain systems and most had not followed through. The common reasons given for not taking up the technologies include:

"Solving problems, I don't have"

Many meat businesses believe that blockchain provides solutions to problems that they simply do not have whilst not addressing the problem that they are trying to solve. This belief stems from the fact that most are seeing verified blockchain systems as anti-fraud solutions and most (with the exception of some like Macka's who are trading branded packs) do not believe that they have a significant fraud issue because they are working through closed-loop supply chains over which they have a high level of visibility. Few see verified blockchain with IoT devices as a supply chain management tool, and have not thought of it as a transactional platform reducing payment time and bad debt. To date,

there have been few attempts to apply blockchain technology as a trading platform because, to the extent that meat businesses have considered blockchain or IoT technologies, it has been more strongly motivated by improving product quality.

Cost and complexity

The belief of many meat businesses is that the integration of blockchain platforms adds significant cost and complexity to the business, requiring a total reengineering of systems and processes, which would be very disruptive. A major issue here seems to be the incompatibility of software systems. The apparent advantage of systems such as the Aglive model is that are simply focussed on data collection with blockchain storage. The Aglive solution interfaces with many existing meat industry systems, reducing the need to invest in additional systems, training or technology costs.

Reliance on the integrity of supply chain partners

Some meat businesses mistrust the integrity of blockchain on the basis that it is reliant on third party supply chain actors to input data, which therefore, opens it up to the risk of actors deliberately or erroneously inputting incorrect data, which defeats its purpose. The other belief is that once there is incorrect data entered into a blockchain system, it cannot be corrected. The Aglive system that is being enhanced through the partnerships with both Two Hands and Macka's, relies on the data being uploaded by IoT devices (in this case, SensaData and/or Ceres Tag), with virtually no human intervention. The technology does have the potential to greatly reduce the incidence of product fraud. However, this advantage comes with the caveat that Aglive uses a KYC (Know your Customer) approach through which their technology works with trustworthy parties. If brand owners trade into undisciplined channels, such as wet markets, it is virtually impossible to prevent fraud.

3. The potential application of a smart tag at the industry level

The learnings from this case study suggest that the potential exists to apply some type of smart tag verification system at the industry level. Given that Australia's competitive advantage in export markets is built around product integrity and that the NVD and NLIS provide sound foundations for Australia's traceability system, this could be taken to the next level by introducing a national smart tag verification system. The functionality of the smart tag system would need to be developed with industry input, but the starting point could be a basic system that verified Australian provenance.

Obviously, the introduction of such a system would need to be subject to a business case and a process of industry engagement that examined more closely the nature, extent and impact of the fraud issue, because many in the industry feel that the fraud events are being significantly overstated or are only relevant in the China market.

Case study 2: A blockchain supply chain management system

About this case study

The Argyle Food Group (Argyle) case study has been selected because it provides a good illustration of the development of a bespoke blockchain product integrity and inventory management platform. The Argyle traceability solution, created and operated by KPMG, is currently being implemented in their export beef supply chain.

The integrity system	Blockchain product verification and supply chain management
The applications	Proof of provenance, supply chain process efficiency improvement, inventory management, financial management, fraud elimination (longer-term potential for processing in China)
The problems being solved	Lack of transparency and trust, lack of provenance information, limited access to working capital
The parties	• Argyle Food Group • KPMG • IOT Tracking Device Company

Argyle Foods Group is one of the few established meat businesses that has committed to invest in the implementation of a blockchain platform. Many meat businesses have looked at blockchain and other related IoT technologies but have dropped their plans or have put them on hold. The issue is that they do not see the value in the technologies believing that the key function of blockchain is to eliminate fraud, which most believe is not a significant issue because they are dealing with trusted customers which they are servicing through closed-loop supply chains involving trusted partners.

This case study demonstrates that it could deliver bankable, flow-on benefits including the ability to finance inventory, cost savings from improved supply chain management and extended shelf life (completion being subject to the development of a successful commercial model) and improved access to future markets which require provenance.

Importantly, the impetus for Argyle Foods Group's decision to invest in the implementation of a blockchain traceability solution has largely been increasing pressure from one very large global retail customer in China. The customer was requiring more rigorous systems of verification of authenticity of the product range, given the substantial premiums they were paying for Australian red meat compared with products from other countries. This is a significant point because it may indicate the beginning of a shift whereby major supermarkets will all soon require trusted blockchain traceability platforms as a condition of their supply agreements.

Although verification of provenance is important to the company as well as its customers, Argyle Foods Group needed to receive benefits beyond provenance alone to justify the investment. Although the major retail customer was pushing for blockchain, they have not

indicated a preparedness to pay any more for the meat, meaning that there would need to be other paybacks.

Argyle Foods Group

Argyle Foods Group (Argyle) is a vertically integrated breeder, fattener, processor and value-adder of beef and lamb. The company markets free range, premium quality, chilled and frozen beef and lamb as well as grain-fed Angus, non-Angus and Wagyu products to major retailers and food service distributors, mostly through on-going programs that deliver customised product for specific customers. Argyle services both domestic and overseas supermarkets and food service distributors under a combination of proprietary brands and customers' own brands. Argyle has branded product in over 3000 retail outlets world-wide in markets including China, Hong Kong, Macau, Singapore, Taiwan, Cambodia, Japan, Vietnam, Thailand and South Korea. It also markets trimmings into the US and operates a distribution and sales facility in Hong Kong in partnership with a strategic shareholder.

Argyle trades through a closed-loop supply chain in Australia, producing cattle on its own farm in Southern NSW as well as sourcing from eight approved and audited partner producers who have access to its genetic line of Angus cattle, which dates back to the early 1900s. The company operates a service-kill and value-add model, working with several supply chain partners, all of which are subject to audit by the major customer groups. The company operates a value-adding, retail production room in a joint venture with a large processing facility in northern NSW that processes Australian product.

Motivations to invest in the implementation of a blockchain traceability solution

The decision to invest in the implementation of a blockchain traceability solution has been driven by three factors:

1. Increasing customer demands for verification of provenance
2. To drive process improvement, particularly through harmonisation of operating systems
3. For financial reasons, increasing the availability of working capital.

These three factors are explained further in the following pages.

1. Verification of provenance

The driving reason for investing in the implementation of a blockchain traceability solution came from increasing pressure from a major retail customer in China who was demanding more rigorous verification of the Australian provenance, in the face of large amount of fraud that was occurring, which was undermining shopper confidence in the product. Increasingly, retailers and distributors are asking for blockchain verification and tracing systems. Many believe that in time, trusted traceability will become a condition of trading terms.

For Chinese consumers 'origin' is believed to be the most influential factor in the purchase decision hierarchy. Australian beef is preferred over product from other countries because of its safety, 'clean and green' production and disease freedom status. One of the most

important aspects of this is trust in the integrity of Australia's food supply chains. China currently imports red meat from 11 countries and often cheaper and inferior product is being fraudulently labelled as being Australian. This issue comes at a time when competing countries such as New Zealand and Brazil are improving the quality and integrity of their products, further increasing the pressure on Australia to lift the bar even higher in terms of product differentiation. The competitive pressure point is the fact that Australian beef still sells for up to double the price of product from competing countries. These global supermarkets in China service very affluent shoppers who are demanding more evidence of product authenticity, meaning that a consumer-facing, trusted source of authenticity back to Australia was becoming more critical.

Argyle has a high degree of visibility of their supply chain across the Australian links, because it works with trusted partners and is subject to supermarket and other industry audit trails. The visibility issue is largely in export markets, particularly at the China end of the chain from the point of landing at the port through to the supermarket shelf. The issue is that the product is carried by third-party logistics companies, through third-party warehouses and distribution networks, over which Argyle has no visibility.

Although Argyle has good internal traceability from the processor back to the farm, the problem is, that to a large extent, visibility is lost from the processor to the customer as the product passes through the custody of third parties in the supply chain. What is needed is a tamperproof labelling system linked to a blockchain traceability solution that connects all the way through to the consumer.

The need for a reliable and trusted traceability solution will be elevated to a new level when Argyle starts value-adding through a facility in China, which has the potential to introduce an escalated level of doubt in the minds of the customer and the shopper due to the risk of product substitution.

2. Process efficiency improvement

The second factor driving the intention to invest in the implementation of a blockchain traceability solution was to improve operational efficiency. The company had a major issue with incompatibility of the various Enterprise Resource Planning (ERP) systems. Different operating systems were being used by various supply chain partners which introduces a great level of complexity. The inability of these systems to talk to each other increases the back-office resource requirement. It means that much of the paperwork has to be uploaded manually, but more importantly, much of the valuable data associated with a particular product is lost in the transfer process as it flows through the supply chain. This was particularly problematic with respect to inventory management which was complex given the wide range of products, markets and customers. The management of the commercial and compliance documentation also required a large amount of human input, which added to cost and exposed the system to increased human error.

3. Financial drivers

The third reason for investing in the implementation of a blockchain traceability solution was financial. The need was to finance inventory in order to increase the available working capital so the business could scale up to meet growing customer demand. Under present trading arrangements, it is not possible to get trade finance for inventory from the time of processing until the point where the product departs from the port, primarily due to the siloed nature of existing financiers and also because financiers are not satisfied with the level of security over the asset due to the fact that they do not have sufficient visibility of its quality and ultimately it's value. Exporters are required to repay livestock purchase loans before they can access receivables against the export sale, leaving a finance gap in between.

Blockchain provides immutable proof and increased trust in the value of the inventory asset, which is bankable in its own right. Financiers will only finance inventory when there is trusted, documented evidence of its existence, the location, quality and value.

Inventory requires a significant amount of working capital in meat businesses given the extended time delay between the farm and the end customer, which is particularly long for a grain-fed, exported product. The issue is that the value of the inventory grows exponentially at each point in the supply chain. For a large meat business, at any point in time, the value of inventory within the supply chain will be in the millions, which at present must be covered by costly working capital.

The financing of meat inventory is quite complex given that the financial products tend to be very siloed with different financial institutions offering products specific to a particular point in the supply chain (e.g. on-farm versus product in the chiller). The issue for Argyle is that a trusted system of inventory management across the fully vertically integrated business and its supply chain is very difficult to find, particularly from the point of processing to the point at which the customer purchases the product. Where it is available, it is costly because of the added risk factor. Financiers are particularly cautious about financing inventory and require robust reporting systems with immutable evidence of the nature, location, custody and value of inventory.

Generally the assets of the business are used as collateral for most finance. The proposal with a blockchain traceability solution is to be able to give permission for data to be shared with a trusted financier who would then have full visibility over the inventory and would therefore be able to use the actual inventory asset as collateral. The financier can issue a line of credit automatically in near-real time, enabled by the data shared from the trusted blockchain traceability solution. Ultimately, the inventory itself will become a bankable asset.

Evaluation of options

With MLA's support, Argyle Foods Group has conducted substantial research on the various traceability solutions (both those currently on the market and in development), to identify the most appropriate system for its purposes. A number of systems were reviewed and assessed against four criteria:

1. **Scalability** - both within the Argyle supply chain and the wider industry supply chain

2. **Comprehensiveness** - the ability for end-to-end traceability from farm to consumer

3. **Agility** - the ability for the traceability solution to work in the complex and highly dynamic Argyle supply chain with existing operational systems

4. **Implementation time** - the ability to integrate and implement within a reasonable timeframe.

As a result of the evaluation, Argyle has selected two parties to work with to develop the platform:

1. **KPMG Origins** – a commodity agnostic blockchain based traceability platform

A provider of IoT tracking devices - to collect and upload objective, real-time tracking data for products throughout the supply chain.

The planned solution

The solution is currently being implemented in the Argyle export beef supply chain. The schematic following provides an indication of the proposed design.

