AUSTRALIAN MEAT PROCESSOR CORPORATION

Economic impact assessment of 10 projects completed in 2021/22

AMPC Impact Assessment Program – FY20-24

Final report

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2021-1044

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Contents

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Abbreviations

AI	Artificial Intelligence
AMPC	Australian Meat Processor Corporation
AMIC	Australian Meat Industry Council
BCR	Benefit Cost Ratio
CRRDC	Council of Rural Research and Development Corporations
DAWR	Federal Department of Agriculture and Water Resources
IRR	Internal Rate of Return
MIRR	Modified Internal Rate of Return
MLA	Meat & Livestock Australia
MHA	Meat Hygiene Assessment
MTC	Meat Transfer Certificates
NPV	Net Present Value
O&M	Operation and Maintenance
OH&S	Occupational Health and Safety
PV	Present Value
R&D	Research and Development
RD&E	Research, Development and Extension
RDC	Research and Development Corporation
WHS	Workplace Health and Safety

1.0 Introduction

This report presents the results of ten ex-post impact assessments completed on a representative sample of AMPC projects finalised during the 2021/2022 financial year.

Evaluations were completed in line with the Council of Rural Research and Development Corporations (CRRDC) *Impact Assessment Program: Guidelines* (2018). They were informed by a desktop review of project outputs, and consultation with researchers and AMPC project managers.

The results provide an objective and independent assessment of the qualitative and quantitative outcomes likely to be realised from the evaluated projects. Where necessary, the evaluations rely on informed estimates of unknown parameters, such as economic benefits from practice change, potential rates of adoption and attribution of benefits.

2.0 Project Objectives

Specific objectives of this impact assessment were:

1. To provide an assessment, in line with the CRRDC Impact Assessment Guidelines, of a representative sample of AMPC investments completed between 1 July 2021 and 30 June 2022.
2. To collect, on behalf of AMPC, relevant industry data to support an understanding of industry issues, and the delivery of future investments.
3. To identify and analyse key drivers of investment success, including investment outputs, industry awareness, industry adoption, cost of adoption, adoption benefit, benefit attribution.
4. To identify and analyse key lessons learned, for future investments.
5. To identify and outline key messages relevant for service providers, AMPC members and key stakeholder groups (including MLA, AMIC, RMAC and the Commonwealth Government).

3.0 Methodology

Economic impact evaluation

As per the *CRRDC Impact Assessment Program: Guidelines* (2018) GHD considered and modelled the project case (with project scenario) against the counterfactual (without project scenario) to determine the likely change in net economic benefit and, therefore, return on investment.

GHD reviewed project reports and outputs, and consulted with key stakeholders, to determine reasonable assumptions for the following:

- Potential impact if/when project outputs and findings are utilised by industry;
- Likely rates of adoption over the coming years (adoption profile); and
- Attribution of benefits, i.e. the extent realised benefits are attributable to the project investment, as separate from previous related research, future implementation costs and other factors.

Impacts were modelled over a 30 year timeline and discounted to present day amounts (applying a 5% discount rate) to determine the:

- Net Present Value of Benefits (NPV): Net benefits minus net costs;
- Benefit Cost Ratio (BCR): Net benefits divided by net costs;
- Internal Rate of Return (IRR): Interest rate at which the NPV of all the impacts from a project (both costs and benefits) from a project or investment equal zero; and
- Modified Internal Rate of Return (MIRR): Similar to the above IRR, but assuming more realistic returns from reinvested benefits and financing of initial outlays (5% applied for both, as per CRRDC guidelines).

All past costs and benefits were expressed in 2021/22 dollar terms using the Implicit Price Deflator for GDP. The AMPC components of project investment costs were all multiplied by a factor of 1.1 to accommodate program management costs. All costs and benefits after 2021/22 were discounted to present dollars using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a high level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2021/22) to the final year of benefits assumed.

Sensitivity analysis was used to test results against changes to key assumptions and discount rates, for both individual projects and aggregate results. For each evaluation GHD also specified confidence ratings in terms of coverage of benefits and accuracy of assumptions.

Project selection

Projects were independently selected by GHD to ensure a balanced representation across AMPC program streams. GHD grouped projects into research streams and used random numbers to select a sample of projects for evaluation from each grouping. The ten projects selected for evaluation had a combined investment of $2.03m or approximately 17% of the total investment into core projects in the 2021/22 financial year.

Alignment with Australian Government Research Priorities

Table 1 below shows how the evaluated projects align with AMPC Program Streams, The Australian Government's Rural Research, Development and Extension (RD&E) priorities, as well as the Science and Research Priorities.

Table 1 Australian Government Research Priorities

		AMPC Program Stream	Rural RD&E Priorities	Science and Research Priorities
	Investment Priorities	1. Advanced Manufacturing 2. Sustainability 3. People and Culture 4. Markets and Market Access 5. Products and Process Integrity	1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D	1. Food 2. Soil and water 3. Transport 4. Cybersecurity 5. Energy 6. Resources 7. Advanced Manufacturing 8. Environmental Change 9. Health
	Project		**Alignment with priorities**	
2019-1038	eMTC implementation including DAWR requirements	1	1,2	5,8,10,13
2021-1223	Shadow Robot - Bandsaw Cutting of Beef Shank - Stage 1	1	1,4	5,11,10,13
2021-1222	Artificial Intelligence (AI) - Non-X-ray Beef Cutting - Stage 2 (Intelligent Robotics)	1	1,4	5,10,11
2019-1060	Megasonic demulsification of oil and grease from meat processing wastewater	2	1,3	5,6,9,10,12
2022-1048	Developing a Voluntary Code of Conduct for Migrant Management (Stage 1)	3	4	5,13
2022-1093	Business Plan for a Red Meat Industry Knowledge Hub	3	4	5,10,11
2020-1066	Utilisation of Augmented Reality for the development of Remote Auditing	4	1,2,4	5,8,10,11
2021-1091	Meat Hygiene Assessment 3 - An Industry Trial	4	2,4	5,10,13
2021-1131	Review of Traceability outcomes from electronic tagging of sheep- implications for small stock processors outside Victoria	5	1,2,4	5,4,11,10,13
2021-1172	Traceability - Primal to Steak/Steak to Primal (Stage 2)	5	1,2,4	5,7,11,13

Source: AMPC, Commonwealth of Australia (2016) and Office of the Chief Scientist (2015).

Evaluation assumptions

Impact evaluations relied on assumptions adopted from:

- Industry data: e.g., plant numbers, throughput volumes, operating costs, prices and profitability;
- Targeted consultation with relevant researchers and project leaders; and
- The consultants informed judgement.

All results are subject to rounding error.

All assumptions and sources are referenced in the individual project evaluations (in Section 8.0 Appendices).

4.0 Results

Economic impact by project

The results for the ten individual projects assessed are presented in Table 2, with results expressed in 2021-22-dollar terms. BCR results of individual projects range from 1.3 to 12.7, with a weighted average of 7.5.

Table 2 Results from impact evaluations (Total Project Investment, 30 years)

Program Stream	Project Code	Project Name	PV Costs ($m)	PV Benefits ($m)	NPV ($m)	BCR
1. Advanced Manufacturing	2019-1038	eMTC implementation including DAWR requirements	$0.08	$0.82	$0.74	10.7
	2021-1223	Shadow Robot - Bandsaw Cutting of Beef Shank - Stage 1	0.24	0.99	$0.75	4.1
	2021-1222	Artificial Intelligence (AI) - Non-X-ray Beef Cutting - Stage 2 (Intelligent Robotics)	$0.27	$2.64	$2.37	9.9
2. Sustainability	2019-1060	Megasonic demulsification of oil and grease from meat processing wastewater	$0.18	$0.23	$0.05	1.3
3. People and Culture	2022-1048	Developing a Voluntary Code of Conduct for Migrant Management (Stage 1)	$0.32	$2.89	$2.57	9.0
	2022-1093	Business Plan for a Red Meat Industry Knowledge Hub	$0.03	$0.29	$0.25	8.7
4. Markets and Market Access	2020-1066	Utilisation of Augmented Reality for the development of Remote Auditing	$0.44	$2.57	$2.14	5.9
	2021-1091	Meat Hygiene Assessment 3 - An Industry Trial	$0.41	$4.79	$4.38	11.8
5. Products and Process Integrity	2021-1131	Review of Traceability outcomes from electronic tagging of sheep-implications for small stock processors outside Victoria	$0.02	$0.27	$0.25	12.7
	2021-1172	Traceability - Primal to Steak/Steak to Primal (Stage 2)	$0.28	$1.46	$1.18	5.2

Overall economic impact

The aggregated results from the five projects modelled over 30 years from the last year of investment (2021/22) is presented in Table 3 below. The results suggest most of the net benefits will be realised in five to ten years' time. This is typical of rural R,D&E as innovations often take up to five years to become fully developed and adopted. After 10 years many innovations are likely to be superseded, or similar outcomes achieved, under the counterfactual scenario.