Figure 6: Argyle Foods Beef Supply Chain – Export Example
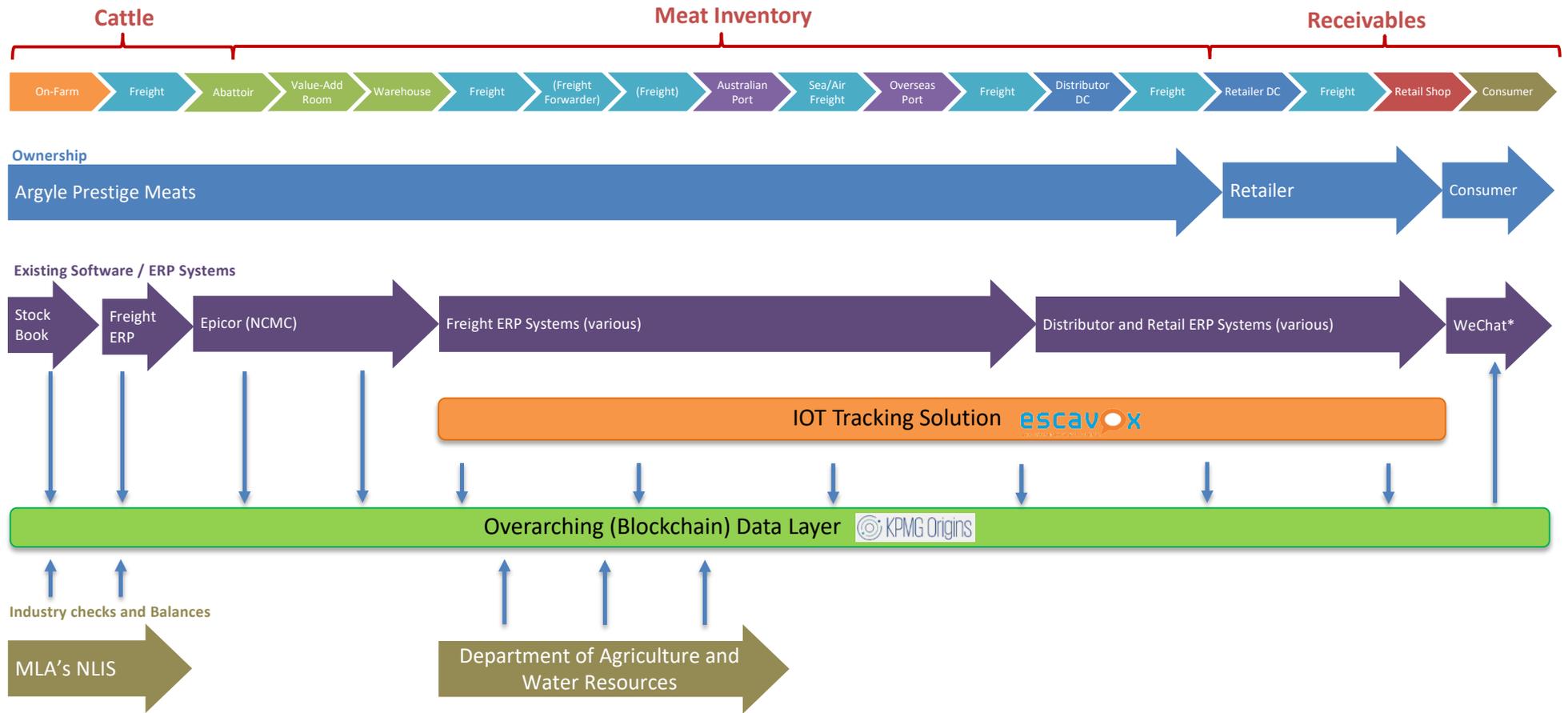
Provided by Argyle Foods Group

The planned solution continued . . .

The KPMG Origins platform will provide an immutable blockchain data layer with validation provided by third parties such as IoT devices, certifiers and government agencies. The commodity-generic traceability platform enables data sharing in a trusted environment with transparent governance and is being developed with the intention of being adaptable for any agrifood supply chain. The platform is essentially a data ledger stored on blockchain that captures existing data collected by supply chain partners. It assists users to standardise, collate and share data.

Without a trusted traceability solution, there is a large amount of work involved to implement data sharing along a supply chain, due to a lack of standardisation. For example, it is critical that the data is standardised to provide a common language for all parties in the chain. Each supply chain partner has their own company ERP system which uses unique language. Even if all users had the same system such as SAP, different parties use different terminology in their internal systems to describe what is essentially the same data point. The traceability solution reduces the amount of required work by providing a standard for each supply chain partner to integrate their data with, forming a standardised data set that is easily sharable.

It is important to note that a blockchain does not verify data, it is totally reliant on the accuracy of the data provided and inaccurate data cannot be corrected once it is on the blockchain. A traceability solution is however able to collate multiple data points from different sources, which when combined, can be used to assess the integrity of the information (for example, combining data from an ERP and IoT device to check that they both have a common location). The Argyle solution will start with the NVD and the NLIS, which with the integration of the 'Stockbook' livestock management tool, will provide a comprehensive profile of the history of the animal, including feed inputs and veterinary treatments.

The platform will have the capability of being integrated with the processor partner's Epicor ERP system as well as those of the various third-party logistics providers. If required, Argyle would also be able to integrate data with any other blockchain providers that their customers may be using.

Argyle is still working with its processor partner to develop the detail of the traceability through the challenging processing and boning stages. The most likely solution will be to process in batches of products of a particular specification or product claim e.g. grass-fed, hormone-free, antibiotic-free Angus cattle. At this point in time, it is believed that it is not economical to trace down to the carcass level in the boning room because the customers are not prepared to pay the additional costs involved and are not asking for it. The batch approach is potentially problematic for small batches (the standard processor batch is 42 cattle), because processors will need to charge an extra amount which will be difficult to pass on to the customer. This does not pose a problem for Argyle because most of their batches are large enough to do this.

The tagging system in this model is being assessed and is yet to be confirmed, but is likely to be a QR code on the packaging linked to a particular product claim via the blockchain traceability solution.

The solution will be designed to ultilise existing standards such as NLIS, MSA and GS1, which is the global traceability standard required by major supermarkets.

The product will be tracked through the supply chain using the IoT tracking device, which will be placed in each shipment to capture a time, temperature, location, custody and cold chain integrity score. All of this data will be uploaded to the blockchain traceability solution via an IoT device. The IoT tracking system provides a data set completely independent of the various ERP systems. This device provides the ability to independently verify the product status outside of the supply chain partners' own ERP systems. It also allows customers and supply chain partners to check the status of the product in the supply chain.

Note: A fuller description of a similar IoT tracking device system is contained in Case Study 3 on Cold chain management and shelf life.

The following is a representation of what a product dashboard is likely to look like:

Figure 7: Product dashboard
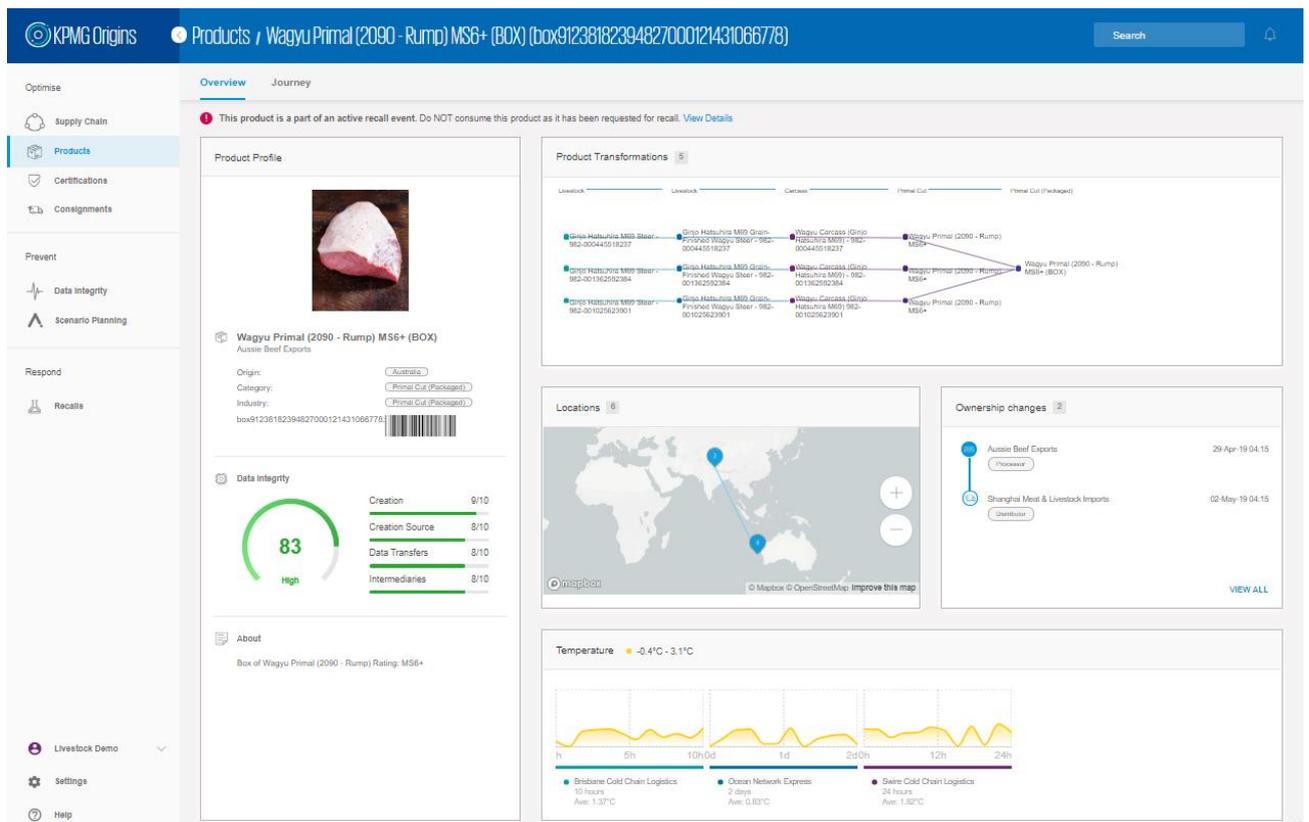
Image supplied by KMPG

Additional features are possible

By applying an algorithm developed by MLA/UTAS that gives an accurate prediction of shelf life based on temperature history in transit, it is possible to accurately predict the shelf life of red meat (Lyons, 2020). With that knowledge applied to the traceability solution data set, an improved inventory and shelf life management capability will afforded by the system that will reduce wastage and improve profitability.

KMPG is also currently collaborating with financiers to implement permissioned sharing of inventory data from the traceability platform that would enable financiers to create data-driven inventory finance solutions. For Argyle, this would enable increased access to working capital from the point of processing to shipment.

Further to these benefits, the intention is to also introduce an AI scenario planning capability which, as an example, could be used to find alternative pathways for a shipment in the event of a disruption in the supply chain, or the optimal way to replenish stock after a food safety recall event. AI scenarios can be worked into the system to advise exporters on the implications of a wide range of possibilities.

Case study 2: Learnings for the red meat industry

Although still in the implementation stage, the Argyle experience to-date provides some valuable lessons for the industry:

1. **Conducting adequate research**

An important lesson to come from the Argyle Foods Group experience is the critical importance of sorting through the mosaic of technologies on offer to find the optimum solution to suit a business' individual needs. There are a large number of technology companies marketing product integrity, traceability and supply chain management solutions, often making inflated claims about their capabilities. Many of these systems do not accommodate the complexity of the red meat category and its supply chains. At this point in time, there does not appear to be any complete end-to-end off the shelf solution for meat businesses. As a consequence, it is necessary to integrate various components from multiple suppliers to create a comprehensive solution. Finding the right combination to suit the needs of each business is critical. As the systems develop and adoption levels grow, these solutions will become more comprehensive and it is likely that the cost of these technologies will come down.

2. **Anticipating retailer demands**

It is likely and perhaps inevitable that global retailers will increasing apply pressure to provide progressively higher levels of proof of provenance as a condition of their supply agreements. Although the issue of fraud is predominantly occurring in China, in time, as retailers see the flow-on benefits of blockchain traceability solutions unfolding, they will put pressure on suppliers to implement the platforms for all countries as a condition of business. Many in the industry believe that it is inevitable that supermarkets in Australia and overseas, will demand blockchain verification. Given the market power of

supermarkets, it is likely that much of the cost burden of its introduction will need to be carried by suppliers. This being the case, it is important that meat businesses can leverage value additional to the provenance proof, through process efficiency improvements as well as financial and cashflow benefits.

3. Factoring the flow-on benefits into the business case for investment

From the industry engagement conducted as part of this project it became apparent that the cost and the disruption involved in the introduction of blockchain systems are a major barrier to adoption. A key learning from this case study is that for the investment in blockchain solution implementation to be justifiable, there needs to be a benefit beyond just provenance. Although customers are increasingly demanding proof of provenance, they are unlikely to pay for it.

One of the important factors for Argyle in the development of their business case to invest in a product integrity system was the ability of the system to overcome the major burden of working capital in order to scale the business and meet customer demand. They were not able to finance inventory from the point of processing to the point of the shipment leaving, because the inventory was not bankable. A blockchain traceability solution enabled this problem to be addressed, plus it created other potential flow-on benefits of improved financial returns from extended shelf life and inventory management.

4. The potential to leverage 'big data' exists by standardising systems and language

This case study highlights that a key challenge to overcome for those contemplating this investment is being able to integrate the diverse range of ERP systems used by supply chain partners and customers. Blockchain traceability solutions need to establish standardised data to operate effectively and achieving standardisation can account for a large part of the investment required to adapt a blockchain traceability solution. However, once this challenge is overcome, collectively these various ERP systems provide a massive and powerful data set which could be applied to create a big data capability to which AI could be applied to streamline supply chain management. At present much supply chain data is lost because of the incompatibility of partner systems and inability to share via a trusted solution.

Case study 3: A holistic cold chain management system

About this case study

The intent of this case study is to showcase the evolving technologies around cold chain and shelf life management and their potential application to the red meat industry. This case study also features the Escavox smart tracking technology (see Case Study 2), although there are other service providers with similar technologies. This case study demonstrates how the system is being used to manage cold chain in the mango and avocado industries. These two horticultural industries have been selected because they have been at the forefront of technology adoption.

The application	A holistic cold chain management system that provides 'whole of cold chain' visibility
The problem being solved	Loss of product value through mark downs and shrinkage Waste in the supply chain
The parties	• Australian Mango Industry Association • Australian Organic Meats • Avolution • Escavox
The integrity system	A real time cold chain monitoring and analysis system

Data logger systems

Data logger systems for monitoring temperature and location have been in use for cold chain management for many years. To date, most of the data logger systems have been of the passive type whereby data can only be retrieved at the end of the journey and extracted by downloading it manually onto a computer. Furthermore, most of the early versions did not have the capability to record additional data such as location and custody.

Most red meat companies use passive data loggers largely as a defence or risk management tool. In the event of a breakdown in the supply chain, the exporter has proof of where this occurred and can assign liability and make a claim. Typically, the data loggers were only intercepted in the event of a problem and most were only used once because of the cost and effort of returning them.

Feedback from the interviews conducted with red meat exporters as part of this project suggested that red meat companies treated cold chain management with only passing interest, on the basis that their responsibility ended once the product left their premises. Most said that they only became interested when there was a breakdown or a claim by a customer.

Successfully pursuing a case of cold chain mismanagement against shipping companies, airlines or freight forwarders is becoming increasingly problematic because of the wording of contracts and as a result, claims against these parties are only seldom made because of

the relative ease of claiming against the insurance coverage. However, excessive claims also lead to significant increases in insurance premiums over time.

Compared to other industry sectors, notably dairy and fresh produce, the meat industry has been reluctant and slow to embrace these emerging active cold chain management technologies. There are two reasons for this:

1. The cost

2. The fact that food poisoning is nowhere near as big a risk in red meat as it is in other more highly perishable products because meat becomes inedible before the stage that it poses a significant food safety risk.

Early versions of the active data loggers cost around $200 each plus the cost of returning them. This perceived high cost has been met with resistance from the meat industry, which is somewhat surprising given that it is a minute expense relative to the average value of a shipment of red meat. However, to put this into perspective, a major meat exporter would be shipping thousands of containers per year requiring many data loggers plus breakdowns in the red meat supply chain to the extent of causing food safety risks are relatively low and can be mitigated through insurance.

There has been a shift in focus from food safety to shelf life and wastage in cold chain management

Over the past five years, cold chain managers have shifted focus towards efficiency improvement, shelf life maximisation and wastage reduction. Food safety is now taken as a given in Australia. Cold chain management has taken on greater importance for perishable food companies because of the cost to the industry of an integrity breech or inefficiency. Effectively, the cost of food wastage is driving perishable food companies and their cold chain suppliers to move from a 'risk management' mindset to a 'proactive' mindset. By definition, cold chain involves several links where the custody of the product changes. The link between cold chain temperature fluctuation and shelf life is now scientifically proven, particularly when there is a sharp variation in temperature, which can occur for example when a container refrigeration unit is unplugged in transit.

The intent of cold chain management systems now is to proactively and positively engage each link in the supply chain to take responsibility while the product is in their custody rather than playing the blame game. As a consequence, the major suppliers of refrigeration services and products and major perishable food companies have formed the Australian Food Cold Chain Council (AFCCC) which serves to advocate and drive innovation and compliance to reduce waste and improve food safety in Australian food cold chains. Effectively, this has stimulated a change of philosophy regarding cold chain management from an adversarial to a partnership approach. The intent of the AFCCC is to embrace all stakeholders in the cold chain with the intention of sharing responsibility for the outcomes in recognition of the fact that custody and responsibility changes several times in the cold chain and that the final outcome is a reflection of their collective behaviours. It also reinforces an industry-wide culture of continuous improvement. Central to continuous improvement is the critical importance of sharing information and providing all parties with complete and open visibility.

For highly perishable food companies, a breakdown in the cold chain imposes significant food safety risks. However, what is becoming more important is the wastage issue, because a small compromise that does not jeopardise food safety, can still impact shelf life necessitating wastage and price discounting when product gets close to the use-by date. This latter factor is being heavily driven by the major supermarkets where the continual need for price discounting is heavily eroding profit margins. For perishable foods, supermarkets typically factor an additional 10% margin to cover mark downs and wastage which dilutes their profit.

It would appear the meat industry is lagging behind other perishable food categories in proactive cold chain management. Many in the red meat industry grossly underestimate the significance of wastage in the supply chain due to cold chain breakdown.

A report commissioned by DAWR and Refrigerants Australia (Expert Group, 2020, p5) estimates that 3.5% of annual red meat production is wasted in the supply chain due to cold chain breakdown. This wastage amounts to 155,000 tonnes with an estimated wholesale value of $670 million. Ultimately, this cost is being absorbed by the industry, largely in the form of hefty insurance and rising premiums.

Active data logger technologies

The technology of active data logger systems is evolving rapidly. This is largely being driven by the growing interest from perishable food companies and their cold chain service providers. At the centrepiece of this emerging technology is the 'active, and real-time data' aspect, because the devices now enable uplift of comprehensive data on the status or location of product via IoT devices. This enhanced information provides stakeholders with a comprehensive picture of the product as it moves through the cold chain.

The capabilities of the active data loggers are continually evolving and include time, temperature, location and custody. The next generation of devices will include shock and movement, light, atmosphere and the presence of gas. The newer systems will be able to be customised for each commodity. Escavox is one of a number of companies developing these technologies.

Escavox

Escavox is a relatively new company (established in 2018), that provides supply chain management services. Escavox is a Latin derivative meaning 'voice of the food'. The centrepiece of the Escavox system is a tracking device that is placed in the cartons during transit and transmits real-time data on time, temperature location and movement (when in the range of a mobile phone signal). The tracker takes a reading every 15 minutes and transmits every 30 minutes. Even when outside of mobile phone range the data is captured, held, then downloaded once it re-enters telephone range. The devices are reusable and at the end of the shipment they are returned to Escavox where the unit is recharged and checked for reuse.

Figure 8: Escavox active data logger

Source: Image provided by Escavox

If required, the device can stay with the shipment right from the point of packing to the point of unpacking on the supermarket shelf, providing comprehensive visibility for the entire journey. The data is then used to generate dashboards of information, tailored to each customer's needs, which can become a powerful cold chain management and diagnostic tool. The data can also be applied to algorithms which accurately predict the shelf life of the product. The dashboards can be readily monitored on smart phones.

As required, all stakeholders in the supply chain can be given visibility of the Escavox dashboards if granted access to the website. The intention is, that by openly sharing the information, each party can better understand its performance, which will automatically drive positive change.

Escavox charges on a per track basis, which includes the hire of the device and access to tracking data through dashboards. If further customisation of the system and the dashboards is required, this is charged commensurate with the work entailed.

## The Australian mango industry experience

The Australian Mango Industry Association (AMIA) began using the Escavox services last season. This application was initially in the domestic market, but the intention is to also adopt it for export shipments.

Mangoes are a highly perishable product with a very short saleable shelf life once ripened. As a consequence, there is a high level of wastage and price discounting at both the wholesale and retail level, which erodes the profit pool for growers. Ultimately this loss is passed down the supply chain to the grower.
The mango supply chain involves the following steps: orchard, grading, packing, pre-chilling and shipping to a ripening facility close to the markets, then on-shipping to retailers and wholesalers. Last season AMIA tracked 82 mango shipments from all parts of Australia, most of them quite remote locations. Each track was assessed against the industry

recommended temperature range for the specific leg of the journey, right through to the supermarket distribution centres. The following is the dashboard for a track from far North Queensland to Alice Springs:

Figure 9: Escavox tracking data for mango shipments
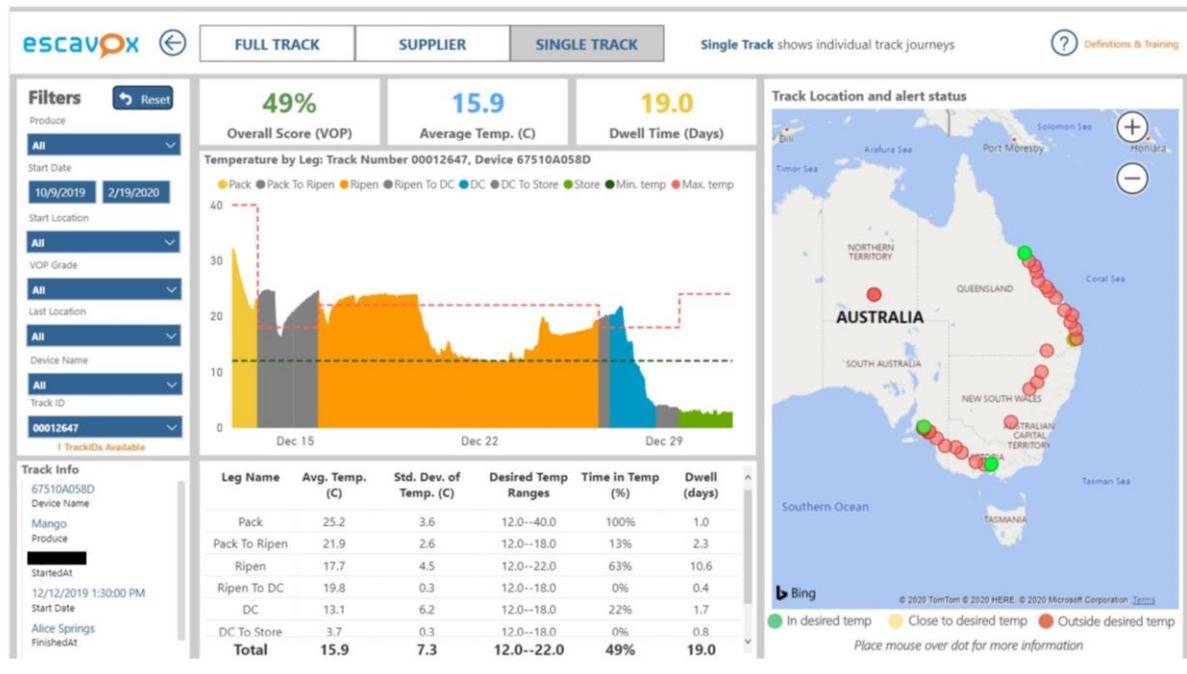
Source: Image provided by Australian Mango Industry Association

The results from this track show that the journey lasted 19 days and the product was only in the ideal temperature range for 49% of the time. This percentage figure is referred to as the Escavox 'voice of product' (VOP) score.