Table 3 Summary of overall results from evaluated projects

Years from project investment (2021/22)	0	5	10	15	20	25	30
Present value of benefits ($m)	$0.14	$9.08	$15.79	$16.94	$16.94	$16.94	$16.94
Present value of costs ($m)	$2.26	$2.26	$2.26	$2.26	$2.26	$2.26	$2.26
Net present value ($m)	-$2.12	$6.82	$13.53	$14.68	$14.69	$14.69	$14.69
BCR (weighted average)	0.1	4.0	7.0	7.5	7.5	7.5	7.5

Sensitivity Analysis

Table 4 shows how the overall economic impact results would change based on changes in the discount rate. The results show that even applying a discount rate of 9%, the projects would still deliver a positive NPV ($M) and favourable BCR (6.1).

Sensitivity analysis was also undertaken for individual projects, adjusting both discount rates and assumed benefits once innovations are adopted. These results are detailed in the report appendices.

Table 4 Aggregated economic impact (total project investment, after 30 years) applying different discount rates

Discount rate	NPV ($M)	BCR
0%	$19.26	9.5
3%	$16.33	8.2
5%	**$14.69**	**7.5**
7%	$13.25	6.9
10%	$11.41	6.1

6.0 Discussion

The overall estimated economic return from the ten evaluated projects (7.5 weighted average BCR over 30 years) is above the typical assessed returns from RDC investments. An assessment of 111 RDC project cluster evaluations, between 2014 and 2019, found a comparable weighted average BCR of 5.5, with annual weighted average BCRs from 3.3 to 9.1 (Agtrans Research 2019).

Figure 1 below compares the weighted average BCR from this analysis with previous annual evaluations of AMPC core projects completed by GHD. The results suggest slightly higher than average returns.

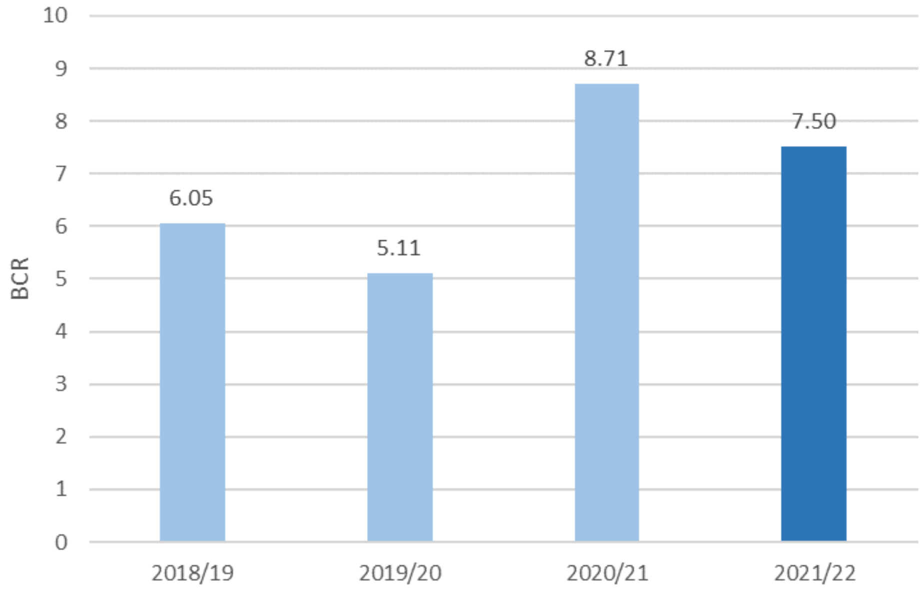

Figure 1 Weighted average BCR from annual evaluations of a sample of AMPC core projects.

Overall, the results from the sample of evaluated projects suggests that AMPC R&D projects concluding in the 2021/22 financial year, are likely to yield substantial economic benefits to processors over the coming years, realised primarily through reduced costs and higher productivity.

7.0 References

Agtrans Research (2019) *Cross-RDC Impact Assessment 2019*. Prepared for The Council of Rural Research and Development Corporations.

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GHD (2019) *2019-1067 AMPC Ex-Post Impact Assessment Program — 2019*. Australian Meat Processor Corporation.

GHD (2020) *2021-1044 AMPC Impact Assessment Program — FY20-24: Financial Year 2020 Report*. Australian Meat Processor Corporation.

Office of the Chief Scientist (2015). Science and Research Priorities, Office of the Chief Scientist, Department of Industry, Science, Energy and Resources, Canberra. https://www.industry.gov.au/data-and-publications/science-and-research-priorities

Additional references for each project assessment are outlined in appendices.

8.0 Appendices

Appendix	Project Code	Project Name
A	2019-1038	eMTC Implementation Including DAWR Requirements
F	2021-1223	Shadow Robot – Bandsaw Cutting of Beef Shank – Stage 1
G	2021-1222	Artificial Intelligence (AI) – Non-X-ray Beef Cutting – Stage 2
B	2019-1060	Megasonic Demulsification of Oil and Grease from Meat Processing Wastewater
H	2022-1048	Developing a Voluntary Code of Conduct for the Management of Migrant Workers – Stage 1
C	2022-1093	Business Plan for a Red Meat Industry Knowledge Hub
D	2020-1066	Utilisation of Augmented Reality for the Development of Remote Auditing
I	2021-1091	Meat Hygiene Assessment 3 – An Industry Trial
E	2021-1131	Review of Traceability outcomes from electronic tagging of sheep- implications for small stock processors outside Victoria
J	2021-1172	Traceability – Primal to Steak/Steak to Primal -Stage 2

8.1 Appendix A: 2019-1038 Electronic Meat Transfer Certificate Protocol (eMTC) implementation including DAWR requirements

Background

Meat Transfer Certificates (MTC) are necessary under the DAWR [now DAWE] export market access system. A MTC is a document that accompanies any meat being transferred between export registered establishments within Australia, including abattoirs, cool storages and shipping facilities. MTCs, along with other documents necessary for transportation are time consuming and prone to errors. The industry is working towards onboarding meat information to a single platform; Meat Messaging. This includes regulatory and additional documents to assist in the compliance and traceability of information. On a larger scale, this is to address high rates of error in exported meat containing the supporting information – leading to large wastage and costs to the industry. Approximately 80% of exported meat already utilises Meat Messaging – which requires approval by regulatory bodies, meaning that their systems are suited to supporting further onboarding of documents like MTCs. Although some export facilities had already established automated eMTCs - project 2019-1038 extended this by integrating use into the Meat Messaging platform.

Description of the project

Project 2019-1038 worked to create an eMTC system that could be integrated into the Meat Messaging platform. This system had to be approved by DAWE, implemented into industry and acceptable by export market standards.

Table 5 Project description and logic

Project Details	Organisation: Management for Technology Pty Ltd Date: Sep 2021 Principle Investigator: Des Bowler
Rationale	To develop a commercially viable eMTC system that is accepted by DAWE to be able to integrate into the Meat Messaging platform. Furthermore, for it to be accepted by industry and the export markets.
Objectives	The objectives of this project include creating an eMTC system that: / Is a commercially viable system endorsed by DAWE. / Is easily implemented by industry. / Acceptable by export market standards
Activities and Outputs	To achieve the identified objectives, this project: / Identified and worked with five export establishments and their system vendors to implement and demonstrate the eMTC system effectively / Utilisation of the Meat Messaging industry portal as a data store / Assuring operation and reporting requirements are met through working with DAWE and integrating with Meat Messaging / Development with DAWE of a Meat Notice covering the system / Development of training and information that can be utilised by the export establishments
Potential Outcomes	/ Additional establishments were predicted to begin adopting the technology in the following 12 months – utilising the training material made available
Potential Impacts	/ Decrease labour costs involved in filling out manual eMTCs for establishments nationally / Decrease errors that occur due to manual recording

	/	Further implement the Meat Messaging platform into industry, encouraging plants to update old systems and increase compliance

Project investment

AMPC invested **$75,900** into the project over the 2021/22 financial year, including project management costs.

Summary of impacts

Table 6 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 6 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Labour savings and integration into the one platform**
Environmental	/	Meat Messaging in general leads a push to an online centralised platform for any traceability/documentation of meat, this will help the environment by encouraging processors to move away from old paper systems
Social	/	Increasing the compliance of the meat industry in general

Quantification of impacts

Estimated benefits

The primary benefit from the project is enabling the labour savings from avoiding manual data entry and filing within organisations. Consultation suggests each MTC costs approximately $25 to enter and file, with the industry processing around 200,000 MTCs per year at a cost of $5,000,000.

Table 7 Benefit assumptions

Variable	Assumption	Source/ Explanation
a) Labour savings from moving from manual MTC to eMTC	$25	Previous industry projects have calculated the cost of the manual MTC process at an average of $25 in labour per MTC.
b) Amount of manual MTCs processed per year	200,000	Project report
c) Potential savings/year	5,000,000	a x b

Adoption costs

The above potential benefits will be offset by the costs incurred by processors adopting the technology, including capital costs as well as potential disruption to existing activities. However, as Meat Messaging is already adopted by approx. 80% of total volume for processed meat, their systems should not require significant implementation costs for this addition. Rather, the original process of aligning the needs of approval for Meat Messaging requires a large amount of input by the processor. Therefore, the costs of the project can largely be allocated to the past for these processors. There will still be small training and integration costs that are marginal compared to the savings apparent by automating MTCs.

Table 8 Adoption cost assumptions

Variable	Assumption	Source/ Explanation
Processor adoption costs per eMTC	$2	GHD estimate based on consultation. Taking into account the need for some processors to train staff and upgrade systems.

Counterfactual

Under the counterfactual, it is expected that the implementation process of eMTC automated systems would still be completed, however with greater cost and over a longer period of time. Furthermore, there are significant advantages in integrating all traceability and documentation onto the Meat Messaging platform. Therefore, it is a natural progression of the industry, however, projects such as Meat Messaging and extensions such as this are successes.

Attribution

The majority of the benefits are attributable to the prior effort to develop and adopt the Meat Messaging platform, this has allowed the eMTC integration to be implemented with relative ease for 80% of produce.

Table 9 Attribution assumptions

Variable	Assumption	Source/ Explanation
a) Past research	96%	The outcome is largely attributable to the significant prior investment into developing the Meat Messaging platform (estimated at $2m). Extending this platform to manage eMTCs was a natural extension requiring minimal investment.
b) Future Development	0%	Meat Messaging will continue to be extended, however, the eMTC system's identified advantages will continue.
c) Promotion and extension	0%	NA
d) Attribution of remaining benefits to project	4%	=100 – a – b - c

Note: Subject to rounding error

Adoption

Of the current 200,000 manual MTCs entered per annum, it is estimated that 85% will eventually be processed using eMTCs over the coming years. Under the counterfactual scenario (without the project) it is estimated that uptake of eMTCs would slowly increase as individual processors develop their own internal systems for automating part of the process.

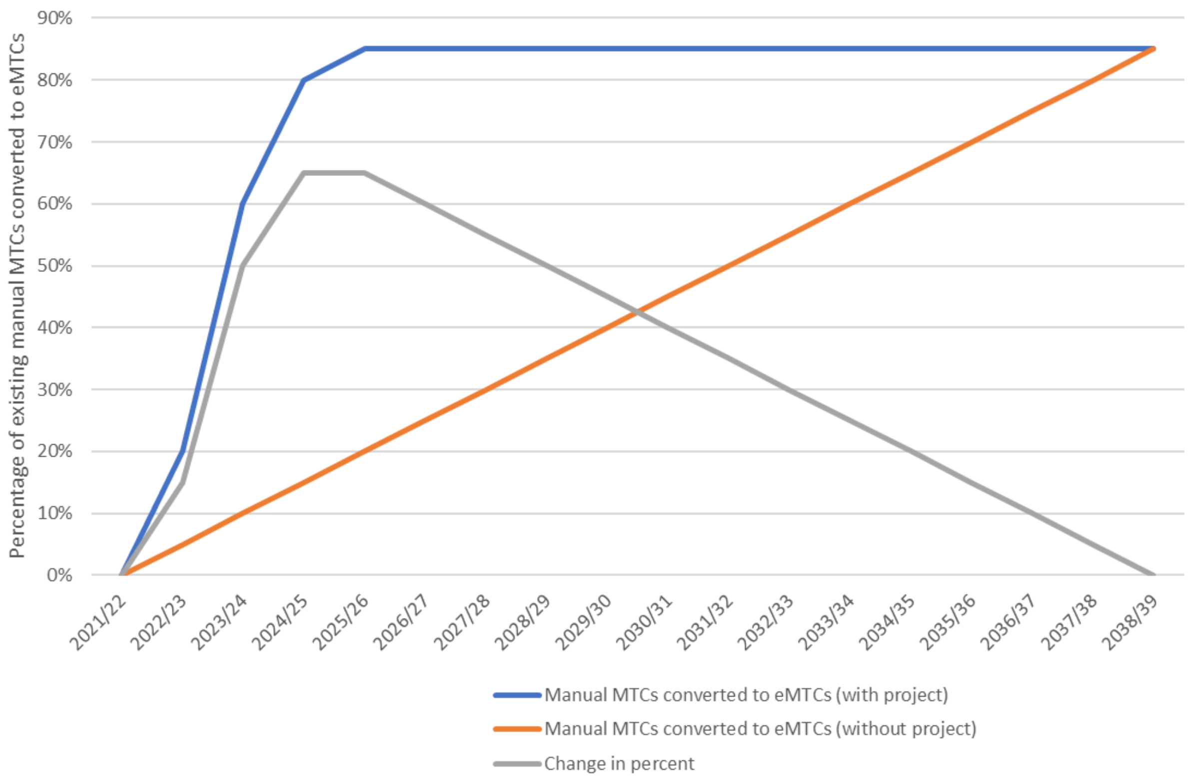

Figure 2 Projected adoption rate of eMTCs

Results

Table 10 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2021/22 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to current dollars using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2021/22) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $0.74 and a favourable Benefit Cost Ratio of 10.7.

Table 10 Investment criteria for total investment in Project 2020-1038 ($m)

Year	0	5	10	15	20	25	30
PV Benefits	$-	$0.41	$0.71	$0.81	$0.82	$0.82	$0.82
PV Costs	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08
NPV	-$0.08	$0.34	$0.63	$0.74	$0.74	$0.74	$0.74
BCR	-	5.4	9.3	10.7	10.7	10.7	10.7
IRR	NA	88%	92%	92%	92%	92%	92%
MIRR	-100%	30%	25%	20%	16%	14%	13%

The flow of total undiscounted costs and benefits from the project is presented below.