The results for the overall trial indicated that only 15% of the product stayed within the recommended temperature range and 49% of the product was in the 'very poor' range. The analysis indicated that the breakdown was largely due to poor product preparation and inadequate pre-cooling, although there were also significant issues detected at the ripening stage. Industry separately reported issues at supermarket DC. The data highlighted supported the fact that the industry is grossly under-resourced in terms of on-farm cooling.

Because mangoes have a short, sharp season with very high volumes of product needing to be moved within a few weeks, most farms tend to be under-resourced in terms of refrigeration because of the large investment it entails. This research clearly highlights to the industry, the critical need for investment in refrigeration capacity. AMIA is using the resulting information from these trials to develop a best practice cold chain manual and is working with all supply chain parties to improve their systems. It is also encouraging individual businesses to invest in the system on an ongoing basis.

The avocado marketing experience

The situation for avocados is very similar to mangoes, in that avocados have a short shelf life once ripened. Avocado ripening is triggered once the fruit reaches a temperature above 12°C.

Avolution is one of Australia's biggest marketers of avocados in Australia trading 20% of the domestic market share. The company has been using the Escavox system for the past eighteen months to track shipments through the domestic supply chain and in more recent times, for monitoring export shipments. In the first season of use, the devices were used right up to the point of delivery to the supermarket distribution centre.

Avolution has been using the Escavox system to engage supply chain partners to improve practices and reduce wastage. It is also able to use the technology to manage inventories.

Figure 10: Avolution usage of the Excavox tracking device
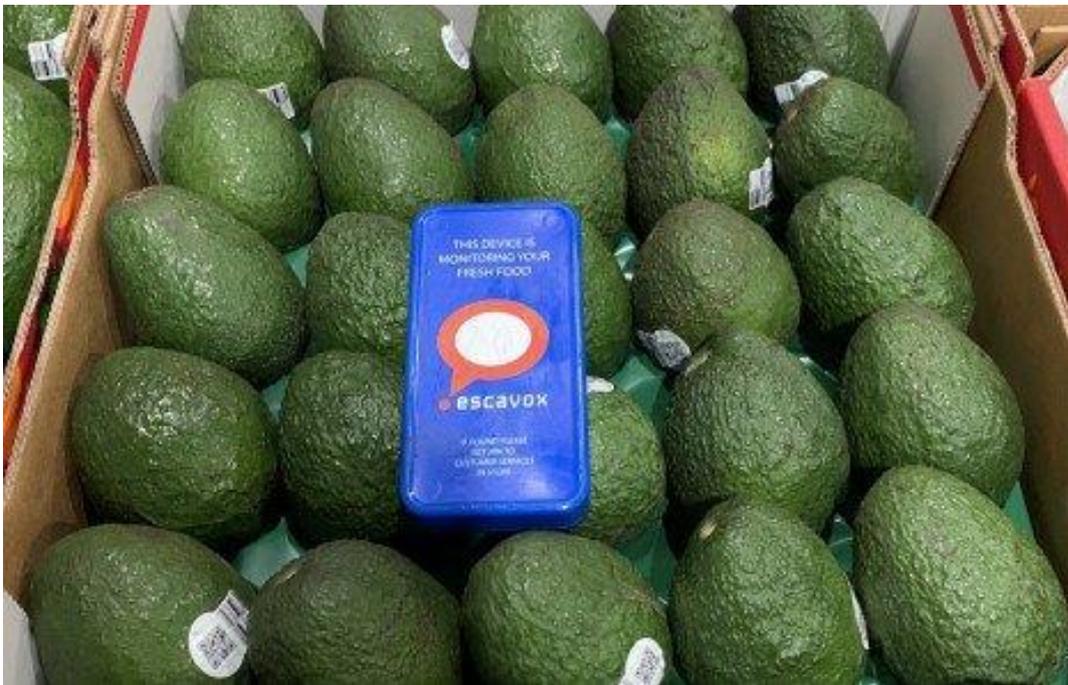
Source: Image provided by Escavox

Antony Allen, Chief Executive of Avolution, indicated that gains from the usage of the system for his business were being achieved by assessing every link in the cool chain from packhouse to retail shelf and making quick adjustments as the information is relayed in real time. He summarises this as follows:

"It's like a closed-circuit television for your supply chain,"

"For us it's a tool that gives us the information to share with all of our supply chain partners so that we can do better at every point of the supply chain journey."

Australian Organic Meats

Australian Organic Meats is a marketer of certified, grass-fed beef and lamb, supplying both domestic and export markets. The company has retail-ready programs in South Korea, Middle East, Singapore, Hong Kong and the USA. Australian Organic Meats has just started to work with Escavox on a project to improve shelf life performance through using a verification device to track the temperature state in transit. The impact of temperature variation on shelf life is well established scientifically in the work by University of Tasmania (outlined in the following pages).

Shelf life is always a key consideration for any retail executive making choices about entering into a supply program. It is the personal experience of the executive with that product which ultimately influences their decisions to range or not range it. Their decision, therefore, is not always based on science. An evidence base is required to enable the executive buyer cohort to better understand shelf life and how to maximise it with the aim of eliminating shrink and factoring 'just in time' market risks. The current lack of understanding of the impact that cold chain management can have on shelf life in the USA retail environment is limiting the opportunity for both the supplier and retailer to retain additional margin. This situation ultimately hurts Australian meat producers.

Managing inventory is always a challenge for retailers, particularly with retail ready product because of the day to day fluctuations in demand for particular cuts. Having a longer shelf life gives them more room to move. Shelf life is particularly a challenge with markets where there is a long transit time such as the USA. Supermarkets routinely factor in an additional 10% margin to cover 'mark down' discounts and shrinkage. The full cost of the discount is effectively passed on to the marketer and ultimately the producer as part of the trading terms. To put this discount into context, a shipment with a wholesale value of $150,000 and a resale value of $300,000, is estimated by the customer to have 10% leakage for price discounting, which is a $30,000 cost due to poor supply chain management.

Australian Organic Meats wishes to better understand at which point in the product journey that the temperature state is being compromised and why this is occurring. Once it determines the breakdown points, the company can then work with its supply chain partners and customers to address the issue. Often the breakdown actually occurs when in the customer's custody.

The data collected using the Escavox device will provide a detailed evidence base of the product's status in transit. This data will also shine a light on the level of care and attention from supply chain partners in transit, including airlines and sea freight companies who had become complacent. The evidence base will also provide the additional benefit of minimising insurance claims and ultimately safeguarding against rising insurance premiums. A further motivating factor for Australian Organic Meats in implementing the Escavox system is that correct temperature and handling in the cold chain will be able to deliver an additional seven-day shelf life. This extra 7 days will give customers in the Middle East the

confidence to transition to sea freight from air freight, which would significantly reduce freight costs. It is a condition of market access into some Middle Eastern markets that there must be a minimum shelf life remaining at the time of arrival. AOM are confident that the improvements in cold chain management made possible by real time cold chain monitoring will make sea freight feasible.

The MLA shelf life trial

Over the past few years the University of Tasmania, in partnership with MLA, has been working on a method to improve the shelf life of beef and lamb (Kaur *et al,* 2018). The project has involved a series of trials with commercial parties to investigate the methods of extending shelf life.

The research has been used to develop an algorithm to predict the shelf life of product based on a combination of microbiological research and sensory analysis. The initial trials show a very high level of accuracy in predicting shelf life.

Australian Organic Meats as applied the UTAS/MLA shelf life algorithm, calculating that by improving cold chain management through working with its supply chain partners, it can achieve an additional seven days of shelf life, which greatly reduces wastage and the need to rush to prepare orders for shipment.

MLA has supported a trial with Escavox to define the commercial benefits of continuous tracking of red meat supply chains (Lyons, 2020). The trial tracked 100 supply chains across abattoir to processor; processor to the store; and DC to store. The MLA/UTAS algorithm was used to predict the product shelf life for beef and lamb. The study findings highlighted the high degree of temperature variation in the supply chain, particularly with long haul transport, which was significantly reducing product shelf life.

The following are some examples of the dash boards from that trial as used for Australian Organic Meats.

Figure 11: Example of MLA Shelf life algorithm
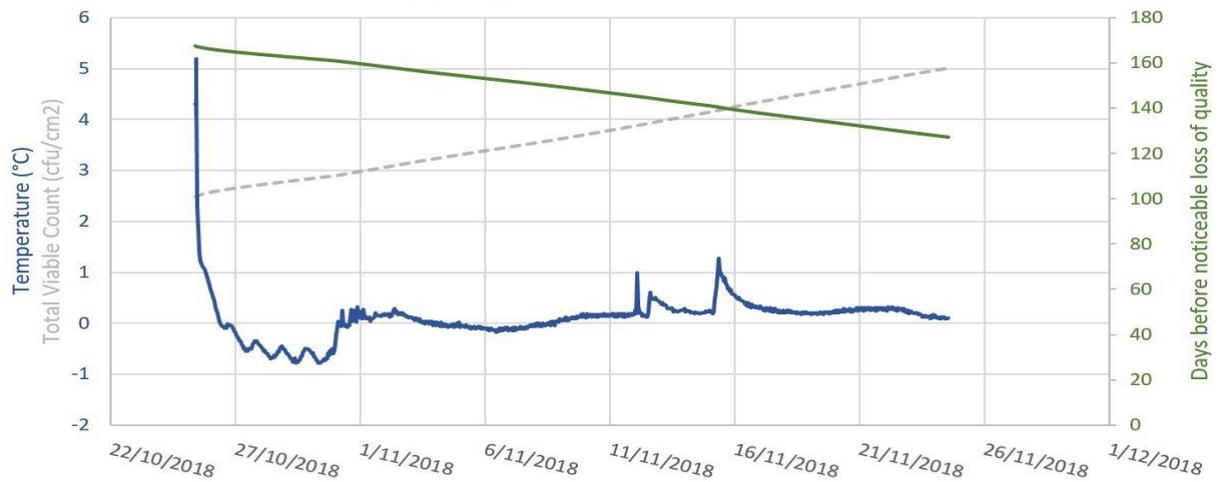
Source: As presented in Lyons, 2020, MLA Project P.PHS.1216.03.2