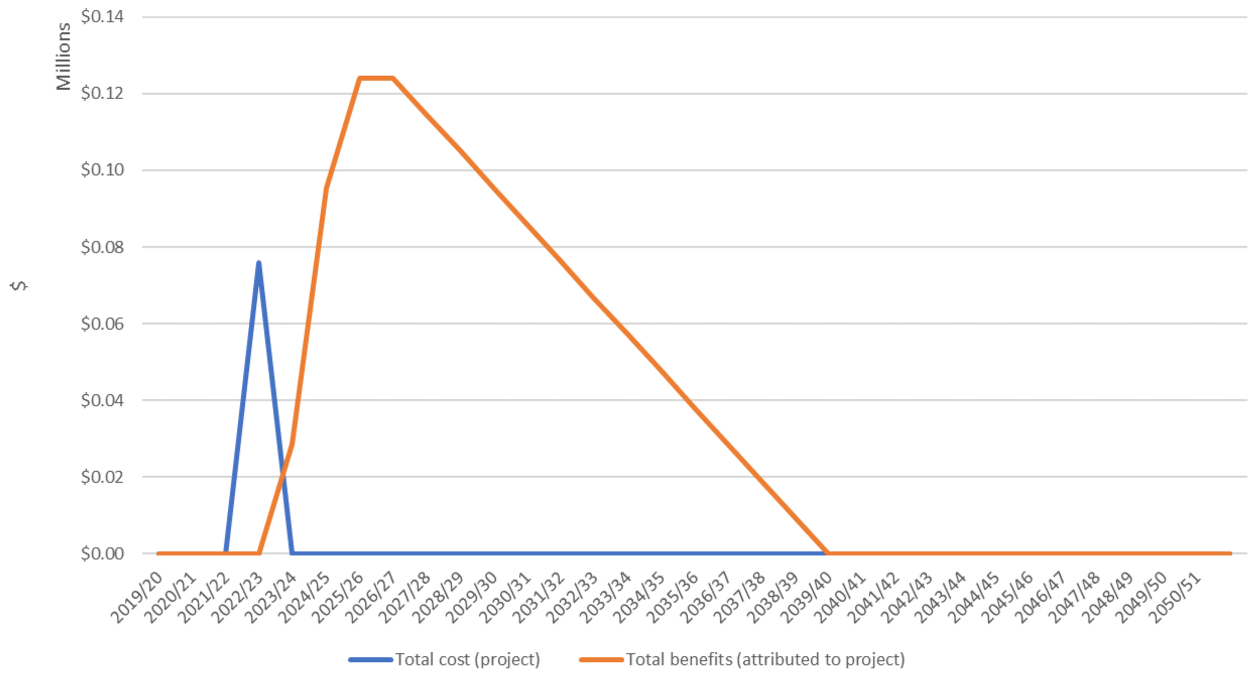

Figure 3 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 11 below.

Table 11 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		$0.74	10.7	13%
Adjusted discount rate				
	0%	$1.04	14.7	8%
	10%	$0.55	8.2	17%
Adjusted potential benefits				
	+20%	$0.89	12.7	14%
	-20%	$0.59	8.8	11%

The accuracy of the assessment is highly dependent on both the extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and the level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions). Presented below is an assessment of coverage and confidence ratings for this project.

Table 12 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	High	The evaluation covers the main benefits in reduced administrative costs from data entry and record keeping.
Confidence in assumptions	High	The potential cost savings and projected adoption are well understood. The project is already showing benefits as it is adopted by DAWE and many processors.

Conclusions

Project *2019-1038: Electronic Meat Transfer Certificate Protocol (eMTC) implementation including DAWR requirements* worked to create an eMTC system that could be integrated into the Meat Messaging platform. This system had to be approved by DAWE, implemented into industry and acceptable by export market standards. Uptake of this system is expected to deliver significant administrative cost savings from data entry and record keeping.

Based on the adopted assumptions this analysis has estimated the project investment will likely deliver a positive economic benefit (BCR 10.7). This investment return remained positive under all scenarios modelled.

References

Bowler. D (2022), *eMTC Implementation including DAWR (DAWE) requirements*, Management for Technology, prepared for AMPC.

Acknowledgements

Consultations undertaken with project lead Des Bowler (Data42, 5/30/2021)

8.2 Appendix B: 2021-1223: Shadow Robot – Bandsaw Cutting of Beef Shank – Stage 1

Background

Shadow robotics present an opportunity to remove the risks of injuries from processing lines. Operators having the capability to control robots to complete these tasks reducing the likelihood of injuries caused by sharp equipment, such as knives and saws, and reducing the stress and fatigue caused by heavy duty tasks. The technology is still in the early development stage with considerable work required to refine and tailor uses for commercial meat processing.

This project explored the feasibility of using state-of-the-art telemanipulation technologies to remove human work force from hazardous meat processing tasks. The project specifically focused on the task of cutting beef shank on a band saw.

Description of the project

Table 13 Project description and logic

Project Details	This project was carried out by Danish Meat Research at a budget of $215,000. It classifies under AMPC's program stream '1. Advanced Manufacturing: 1.1: Hands-off Processing'
Rationale	The technologies of telerobotic solutions that integrate with low cost cobots have become commercially available which may offer a solution to remove the operator from the hazardous processes on the slaughter floor.
Objectives	/ To provide the industry with working knowledge on state-of-the-art telemanipulation technologies, and their potential applications / To investigate the feasibility of at least 2 telemanipulation technologies in removing human work force from the hazardous meat processing tasks, when cutting beef shank on a band saw / To develop a methodology using telemanipulators for the task meeting capacity and quality requirements
Activities and Outputs	/ Develop and test pilot plant experience with the 2 technologies and gain understanding for the potential capabilities they provide. Software interfaces were built and configured, and integration between telemanipulators and robots was set up. / Design and construction of a safe testing site, for beef shank cutting with band saw, executed by a cobot controlled remote by an operator with telemanipulator, ensuring that safety measures are undertaken to protect equipment from damage and personnel from harm. The use of safe zone in the robot software was also useful to this end. A mechanical guide was used to ensure a consistent cut thickness every time. / Tests for the necessity of force feedback in the operation loop was made. The capacity and quality of the cutting was tested for Virtuose 6D telemanipulator, as the lack of force feedback, as is, in the VIPER™ System did not permit safe control and cutting, as the operational value of force feedback was high. / Developed and demonstrated iterative steps in the processing of meat utilizing shadow robot cutting
Potential Outcomes	/ A step towards partial/complete automation of these tasks / Plants will have greater knowledge and capacity to adopt this technology

	/	Plants will not waste resources on the TRL9 which was deemed as not being ready for integration into everyday equipment
Potential Impacts	/	Reduced operating costs due to reduced staff costs, increased staff retention, reduced injury time and costs and increased yield (reduced waste)
	/	Improved Workplace Health and Safety

Project investment

AMPC invested $**236,500** into the project over the 2021/22 financial year, including project management costs.

Summary of impacts

Table 14 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 14 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Reduced operating costs due to reduced staff costs, increased staff retention, reduced injury time/costs and increased yield (reduced waste)**
Environmental	/	
Social	/	Improved Workplace Health and Safety

Quantification of impacts

Estimated benefits

The project provided a use case for shadow robotics while highlighting the challenges and limitations. Consultation suggests that shadow robotics is likely to be an important "stepping stone" in a gradual transition towards automation of processes.

The project demonstrated that it is possible, with some training, to use a telemanipulator like the Virtuose 6D controlling a cobot, to execute a process such as cutting shanks on a bandsaw with the operator placed at a remote location. The quality of the cut samples was of acceptable thickness variation within the specification of 50 [mm] ±10 [mm]. The project highlighted some limitations to shadow robotics, such as the need to have "force feedback in the telemaniputator, to navigate through the bandsaw without any load error". The project also highlighted challenges in removing human senses and years of experience from the process.