Figure 12: Information dashboard 2 showing aggregated data of 10 supply chains from abattoir to retail store
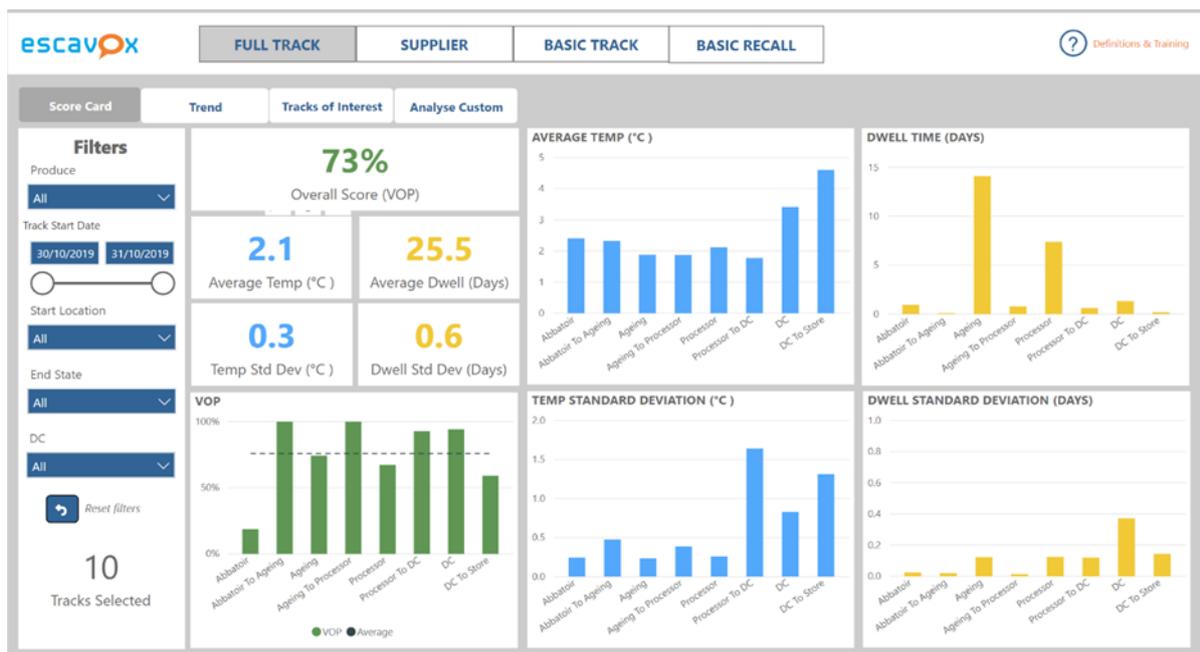

Provided by Escavox with the approval of AOM

Figure 13: Track from abattoir through to retail store, device moved from primal to retail ready pack at processer/value adder plant with remaining shelf life days
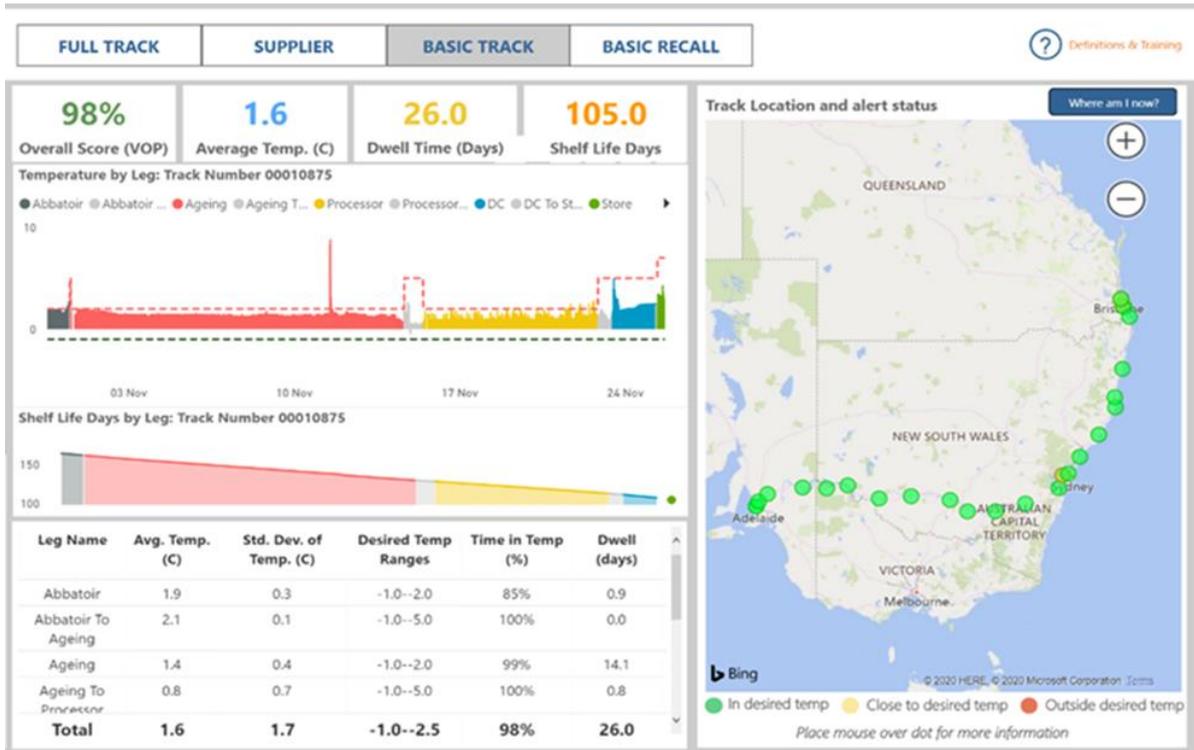
Provided by Escavox with the approval of AOM

Figure 14 : Information dashboard 4 showing aggregated data of 77 tracks across Australia wide sample of supply chains from abattoir to retail store
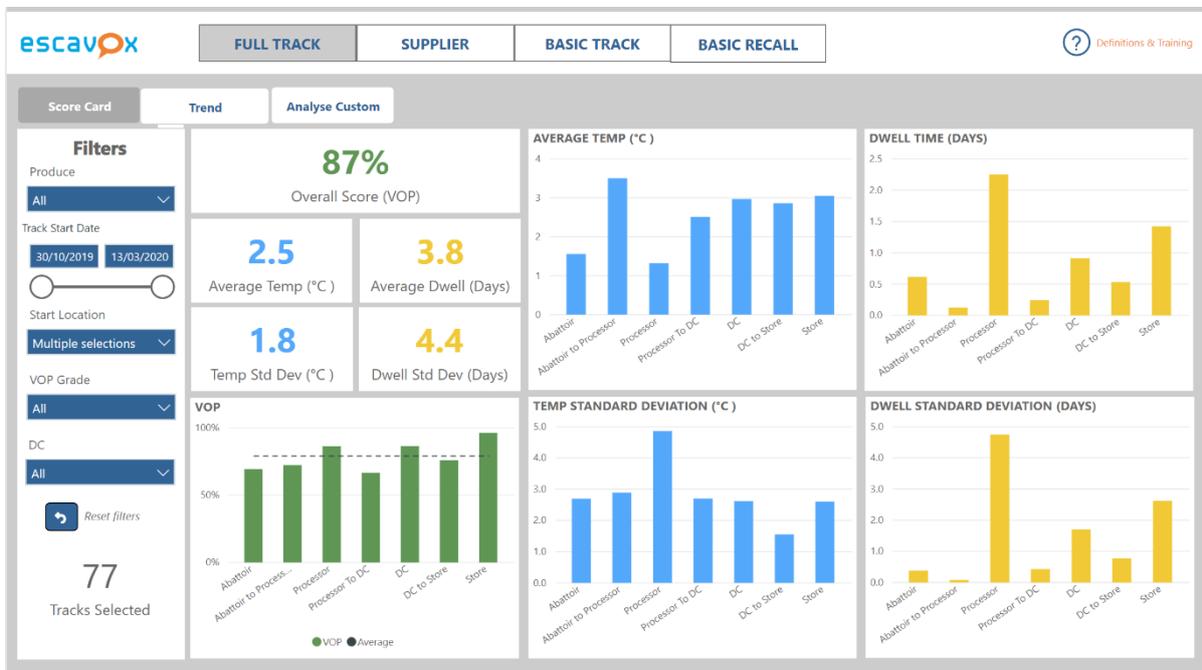
Provided by Escavox with the approval of AOM

Case study 3: Learnings for the red meat industry

This case study provides a number of valuable learnings for the Australian red meat industry which are outlined below:

1. The Australian red meat industry appears to be falling behind most other perishable food categories in terms of the adoption of cold chain tracing technologies. Furthermore, to the extent that the red meat industry is using tracking systems, it appears to be largely as a risk management measure to apportion liability in the event of a breakdown. In contrast, most other perishable food categories are proactively adopting real time data tracking systems to improve cold chain efficiency, reduce waste and to enhance customer value.

Based on the report prepared for DAWR on food wastage (Expert Group, 2020), it would appear that the red meat industry significantly underestimates the extent of losses due to cold chain breakdown. The report estimates that 3.5% of red meat production valued at $167 million is lost each year. This loss is diluting industry profitability. In particular, its impact on the profit pool is disadvantaging marketers and producers, given the fact that retailers and wholesalers factor in wastage and mark-down margin into their trading terms. All of this loss is being borne by the red meat industry, even though much of the damage is arguably being caused after the product is out of its custody. From the consultation undertaken for these case studies, it would appear that typically this loss figure is around 10% of the wholesale value which is deducted from the wholesale value even though much of the damage could be caused at the customer end. With improved cold chain improvement and data to provide an evidence base, there is a likelihood that part of this lost margin could be recovered by the industry.

The adoption of real time cold chain monitoring provides the opportunity to drive continuous improvement by positively engaging all levels of the cold chain, rather than perpetuating the adverse 'blame game' relationship that currently exists. The provision of accurate, real time data will drive behavioural change. Other perishable food industries indicate that they are moving from an adversarial to a partnership approach, which is reaping benefits for all. The red meat industry is only in the early stages of this journey.

Cost has been given as a major barrier to adopting real time cold chain monitoring systems. The cost of tracking varies depending on the technology being used, which is dictated to some extent by the markets being serviced. Domestic tracking and analysis is indicatively about AU$20 to AU$30 per track and international tracking from AU$45 to AU$85. This cost is small relative to the value of a shipment of meat and the leakage of value due to wastage and price markdowns. There is a need to raise awareness of the potential cost savings possible from extending shelf life, which would flow on down the supply chain.

Shelf life management will increasingly come into the fore both in the domestic as well as export markets. The adoption of these real time monitoring technologies by other perishable food categories will raise the expectations of major retail groups who in

time will make their use a condition of doing business for all categories requiring cold chain.

Shelf life management will become more important in Asian markets as they transition from frozen to chilled product. In particular, the systems will provide a powerful education tool for customers and supply chain providers in markets where the cold chain environments are still in a developmental state.

The ability to extend shelf life has other flow-on benefits to meat processors and exporters. In markets where sea freight brings product close to the shelf life threshold, it will allow more time to assemble orders and, in some cases, such as Middle Eastern markets, an extended shelf life may allow sea rather than airfreight, which would generate a significant cost saving. In countries with strict shelf life regulations, it may be a deal making factor with market access.

Quite apart from monitoring cold chain integrity, these real time monitoring technologies deliver other supply chain efficiency improvements. Knowing where the product is, who has custody of it and its temperature will enable better planning and management of inventories and logistics.

Case study 4: Big data export trade management platform

About this case study

This case study was selected because it illustrates the journey that one meat business has gone on, to explore how emerging blockchain offerings, might complement existing supply chain integrity solutions.

In recent times, OBE Organic has invested time, dollars and effort into exploring emerging solutions to streamline data flow through its export supply chain. Like many beef businesses in Australia, OBE Organic sells branded, boxed beef in domestic and export markets. It outsources the operational aspects of its supply chain to third parties, including livestock transport, processing, and freight shipments to market. Having a relatively small team, OBE Organic is continuously working to optimise the transfer of complex operational and verification data along its supply chain for both customers, supply chain partners and to comply with government reporting.

The integrity system	Big data export trade management platform
The applications	BSM export trade management tool
The problems being solved	• Lack of visibility across supply chain • Inefficient and error prone paper trail
The parties	• OBE Organic • BSM Global

About OBE Organic

OBE Beef Pty Ltd (OBE Organic) was formed in 1995 by a collaboration of 30 Channel Country farming families who were naturally producing organic livestock by virtue of the fact that they were range grazing, which is a feature of the region. Some of the OBE Organic producers are now second and third generation cattle farmers who have continued the tradition of range feeding cattle. OBE Organic is a producer-owned company and a non-packer exporter.