The report concludes that "many of the actual moves seem within reach of a fully automatic control in the system, and thus only requiring shorter operator validation or more delicate manipulation in the critical steps, after which the system can work with full automation. It is envisaged that such a mix of automatic-manual-automatic-manual- control interchange would allow for both capacity improvement and reduce the control load on the operator". In summary, while the project demonstrated that this remote application is possible, it would be more logical and beneficial to automate certain aspects of the task therefore only requiring in-person human validation and manipulation at certain points. This would be a progression towards full automation.

With these findings in mind, this analysis considers that the main outcome from the project will be more targeted and efficient future research into shadow robotics and automation, placing more focus on targeted human interventions supported by automated processes where appropriate.

Given the above findings, the benefits from the project have been modelled as a dividend on future research. This approach assumes that industry R&D investments in the coming years will yield slightly higher benefits than would otherwise be expected, on account of the learnings derived from this project. This assumption was supported by consultations with AMPC and researchers.

Table 15 Benefit assumptions

Variable	Without Project	Source/ Explanation
a) Typical annual AMPC investment into shadow robotics	$1.32M	In 2021/22 AMPC invested approximately $4m in core projects within the Advanced Manufacturing (Hands-Off Processing) Program Stream. A review of project titles suggests around 33% relate to shadow robotics. This is a conservative estimate excluding plant-initiated projects.
b) Indicative ROI without project	5.5	Weighted average return from rural R&D investments (Agtrans Research 2019).
c) Indicative returns from R&D without project	$7.26M	= a x b
d) Dividend on returns due to project	5%	Slightly higher returns from future R&D due to investments being more targeted and informed by the findings of the study. Investments taking into account the limitations of shadow robotics as well as the opportunities for targeted human interventions supported by automated processes where appropriate. A 5% dividend would increase the indicative ROI from R&D investments from 5.5 to approximately 5.8.
e) Additional returns from R&D investment	$363,000	= c x d

Adoption costs

The outcomes from the project will be used to inform future R&D, therefore no adoption costs were considered.

Counterfactual

Under the counterfactual scenario future R&D into shadow robotics would be less informed by the outcomes from the project. Future research would have been more likely to continue to pursue the goal of fully-remote shadow robotic applications to the detriment of more practical semi-automated and/or semi-remote applications. As a result, the return on investment from future investments would be slightly lower (as outlined in Table 15 above).

Attribution

100% of the benefits calculated are attributable to the project.

Adoption

The analysis assumed that additional returns from R&D investments into shadow robotics and automation will be yielded for 3 years from 2022/23 to 2024/25. After this time the findings of the project will be superseded by new knowledge.

Results

Table 16 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2021/22 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to current dollars using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2021/22) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $0.75m and a favourable Benefit Cost Ratio of 4.1 modelled over 30 years.

Table 16 Investment criteria for total investment in Project 2021-1223 ($m)

Year	0	5	10	15	20	25	30
PV Benefits	$0	$0.99	$0.99	$0.99	$0.99	$0.99	$0.99
PV Costs	$0.24	$0.24	$0.24	$0.24	$0.24	$0.24	$0.24
NPV	-$0.24	$0.75	$0.75	$0.75	$0.75	$0.75	$0.75
BCR	0	4.1	4.1	4.1	4.1	4.1	4.1
IRR	NA	72%	72%	72%	72%	72%	72%
MIRR	-100%	22%	16%	13%	11%	10%	9%

The flow of total undiscounted costs and benefits from the project is presented below.

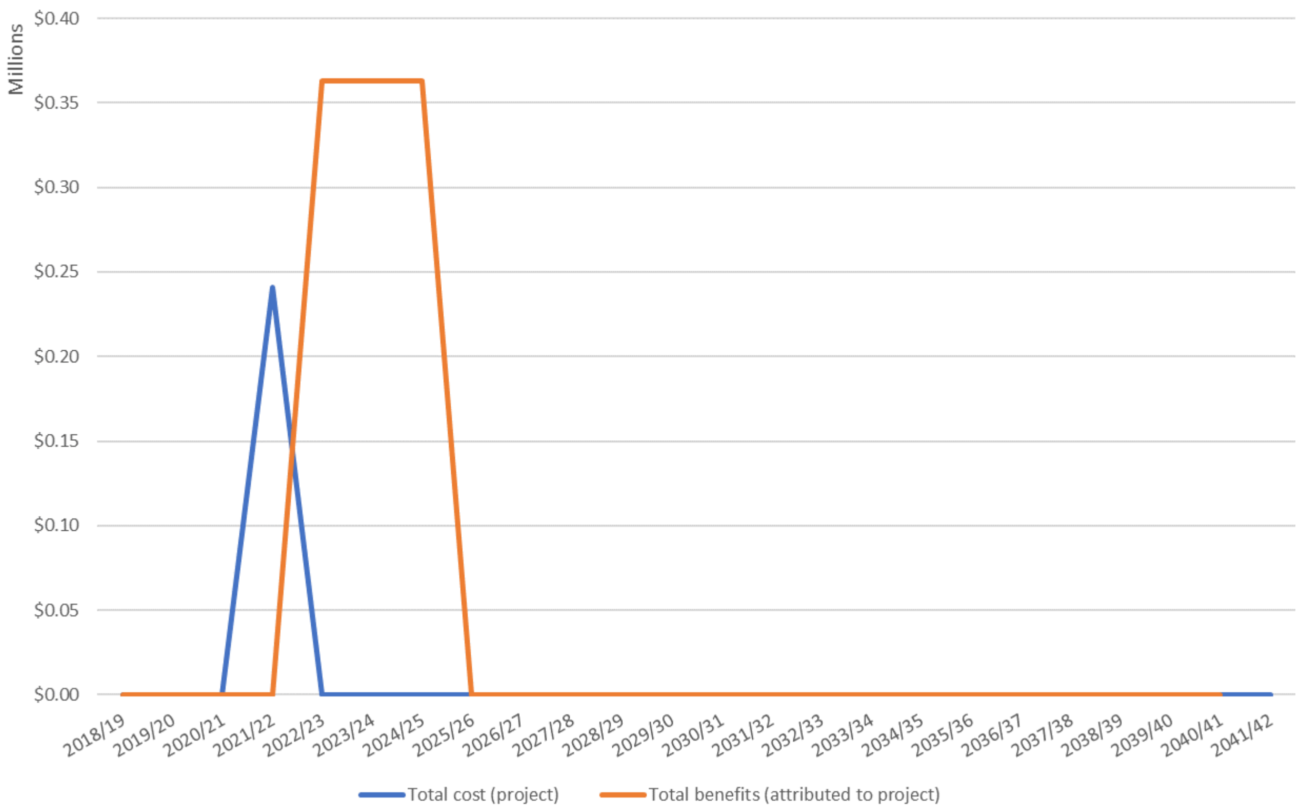

Figure 4 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 17 below.

Table 17 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		0.75	4.10	9%
Adjusted discount rate				
	0%	$0.85	4.52	5%
	10%	$0.66	3.75	14%
Adjusted potential benefits				
	+20%	$0.95	4.93	10%
	-20%	$0.55	3.28	9%

The accuracy of the assessment is highly dependent on both the extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and the level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions). Presented below is an assessment of coverage and confidence ratings for this project.

Table 18 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	Low-Medium	The analysis covered the intermediary benefit from the project, being to better inform future R&D in this area. However, the full nature of future benefits remains unclear and for example may include social outcomes from increased employment opportunities for disabled people.
Confidence in assumptions	Low-Medium	Shadow robotics is considered "blue sky" technology, therefore the applications, expected benefits, costs and timeline for adoption remain very unclear. In the absence of more certainty, very high-level assumptions were used.

Conclusions

Project *2021-1223 Shadow Robot – Bandsaw Cutting of Beef Shank – Stage 1* explored the feasibility of using state-of-the-art telemanipulation technologies to remove human work force from hazardous meat processing tasks. The project specifically focused on the task of cutting beef shank on a band saw. While the project demonstrated that this remote application is possible, the report concluded that rather than having a human perform the task in a remote location, it would be more logical and beneficial to automate certain aspects of the task therefore only requiring in-person human validation and manipulation at certain points. This would be a progression towards full automation.

With these findings in mind, the evaluation considers that the main outcome from the project will be more targeted and efficient future research into shadow robotics and automation, placing more focus on targeted human interventions supported by automated processes where appropriate.

Based on the adopted assumptions this analysis has estimated the project investment will likely deliver a positive economic benefit (BCR 4.1). This investment return remained positive under all scenarios modelled.

References

Danish Meat Research Institute (2022) *Shadow Robot – Bandsaw Cutting of Beef Shank – Stage 1*, prepared for AMPC.

Acknowledgements

Consultations undertaken with Stuart Shaw (AMPC) and Niels Toftelund Madsen (DMRI).

8.3 Appendix C: 2021- 1222: Artificial Intelligence (AI) – Non-X-ray Beef Cutting – Stage 2

Background

Beef scribing is the first step in the deboning process and most critical to ensuring processors get the most out of each carcase. The manual task of beef scribing is one of the most dangerous for employees and AMPC has focussed on improving this task to benefit both employee safety and carcase yield. The first iteration of beef scribing at NCMC (now known as the Casino Food Co-Op) initially targeted fully automatic placement of cut lines using pattern matching with colours however this was considered unsuccessful in accuracy. The DEXA sensing technology has since been implemented successfully and provided proof of the advantages of improving accuracy in beef scribing processes, however, this approach utilizes x-ray technology which is not easily adopted by most plants due to price, size, and energy usage. The improvements in imaging technology along with application of AI mean there is an opportunity to use non-x-ray beef cutting.

Description of the project

Table 19 Project description and logic

Project Details	This project was carried out by Intelligent Robotics at a budget of $237,929. It classifies under AMPC's program stream '1. Advanced Manufacturing: 1.4: Carcase Optimisation'.
Rationale	The current options available for beef scribing are x-ray based technologies. This is a costly, complex, and large system. The rational for this project is to test the feasibility of a non-x-ray solution that will be easier and cheaper to implement.
Objectives	/ To explore and test non-x-ray substitutes for beef scribing technology that is acceptably accurate / Determine the feasibility of software in identification of the necessary locations and implementation of a beef scribing system based on imaging identification rather than x-ray
Activities and Outputs	/ Implemented lighting and a camera configuration to be used for testing in 2 plants / Recorded a large test set of data / Developed and tested a neural network AI model which successfully identifies key points on the carcase / Validated results against another set of data from an experienced manual operator
Potential Outcomes	/ This project has shown that by utilising software which analyses images under the correct conditions it is possible to identify key carcase locations accurately – this allows for further development of software to integrate into an automatic beef scribing set up.
Potential Impacts	/ A cheaper, less complex and safer alternative to the x-ray beef scribing system currently being utilised by plants / Feasible for smaller plants to adopt this technology / Step towards utilisation of AI to be implemented for full automation

Project investment

AMPC invested $**261,722** into the project over the 2021/22 financial year, including project management costs.

Summary of impacts

Table 20 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 20 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Increased carcass yield due to improved accuracy of cuts and reduced wastage. Benefit estimated at $8/head.**
Environmental	/	Lower energy usage compared to x-ray options.
Social	/	The potential to automate beef scribing along with other manual tasks would take humans away from some of the more dangerous processing activities

Quantification of impacts

Estimated benefits

This project demonstrated the proof of concept for image based AI identification of a key carcase locations allowing for improved accuracy in beef scribing. This proof of concept is expected to provide an important step towards commercially viable automation of processes within the industry.

The project has provided scope for an image-based option which is potentially more accessible than the large-scale DEXA unit previously implemented. Further, steps have been outlined to increase the level of accuracy with identified changes. Consultation with AMPC and Intelligent Robotics suggested that the technology generated improved yields valued at approximately $8 per head (cattle) due to greater accuracy in cutting leading to a higher volumes of higher value cuts.

The potential application of this technology in processing plants to inform automated beef scribing processes is seen as the main outcome and is the output quantified in this analysis. This could contribute to further application and automation into other processes within processing plants, however, there is more refining and integrating steps required to fully implement this technology.

Table 21 Benefit assumptions

Variable	Assumption	Source/ Explanation
a) Value of improved yield	$8 per head	AMPC and researcher consultation
b) Indicative throughput per plant	200,000	Typical annual throughput of larger beef processors most likely to implement the technology.
c) Annual benefit per plant	$1.6m	a x b
d) Cost to adopt	$3m	Conservative estimate based on AMPC and researc consultation.

Adoption costs

As outlined above, the adoption costs are estimated at approximately $3m validated through consultation with AMPC and Intelligent Robotics. Considering this project was a proof of concept rather than full implementation the adoption costs are still to be explored.

Counterfactual

Under the counterfactual scenario it is assumed that outcomes (improved beef scribing) would be delayed by 5 years, as other technology options are developed, or similar technology enters Australia after becoming established in overseas processing sectors.

Attribution

Attribution of benefits was based on the estimated costs incurred by all parties in delivering the outcomes, including past research, future development and extension. In this case

10% of the benefits were assumed attributable to this project considering it plays a small role in the total beef scribing automation process. However, this project has provided advantages in potentially making the automation of beef scribing more commercially feasible and practical compared to x-ray solutions.

Table 22 Attribution assumptions

Variable	Assumption	Source/ Explanation
a) Past research	51%	Past research and development of beef scribing options and specific AI technologies used to support the proof of concept. Past costs were estimated at $0.4m per annum over past 4 years ($1.6m total).
b) Future Development promotion and extension	42%	Before broad implementation is achieved, the proof of concept will be trialled in plant and incorporated into a much larger automation initiative. Future costs were estimated at $0.5m per annum over the coming 3 years ($1.5m total).
c) Attribution of remaining benefits to project	8%	=100 – a – b

Adoption

Through consultation with Intelligent Robotics, it is estimated that the larger beef processing plants will adopt this technology over the coming 10 years at a rate of 1-2 plants per annum. As can be seen in Figure 5 below, the counterfactual would be the same pattern of adoption delayed by 5 years.