The Channel Country is a 29 million-hectare region in Central Australia on the river systems Georgina, Diamantina, Barcoo, Thomson, Bulloo, Parroo and Cooper Creek, plus their tributary channels.

The OBE Organic business sells branded, boxed beef in domestic and export markets procuring livestock and marketing organic beef on behalf of its shareholders as well as non-shareholder suppliers. The key operational functions, including processing, are outsourced. The livestock is purchased on an 'over the hook' pricing grid basis.

The business markets around 12,000 head of cattle per annum. All of the beef is certified organic, which on average, attracts a premium over non-organic beef. Producers receive direct quality feedback on each beast after processing.

The company exports certified-organic, grass-fed beef to multiple markets across North America, South East Asia, the Middle East and North Asia. More than 50% of the total OBE Organic production is exported with the vast majority of the meat being sold to importers, distributors and food service businesses, although there is a growing amount being sold directly to overseas supermarkets. All OBE Organic beef is sold in a boxed form. The product range includes primal cuts and trimmings.

The company executes an extensive marketing program based on a push-pull marketing strategy (i.e. trade marketing to drive distribution and consumer promotion to pull through sales), although the marketing is predominantly trade-oriented rather than consumer-facing.

A beef business' challenge

One of many challenges for beef businesses like OBE Organic, is inventory management and its ensuing impact on cash flow. The company needs to know the location, custody and status of the product at every point in the supply chain.

Like all export meat businesses, OBE Organic deals with a large number of customers across many markets trading 100% certified organic beef products. It operates with a lean team. The complexity of meat logistics is challenging, as exporters are managing a maze of documentation, dealing with multiple freight companies, many different protocols and reporting requirements for each country and OBE Organic has the added complexity of organic certification. There is also the challenge of accommodating the differing shelf life regulations in each country. The export documentation is particularly critical as one small error on a form such as a misspelt word can result in the delay of a shipment worth tens of thousands of dollars. Further complicating this work is the fact that a company's operating systems are required to both transfer and receive data from third-party systems, with data sometimes being manually entered from one system to another. OBE Organic is managing the risk inherent in all this complexity by employing a set of checks and balances to verify information.

All meat exporters carry a high level of risk including commercial trading risks, cold chain breakdown, price volatility (both on the supply and demand side), exchange rate risk and more.

A potential 'blockchain' solution

In recent times OBE Organic has invested time and resources working with blockchain companies to explore how blockchain solutions might overcome some of the complexity and risk associated with manual documentation processes and data transfer along its supply chain. With the benefit of this experience, the business reached the conclusion that blockchain was one of the more complicated and expensive solutions available. It became evident that blockchain solutions solved many identified issues in global beef supply chains,

but did not necessarily solve the issues of data transfer and visualisation in the most practical and least-cost way.

In OBE Organic's experience, blockchain providers, both established and start-up, vastly underestimate the complexity of meat export supply chains, particularly for those meat companies using third-party processing (toll processing) and where is there is not one single source of truth. In supply chains like OBE Organic's, where operational aspects of the supply chain are outsourced, various ERP operating systems are used by participants. They are not always capable or compatible for automatic real-time data transfer, meaning that the data still needs to be manually uploaded to the blockchain, which is both time-consuming and subject to human error.

OBE Organic's open minded approach

OBE Organic has always been open minded in its approach to technology with a refreshing willingness to trial new products and services from the start-up community, in order to find cost effective solutions to meet its needs. This is best summed up by Managing Director, Dalene Wray as follows:

"We know that 'digital' is the key to navigating evolving opportunities. We appreciate that blockchain solutions are among a plethora of digital solutions or 'tools' of the future, which will allow organisations like ours, to proceed in the face of complexity and disruption, and truly advance our digital future.

Rather than focussing solely on the benefits afforded by blockchain solutions, we are taking a whole-of-organisation approach to digitalisation. It requires a whole of business and truly multi-stakeholder approach, a step-change across all parts of our business and our supply chain, which builds trust and delivers value. Our digital strategy involves a change in mindset, backed by action. It is underpinned by continuous innovation, and global and local partnerships. Our actions (including our choice of software providers) are designed to realise benefit and value, quickly and clearly."

A big data solution: BSM Global

OBE Organic has been working with software company BSM Global for over seven years to evolve its export trading management platform. OBE Organic is using the BSM system for order management, documentation and compliance, managing shipping bookings, tracking of shipments, invoicing and exchange rate management. The company also uses the system to keep customers up to date on order status. Prior to implementing BSM, OBE Organic had a paper-based system, which was inefficient, labour intensive and prone to error.

BSM is a software development and support service company that develops customised solutions for holistic export trade management. The acronym BSM expresses this focus on export being an acronym for 'Buy, Sell, Move'. The BSM systems are tailor-made, cloud-based software systems that capture, integrate and manage data from a range of sources to provide a high level of visibility and functionality across the entire supply chain. BSM uses a 'data' rather than a 'technology' driven solution.

The BSM system is akin to a 'big data' network whereby data from a range of sources is used to add functionality and depth of analysis, whilst at the same time providing a means to cross check information from a range of sources. As required, the BSM system can develop customised solutions to manage the entire export trading process including but not limited to:

- Manage customer database
- Demand planning
- Order creation
- Create contracts
- Shipment planning, schedules and rates
- Export documentation
- Logistics planning
- Compliance
- Shipping documentation flow
- Customer communication
- Tariff rates
- Reconciliation and freight management
- Product tracing.

For example, by integrating with a ship's software, the BSM system can provide real time tracing of containers, make electronic bookings, manage documentation such as bills of landing and more. There is also the option to integrate real time data logger devices.   The BSM system still requires the cooperation of the supply chain partners such as processors, shipping and transport companies, etc. Most of the major shipping companies are willing to be a part of the system.

BSM has assisted numerous meat export clients, in the past decade.

Figure 15: BSM Order tracking dashboard

Source: Supplied by BSM

Figure 16: BSM Shipping rates accessible by phone
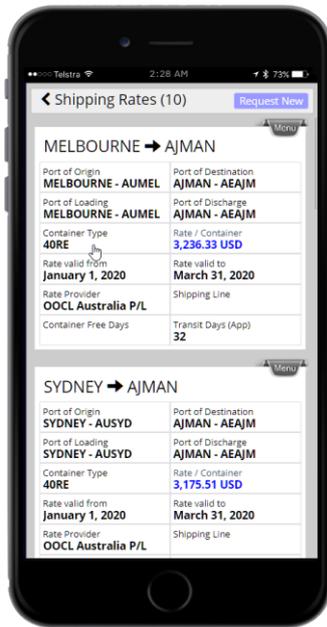
Source: Supplied by BSM

Figure 17: BSM Home screen
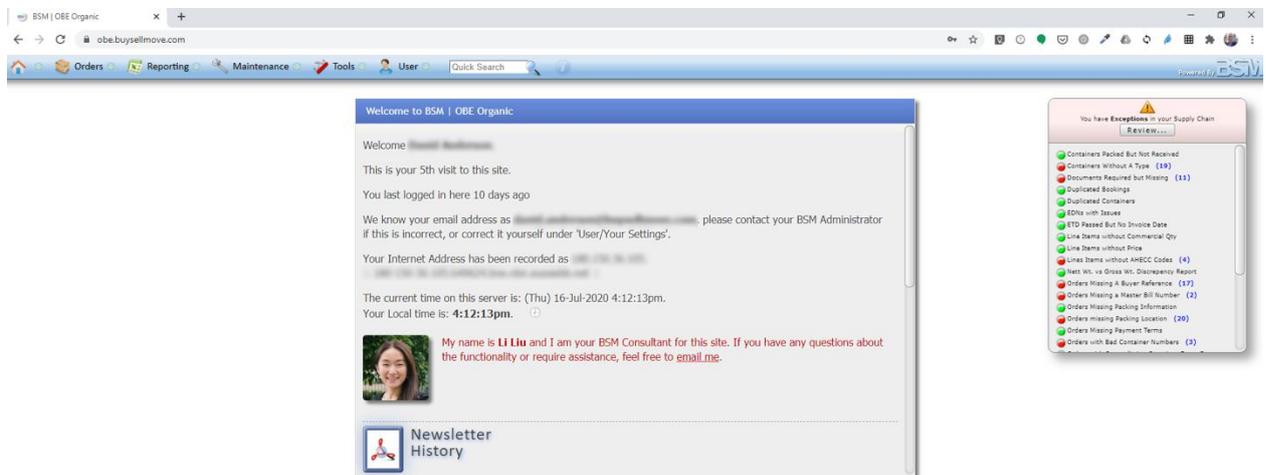
Source: Supplied by BSM

OBE Organic's application of the BSM system

Whilst the BSM solution does not provide product verification or authenticity of provenance in the same way that many of the verified blockchain systems claim to do, it very successfully transfers and visualises complicated information between multiple supply chain participants who use different ERP operating systems. It has the capability to both visualise and bring to life insights contained in the vast amount of highly valuable information which is transferred within logistics documentation. By being able to verify the location and

custody of the product using numerous data sources, it provides an invaluable means to cross-check irregularities.

The BSM solution can easily transfer information into any number of blockchain platforms should this become be mandated by a customer of OBE Organic's, in the future.

Learnings for the meat industry

1. **'One size fit's all' does not apply to supply chain management**

   The OBE Organic experience clearly demonstrates that there is no off-the-shelf solution to a complex set of challenges facing meat businesses, given the wide variation that exists across meat businesses i.e., their size, markets, customer bases and business models. The OBE Organic team noted that there is a myriad of technologies that make impressive promises about their capabilities, yet the company's experience is that many providers underestimate the complexity of export supply chains, particularly those which undertake third-party processing. The OBE Organic experience is that blockchain providers also commonly overpromise on the ease with which their solution can be implemented.

   OBE Organic's central need has been to streamline the management of its complex supply chain data, manage risk and improve business performance.

There is no 'plug in and play' solution

It is apparent from this case study and others that a considerable amount of groundwork needs to be done to adapt whatever technology platform is selected, not just to customise it to deliver the solution required, but also to harmonise the various data sets. All of these systems require standardisation of data and a common language, which is, in itself, a challenge.

Like OBE Organic, many businesses have found that a combination of technologies may be required to build a complete, end-to-end solution and that it takes a considerable amount of time and effort to identify that 'right combination' and then to harmonise the selected components. Furthermore, technology is an ongoing journey which continues to evolve and as it does, so its capability grows, and the opportunity exists to take it to the next level.

The benefits of the 'big data'

An advantage of the BSM solution for OBE Organic is that rather than having to establish dedicated IoT devices to collect primary data, it has the capability to receive and integrate data from existing systems operated by supply chain partners. The various data elements are pieced together to provide an 'end to end' supply chain mapping platform. Not only does this platform capture a comprehensive set of real time data, it also has the means to cross-check against different reference points. The BSM platform holds vast amounts of data, which, when connected, can yield powerful insights.

Case study 5: Scientific Provenance Verification

About this case study

The integrity system	Scientific Provenance Verification
The application	Trace element fingerprinting to confirm provenance
The problems being solved	Fraudulent mislabelling
The parties	Source Certain

This case study profiles various forms of scientific analysis for verifying provenance and their potential application to manage fraudulent mislabelling of Australian red meat at the industry level. Methods such as isotope tracking and elemental profiling present a means of analysis that enables identification of elements occurring in nature that present conclusively in the animal. Along with techniques such as DNA profiling, these scientifically proven methods of product verification have been commercially validated in food categories including eggs, pork, seafood and wine, and have been widely used in other non-food industries such as diamonds, pharmaceuticals, plastics and more.