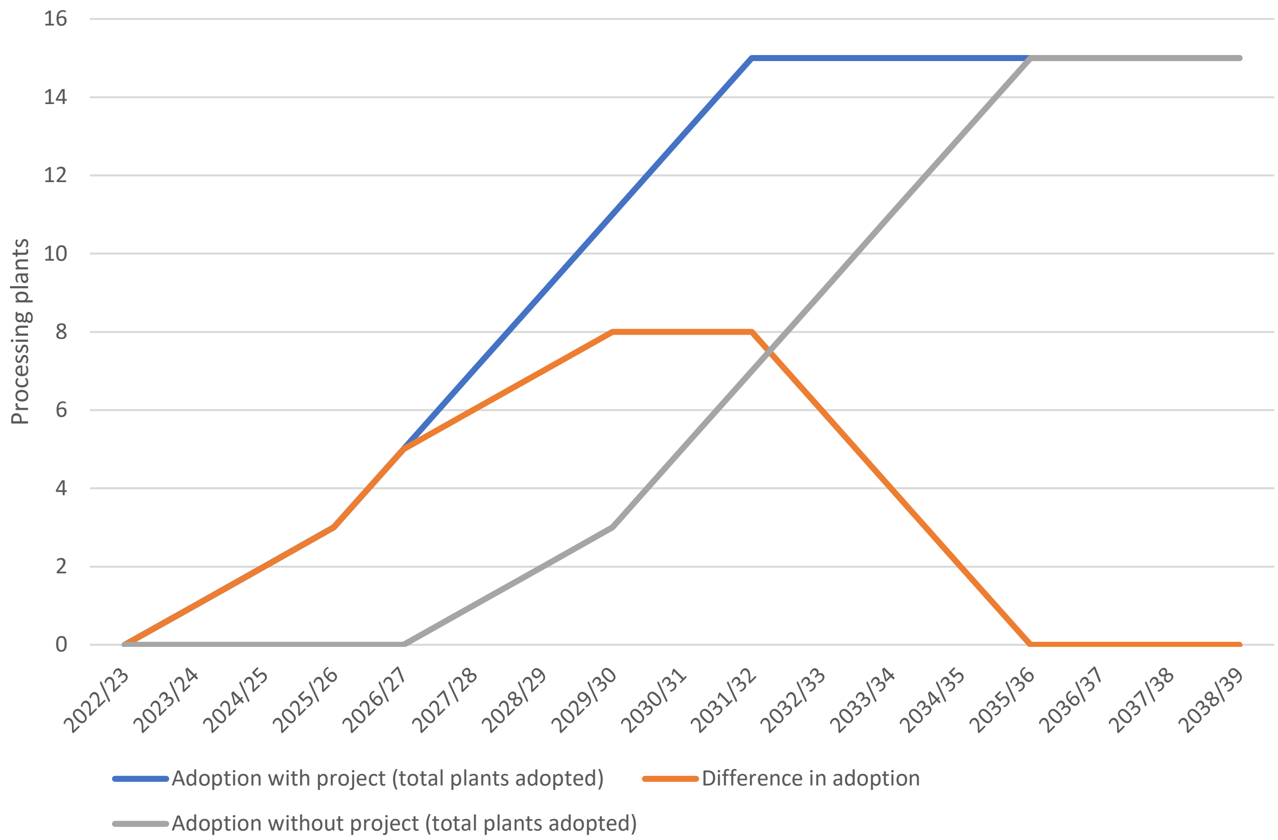

Figure 5 Projected adoption of automated beef scribing utilizing AI analysis on images

Results

Table 23 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2021/22 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to current dollars using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2021/22) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $2.37m and a favourable Benefit Cost Ratio of 9.9 modelled over 30 years.

Table 23 Investment criteria for total investment in Project 2021-1222 ($m)

Year	0	5	10	15	20	25	30
PV Benefits	$0	$0.16	$1.75	$2.64	$2.64	$2.64	$2.64
PV Costs	$0.27	$0.27	$0.27	$0.27	$0.27	$0.27	$0.27
NPV	-$0.27	-$0.11	$1.49	$2.37	$2.37	$2.37	$2.37
BCR		0.6	6.6	9.9	9.9	9.9	9.9
IRR	NA	-4%	33%	36%	36%	36%	36%
MIRR	-100%	1%	18%	17%	14%	12%	11%

The flow of total undiscounted costs and benefits from the project is presented below.

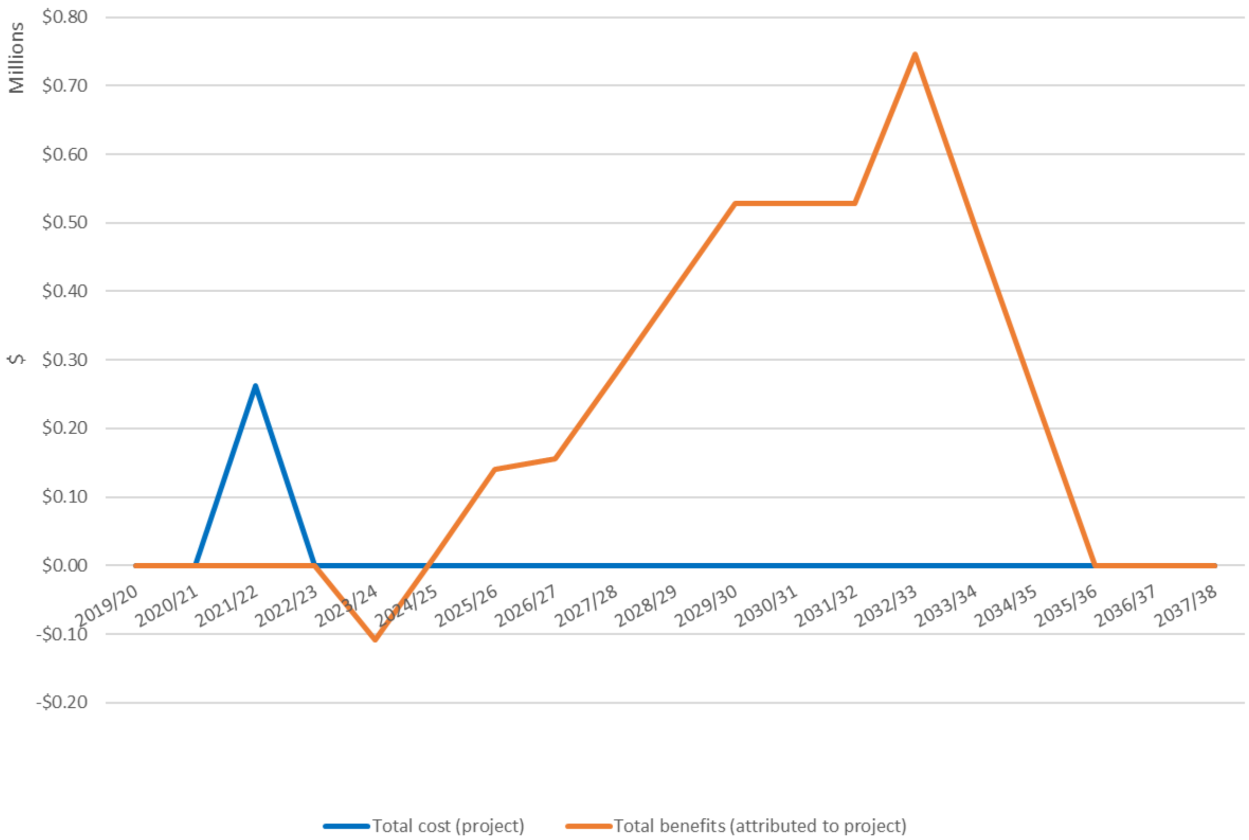

Figure 6 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 24 below.

Table 24 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		2.37	9.90	11%
Adjusted discount rate				
	0%	$3.61	14.56	7%
	10%	$1.57	6.91	15%
Adjusted potential benefits				
	+20%	$3.43	13.89	13%
	-20%	$1.31	5.91	9%

The accuracy of the assessment is highly dependent on both the extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and the level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions). Presented below is an assessment of coverage and confidence ratings for this project.

Table 25 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	High	The analysis includes the main benefit being increased yield per head. Additional benefits may be derived from improved worker safety however these are considered dependent on the automation of processes.
Confidence in assumptions	Medium	As this was a proof of concept, there is still some uncertainty around the full integration into processing, adoption rate and attribution.

Conclusions

Project *2021-1222 Artificial Intelligence (AI) – Non-X-ray Beef Cutting – Stage 2* has provided industry a pathway to implement AI technology in identification of key locations on a carcase. This included trials and recommendations of ideal set up and equipment necessary to produce acceptably accurate results. The project relied on considerable past R&D in developing the technology, and further investment will be required to trial and implement the technology. However, the advantages of successful outcomes in automating these otherwise manual tasks such as beef scribing are large.

Based on the adopted assumptions this analysis has estimated the project investment will deliver a positive economic benefit (BCR 9.90). This investment return remained positive under all scenarios modelled.

References

Intelligent Robotics (2022) *Artificial Intelligence - Non-X-ray Beef Cutting - Stage 2*, prepared for AMPC.

Acknowledgements

Consultations undertaken with Stuart Shaw (AMPC) and Jonathan Cook (Intelligent Robotics).

8.4 Appendix D: 2019-1060 Megasonic demulsification of oil and grease from meat processing wastewater

Background

The CSIRO has a patented technology which uses megasonic vibrations (high-frequency ultrasound) to effectively separate and recover fat, oil and grease (FOG) from emulsions and effluent. This novel technology has been successfully applied in palm oil processing and also in restaurants and food service applications, however had not yet been trialled on treating FOG from abattoir wastewater streams.

Description of the project

This proof-of-concept study explored if megasonic demulsification technology could be used to effectively separate and recover FOG from abattoir wastewater streams. If successful, the technology offered an opportunity to increase the amount of FOG available for the production of tallow and also decrease the amount of treatment needed on wastewater.