Based on various research papers, it is estimated that the Australian red meat industry is being significantly impacted by fraudulent mislabelling of provenance, particularly in markets such as China. Fraud has the potential to damage the reputation of the wider Australian red meat brand. Australian red meat generally sells at a significant price premium relative to the equivalent from other countries because of the Australian industry's reputation for product quality, but more particularly, food safety, freedom from disease or chemical contamination and general provenance credentials. Exporters are concerned that fraudulent mislabelling of meat could in the longer term, dilute Australia's premium pricing structure or result in a serious food safety event that damages Brand Australia. These threats raise the question of whether there is a business case for the industry at large to invest in an industrywide product verification system in the manner that other Australian food industries have done, as profiled in this case study.

Putting fraud into context

It could be argued that the fraud issue is having more impact at an industry level than at an individual business level, as only a small proportion of meat is sold under Australian proprietary brands, whereas virtually all meat is marketed as 'Product of Australia'. However, it is the businesses who are marketing under their own brands that seem to be experiencing the 'front line' issues.

Most Australian meat exported is sold under trade brands rather than consumer brands and the Australian provenance is a critical foundation for these trade brands. The 'product of Australia' identity is a key element in achieving the price premiums and where proprietary brands are traded, their value propositions are also heavily underpinned by the credibility of the Australian provenance.

Claims of fraudulent mislabelling of red meat have not always been borne out by the anecdotal evidence from red meat exporters/ brand owners and MLA country managers, who claim that the extent and nature of brand fraud is grossly overestimated and mainly confined to China, with a lesser presence in Vietnam and Indonesia, where it may be more likely to be documentation fraud. The majority of red meat brand owners interviewed as part of this project were confident that, although fraudulent mislabelling does occur, it was having a minimal impact on their businesses. This belief was based on the fact that most of the branded products (either proprietary or retailer-own brands) are sold to reputable global retailers and food service customers such as global supermarket chains or five-star hotels through closed-loop supply chains and subject to a rigorous audit trail. The feeling expressed was that, to the extent that provenance fraud does occur, it is mostly in low value, commodity products, sold in wet markets or through traders where the premium achieved based on the Australian origin is minimal. The brand fraud that is occurring seems to be where the producer's Australian proprietary brand is being used at food service or retail level to add value.

Notwithstanding the widespread industry belief that the extent of fraud is overstated, there is a strong and universal view that the credibility of 'Brand Australia' needs to be fiercely protected in the face of increasing competition and the volatile geopolitical situation which could compromise market access.

Scientific product verification technologies

There are two streams of scientifically proven technologies to verify product origin:

1.   DNA tracing

2.   Chemical provenance verification

DNA tracing involves analysis of genetics and is being used by some of the integrated breeder/processor/exporters, mainly as a tool for genetic improvement. At least one company has gone further, using DNA tracing through the supply chain to link to a consumer-facing QR code at the request of a major global retailer (Note: this program was put on hold because of low consumer uptake relative to the cost).

Chemical provenance verification, on the other hand, provides forensic tracing of the product back to its geographic origins. Every natural product has a trace element fingerprint or isotope signature. All food products have a direct relationship with the local environment reflected in the distribution of trace elements through absorption from the soil or water into the plant or feed intake. Trace element and stable isotope concentrations provide unique signatures that have been used to validate provenance claims and provide evidence-based support for case law.

There are different technologies for undertaking the analysis of these elements including Elemental Profiling and Stable Isotope Ratio Analysis, both of which can identify the key elemental markers of the product for the determination of its provenance. These are two different analytical methods, using different instruments and sampling methods that ultimately deliver different provenance determinations. Stable Isotope Ratio Analysis can

determine provenance to a geographical level whilst Elemental Profiling can determine provenance down to a farm of origin or in some cases to a production zone within one farm such as an individual shed or pond. Some of the trace elements are extremely stable and tamper proof. This means, for example that a 100-year-old wine will still have many of the same trace elements as when it was produced, so through a wine sample, the terroir (soil in which the vines were grown) can be conclusively matched to a location.

Another variation of chemical provenance verification is trace labelling, whereby an artificial element is introduced (the equivalent of an invisible dye), which stays with the product throughout the supply chain journey and which cannot be tampered with.

The elemental profiling and stable isotope ratio analysis are scientifically proven and have been successfully used to prosecute fraud cases in many local and international jurisdictions. The technology is being used around the world to reduce the risk of:

- product counterfeiting
- product labelling
- contamination
- food terrorism.

Source Certain International

The case studies profiled here have all been based around the Source Certain International (SCI) methodology, but it must be stressed that Source Certain is just one of a number of companies offering chemical provenance verification. Source Certain is indeed one of the pioneer providers of scientific verification technologies with its TSW-Trace ^{TM}, a multidisciplinary analytical technique that analyses a combination of trace elements, stable isotopes and molecular compounds.

Source Certain provides services to a range of agrifood clients as well as a diverse number of other industries including diamonds, gold, seeds, plastics and pharmaceuticals. According to the Source Certain website, it has published over 100 peer reviewed papers on its methodology.

Australian Pork Ltd

The Australian Pork industry has been successfully using elemental profiling and stable isotopes since 2010 to validate country of origin (CoOL) labelling claims. In 2010 Australian Pork Ltd (APL) undertook a project in collaboration with the Singapore Agri-Food and Veterinary Authority (SFA) to assess the validity of elemental profiling and stable isotope analysis for product verification. The Singapore Government applies a high level of scrutiny on food safety systems and is particularly vigilant in monitoring false country of origin labelling. The SFA investigation was initiated to provide a snapshot of labelling compliance at the retail level in the Singapore market (*source: Australian Pork Fact sheet, May 2010)*.

The context of the SFA exercise was that the Singapore market had become Australia's largest pork export market following bans on pork imports from Malaysia in 1999 due to the

outbreak of Nipah virus. Up until that point, Malaysia was the dominant supplier of pork to Singapore. Because of the large amount of trade traffic between Malaysia and Singapore, the Singapore Government was keen to assess the validity of country of origin claims and participate in the project to collect a large sample of product from retail outlets for validation. By comparing the samples with the reference footprint, the technology was able to validate country of origin with 100% accuracy.

The trial coincided with the rollout of the APL Pork Mark and APL trademarked its compliance testing methodology under the Physi-Trace™ brand. The motivation for protecting the product integrity of Australian pork so carefully was largely to do with protection of market access into Singapore. The pork industry was called on to apply the trace system in 2011 when a foreign object with potential to cause serious injury was found embedded in a cut of pork in a retail outlet. This test was significant for Australia because of the risk that it had the potential to impact market access. The APL Physi trace™ system was successfully used to trace the offending farm within 36 hours. The system is now used to validate the Australian Pork Mark as a CoOL verification tool.

Egg Industry

Australian Eggs Limited (now Australian Eggs) commissioned a desktop review to assess the industry needs with respect to traceability. This work also includes a comprehensive review of product verification and tracing technologies. The industry needs to trace the flow of eggs, particularly ungraded eggs (which travel from farm to farm and across interstate borders) because of food safety issues such as salmonella outbreaks. It also has an issue with substitution and mislabelling where cage eggs are passed off as more expensive 'free range' or organic eggs which earn a price premium. The prior system of egg stamping was found to have serious shortcomings.

A paper prepared for the industry (Szabo *et al*, 2020) profiles a case study where the Source Certain elemental profiling technologies were successfully applied to verify eggs down to the shed level. The pilot trial involved sourcing eggs from 100 farms across each state. The report notes that chemical profiling is one of the most robust tracing methods available, but it is complex and needs sophisticated equipment and skilled staff.

Prawn and Barramundi Industries

The elemental profiling methods of geographic foot printing is being successfully applied to both the prawn and barramundi industries. For both industries there is a need for scientifically verified country of origin to differentiate Australian from imported fish. Both categories compete against lower-priced product from imported countries that is not differentiated at the point of sale, especially in food service outlets. Because Australian consumers have a clear preference for Australian fish and are prepared to pay a premium for it, this failure to convincingly differentiate is undermining the profitability of both Australian aquaculture industries. Furthermore, Australian consumers will pay a premium for the assurance of safe handling and production that Australian food safety standards mandate.

In the case of prawns, according to Nielson market research data (as quoted WAFIC, 2016), on average imported fish sell at a retail price 7% lower than the Australian product, which translates into a 20% reduction in value at the farm/beach (*ibid*).

In the case of barramundi, most consumers assume that the fish they are buying is Australian, because of the Australian name, yet 70% of the fish marketed in Australia under the category 'barramundi' is in fact imported Asian Sea Bass, which is being routinely passed off as Australian. The complicating factor here is that by law, the imported Asian Sea Bass must be sold as 'Barramundi' because that is the official species name. Passing off is happening despite the fact that there are CoOL regulations at retail level, but these are not being strongly enforced, furthermore, the Northern Territory is the only state that has mandated CoOL regulations for food service and around 60% of barramundi is consumed in 'away from home' food service establishments.

Both the prawn and barramundi industry representative bodies are strongly advocating to government for improvement and enforcement of the CoOL regulations. Critical to their success will be convincing government that they have immutable evidence of the nature and extent of fraudulent mislabelling. Both industries have applied Source Certain trace element profiling to build a reference data base against which the Australian origin of product can be determined.

By working with regional industry associations and individual operators, the prawn industry has collected one thousand Australian product samples across 35 locations including wild harvest fisheries and 17 farms. The samples were sent by a chain of custody protocol to Source Certain where both cooked and green prawns were analysed to build the reference database. This work indicated that the process could accurately verify geographic location with a 98% statistical confidence level.

The barramundi industry has completed the development of their reference database, whereby it has sampled product from 11 farms across FNQ, WA, SA and Victoria to prove that it could successfully differentiate between the farms. The analysis found that the fish could even be differentiated between different ponds on the same farm.

The following is an example of the farm classification model for barramundi which demonstrates the distinct difference in the elemental profiles between farms. This classification model delivered 100% correct correlation and 100% cross validation. From this work it has been possible to develop a state of origin classification model.
The prawn industry is now working through the next steps as to how it will utilise the scientific evidence.

The second stage of the pilot trial involved profiling down to the pond level (typically, aquaculture farms have several ponds). The ability to trace to a pond level provides the additional benefit of tracing back in the event of a food safety incident and could also be potentially used as a disease management tool. The following are the classification maps at a pond level on one of the barramundi farms. The analysis delivered 100% correct classification with a 95.1% cross validation, achieved with a small sample. These results demonstrate the level of granularity that can be achieved by applying this technology.

Translating this methodology to the meat industry, would mean tracing down to the paddock or feedlot level.

Figures 18: Results of barramundi industry elemental analysis, 2020
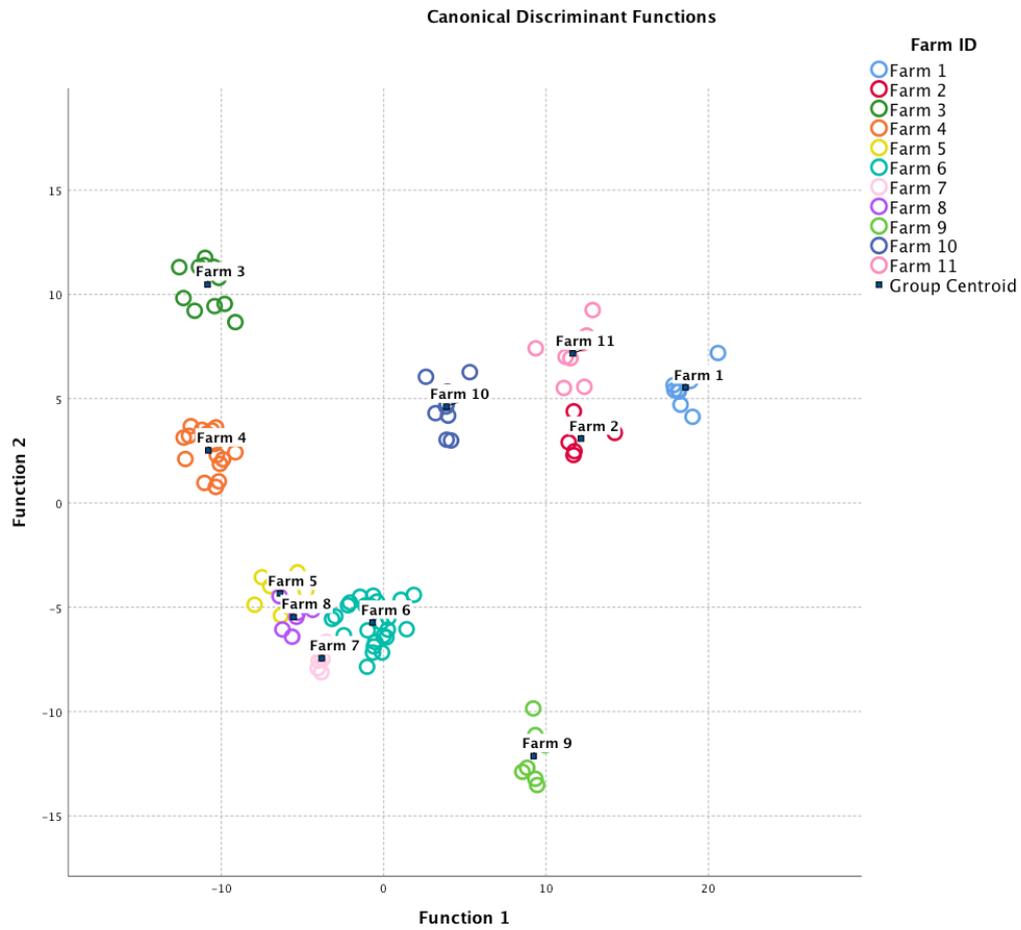
Provided by

Source Certain International with the approval of ABFA

Canonical Discriminant Functions
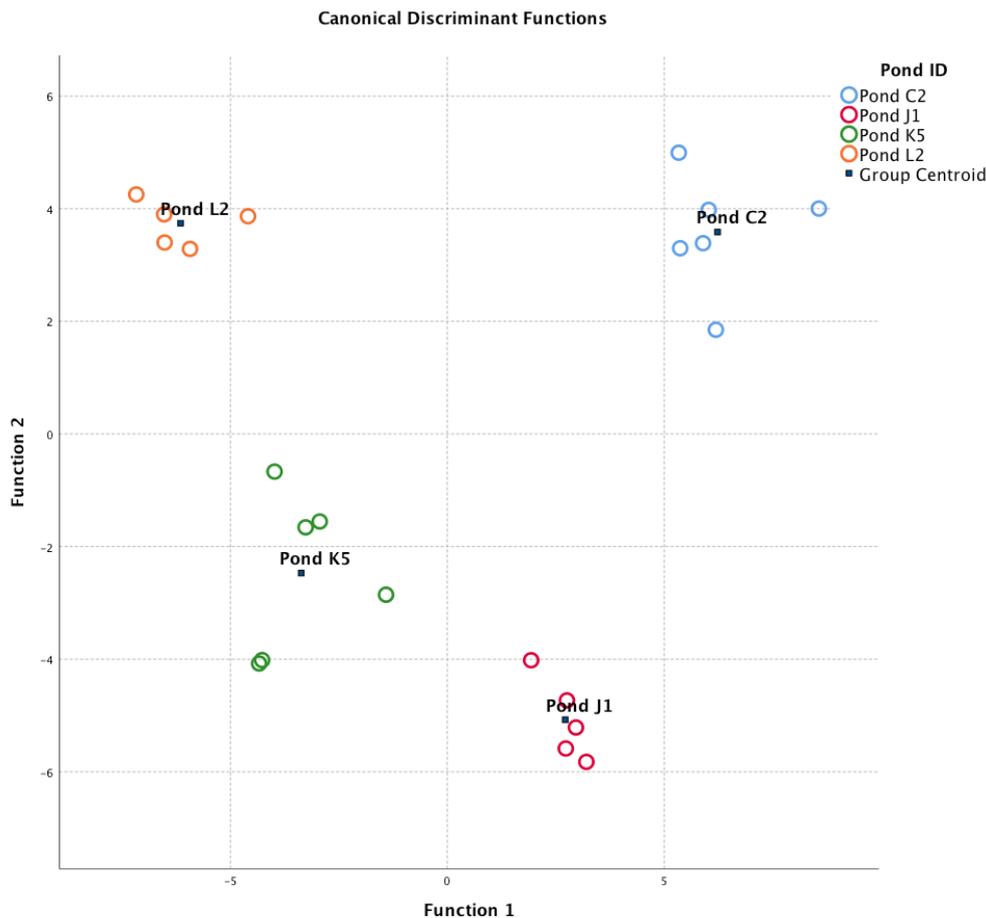
Provided by Source Certain International with the approval of ABFA

The barramundi industry has developed its reference database and has conducted pilot trials whereby it is randomly collecting and testing samples from retail outlets.

Case study 5: Learnings for the red meat industry

Scientific provenance verification has been included in the case studies of integrity systems because it has potential application to address the fraudulent use of 'Brand Australia' on red meat from competing countries. In the first instance it could be applied to conduct a pilot trial to assess the nature and extent of fraudulent mislabelling of Australian red meat.

As previously discussed, there is a common view in the research literature that fraud is a major issue. However, the extent of fraud and its impact needs to be questioned (see milestone 1 report for this project). More importantly, the estimates of fraud are not being validated by the lived experience of many exporters and MLA country managers who believe that the amount and impact of fraud is nowhere near as extensive as the published papers suggest.   Given the potential scale of the impact of fraud on the industry, it is important that the extent and source of fraud be quantified.

Based on the experience of other industries, the Scientific Provenance Verification technologies would appear to provide highly accurate and scientifically valid methodologies to quantify and define the problem.

A pilot trial similar to those run by the prawn and barramundi industries could be conducted in the meat industry to provide a preliminary snapshot to help determine whether a more detailed investigation is justified. A tightly scoped study could be conducted (say one city in China) with a narrow range of beef cuts, working with two or three Australian exporters. It may also be worthwhile to include some proprietary branded product to assess whether brand fraud is more common on Australian branded products. The trial would not only assess the level of fraud but more importantly identify where is it is occurring.

With a scientifically validated understanding of the fraud issue, the red meat industry and individual brand owners could make an informed assessment as whether more work needs to be done on mitigating the fraud risk.

Key themes identified from across all case studies

There are a number of dominant themes cutting across all the case studies which offer relevant learnings for the Australian Meat Industry as outlined below.

1. Technology is a journey not a destination

The adoption of any technology is an on-going journey, and this is no less the case for technologies applying to integrity systems for red meat supply chains. Technology, almost by definition, is a dynamic phenomenon, forever evolving and with each new iteration providing increased capability and functionality than the previous version and usually at a lower cost. Furthermore, as technology evolves, customer expectations increase. As the capabilities improve so does the opportunity and value of wider applications. The bar is continually being raised in terms of service levels, levels of verification or authenticity, visibility and cost reduction because of the improved functionality of the technology.

2. There is no one size fits all technology solution

It is apparent from these case studies that the needs and priorities of red meat companies with respect to technology solutions vary greatly between businesses depending on their product range customer base /markets, business model and resources available. There is a large amount of time, effort and cost required to sort through the various technologies on offer in order to find the optimum solution. A suite of technologies that work for one meat business will probably not be suitable for another.

As the case studies demonstrate, the parties involved are using technologies in very different ways from each other because they are all trying to solve distinctly different problems.

3. Forget 'plug and play' solutions

If meat businesses believe that they can buy a system off the shelf and plug it in, they are in for a rude awakening. There is no such thing as an end-to-end solution, at least for red meat businesses. In most cases, it is necessary to build a customised solution by coupling together a number of technologies to deliver the desired outcome. The first challenge is to

determine the right combination of components, which in itself is a complex task as there are countless service providers offering different answers with some overpromising on what they can deliver and most underestimating the complexity of red meat supply chains.

The bigger challenge, as emphasised in the case studies, is to connect the components, which usually have their own operating systems and language, and which are usually not compatible with each other. Most of the case studies profiled here are in development and still grappling with this compatibility problem.

4.   Blockchain is not in itself a solution - it is a platform for connecting solutions

There appears to be a widely held misconception that blockchain is a complete, end-to-end verification and supply chain management solution in its own right, which is not the case. Blockchain is a distributed ledger platform that holds and transfers information in a secure way and does not generate or verify data. It is a repository of information collected through other means. Three case studies have been profiled in this milestone report which are using blockchain, each in a very different way for a very different motivation and each linking to a very different set of IoT devices.

Proponents of blockchain promote the platforms as providing 'a single source of 'truth'. This is only the case if all of the information loaded into the blockchain is correct and verified by some other means. When incorrect data is inputted at any point, it remains inaccurate and cannot be corrected. The claim of a 'single source of truth' is only true to the extent that once the data is in the system it cannot be altered.

5.   The meat industry has prematurely dismissed blockchain

Many of the meat businesses interviewed as part of this project had looked at blockchain and had dismissed it on the basis that *"it solves problems it doesn't have"*, adds cost and complexity without delivering tangible benefits. In most cases, blockchain has been viewed as a fraud and verification mitigation tool. Two of the case studies profiled here are developing blockchain platforms for distinctly different reasons, one as a B2B trading platform and one as a supply chain management system to streamline processes and facilitate trade finance for inventory.

At face value, and subject to validation, applying blockchain as a trading platform has the potential to simplify the supply chain, drive out costs and put more money in the pockets of the seller. Blockchain also has the potential to capture and provide accessibility and visibility to highly powerful data sets that unlock powerful market insights, much of which is currently lost because of lack of connectivity.

The other important feature of blockchain is its ability to provide a powerful customer feedback mechanism. With both B2B and B2C trading and marketing applications, with the use of QR codes marketers can get direct feedback from their customers, making it a powerful market research tool. For example, with B2C applications it provides data on the location of the customer which is powerful for targeting marketing programs.

6. There needs to be a tangible payback from investment in technology

There needs to be a demonstrable and tangible payback from any investment in technology. Before deciding to invest in supply chain and verification technology, businesses need to assure themselves that there is a tangible and bankable return on their investment. Technology requires a large investment of capital, resources and time and adds considerable cost to a business, which if not recouped, simply dilutes profit. A good illustration of this, is the fact that increasingly, global supermarkets and corporate food service companies are raising the bar in relation to proof of authenticity or provenance and enhanced traceability capabilities, but do not expect to pay for it. This means that this cost has to be borne by the supplier as a sunk cost of doing business, which must be absorbed. Therefore, there needs to be some additional benefit from the investment such as improved supply chain efficiency, reduced inventory, extended shelf life, better market insights, improved cash flow, higher prices, etc. The value proposition of many of the technologies being provided is not yet fully established.

7. The red meat industry appears to be trailing other perishable food categories.

In researching these case studies and engaging with the various technology providers, it could be interpreted that the red meat industry is trailing behind other agrifood industries in the adoption of product verification, supply chain efficiency improvement, cold chain management and shelf life extension product integrity systems.

The issues surrounding product verification and fraud seem to be that most brand owners do not believe that this is a significant issue nor that it is causing material harm.

The issue blocking the adoption of product integrity systems for cold chain management is that red meat businesses see these technologies largely as a risk management tool in the context of a culture of assigning liability to others in the cold chain. The potential of these systems is as a proactive tool to improve supply chain efficiency, extend shelf life and reduce supply chain cost. Part of the problem is that the wastage caused by substandard cold chain management is a sunk or hidden cost which is currently built into the trading terms.

Other industries are working with their customers and supply chain partners to reduce cold chain wastage and share the benefits. There are obvious direct paybacks to the meat industry from extended shelf life, other than wastage specifically. This has implications for market access, the ability to consolidate shipments and the potential to ship by sea rather than air, which would generate significant cost savings.