The study was completed at a laboratory (benchtop) scale utilising wastewater samples from multiple sites across Victoria and Queensland. This included a process of questioning the abattoirs about current practices, technical meetings around wastewater treatment processes, technologies for FOG recovery and issues involving FOG losses in wastewater streams due to emulsions. Site visits were necessary for the scoping phase however were impacted by COVID-19 and weather events.

The study found that megasonic treatment was generally ineffective for FOG separation, however some opportunities were identified for future research.

Table 26 Project description and logic

Project Details	Project title: 2019-1060 Megasonic demulsification of oil and grease from meat processing wastewater Organisation: CSIRO Date completed: May 2021
Rationale	To determine whether the use of megasonic demulsification of FOG can be utilised in abattoir wastewaters to increase FOG retention and decrease processing of wastewaters.
Objectives	/ To determine the effectiveness of Megasonic demulsification of FOG can be utilised in abattoir wastewaters / Provide case studies of effectiveness
Activities and Outputs	/ Visited multiple sites and collected samples of which were then used for testing with the megasonic demulsification
Outcomes	/ Megasonic treatment was generally ineffective for FOG separation, however some opportunities were identified for future research
Potential Impacts	/ Avoided future investment in pre-feasibility and piloting of the technology

Project investment

AMPC invested **$178,734** into the project over the 2021/22 financial year, including project management costs.

Summary of impacts

Table 27 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 27 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/ **Avoided future investment in pre-feasibility and piloting of the technology** / Identification of future research opportunities
Environmental	/
Social	/

Quantification of impacts

Estimated benefits

The laboratory-based study found that megasonic demulsification is generally not effective in separating oil and grease from meat processing wastewater. Despite the unsuccessful results the project can be considered to have delivered benefits to the industry in clarifying this finding and therefore avoiding larger research investments in the future.

In the absence of this preliminary study, it is likely that megasonic demulsification would have been investigated further either by AMPC or individual processors. This investigation would have likely occurred via either a pre-feasibility study or in-plant trial. Based on the results of this project, these investigations would have found the technology to be unsuitable.

Table 28 Benefit assumptions

Variable	Assumption	Source/ Explanation
a) Avoided investment in further exploring the feasibility of using megasonic demulsification in abattoirs	$250,000	Consultation with AMPC suggests that investment could have ranged from a pre-feasibility study (approximately $100,000) up to an in-plant pilot (approximately $500,000).

Adoption costs

The above benefits represent an avoided cost of future research, therefore no adoption costs would be incurred.

Counterfactual

Under the counterfactual scenario additional research would likely be undertaken to explore the feasibility of using megasonic demulsification in abattoirs.

Attribution

All benefits from the avoided research are attributable to the project.

Adoption

Based on the results of the trial the technology is unlikely to be adopted in the near future (notwithstanding some other avenues for research).

Results

Table 29 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2021/22 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to current dollars using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2021/22) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $0.05M and a favourable Benefit Cost Ratio of 1.3. The return from the project was lower because the technology was not found to be effective, however this finding is most likely beneficial in directing future research into more feasible areas.

Table 29 Investment criteria for total investment in Project 2019-1060 ($m)

Year	0	5	10	15	20	25	30
PV Benefits	$-	$0.23	$0.23	$0.23	$0.23	$0.23	$0.23
PV Costs	$0.18	$0.18	$0.18	$0.18	$0.18	$0.18	$0.18
NPV	-$0.18	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05
BCR	-	1.3	1.3	1.3	1.3	1.3	1.3
IRR	NA	18%	18%	18%	18%	18%	18%
MIRR	-100%	8%	7%	6%	6%	6%	6%

The flow of total undiscounted costs and benefits from the project is presented below.

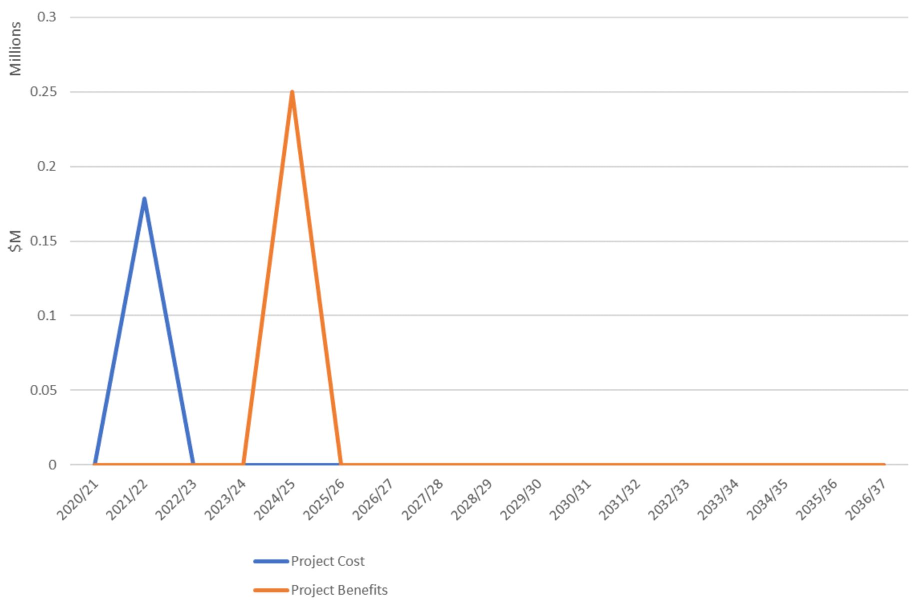

Figure 7 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 30 below.

Table 30 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		$0.05	1.3	18%
Adjusted discount rate				
	0%	$0.07	1.4	18%
	10%	$0.03	1.2	18%
Adjusted potential benefits in avoided research costs				
	+20%	$0.09	1.5	30%
	-20%	$0.00	1.0	6%

The accuracy of the assessment is highly dependent on both the extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and the level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions). Presented below is an assessment of coverage and confidence ratings for this project.

Table 31 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	Medium	The analysis covered the main benefit being the avoided cost of future research. However, the analysis did not value the peripheral future opportunities for the technology identified in the project, as these opportunities remain unclear and would require additional research.
Confidence in assumptions	High	The estimated cost of avoided future research via feasibility studies or in plant pilots is reasonably well understood based on other similar projects.

Conclusions

Project *2019-1060: Megasonic demulsification of oil and grease from meat processing wastewater* explored if megasonic vibrations could be practically used to separate and recover FOG from abattoir wastewater streams. The study found that megasonic treatment was generally ineffective for FOG separation, however some opportunities were identified for future research.

Based on the adopted assumptions this analysis has estimated the project investment will likely deliver a slightly positive net economic benefit (BCR 1.3) by avoiding costs associated with future research.

References

CSIRO (2021), *Megasonics for Separation and Recovery of Fat Oil and Grease from Abattoir Wastewater Streams: A Proof-of-Concept Study,* prepared for AMPC.

Acknowledgements

Consultation undertaken with Peter Mansour (CSIRO, 8/6/2022)

8.5 Appendix E: 2022-1048: Developing a Voluntary Code of Conduct for the Management of Migrant Workers (Stage 1)

Background

The purpose of this project was to deliver a Voluntary Code of Conduct accompanied by a set of best practice guidelines for the management of migrant workers in the Australian red meat processing industry. The project was initiated in response to the National Processor Council identifying a pressing need for industry to develop a consistent and pro-active approach to Migrant Worker management in anticipation of potential further scrutiny on the sector.

The Project developed a draft Voluntary Code and Compliance Guide, in an ISO auditable format, which may be incorporated into existing compliance auditing processes. At the time of writing AMPC was progressing stage 2 of the process, including piloting the Voluntary Code and developing communication strategies with industry and government to aid implementation.

Description of the project

Table 32 Project description and logic

Project Details	This project was carried out by KPMG Australia at a budget of $286,951. It classifies under AMPC's program stream '3. People & Culture: 3.1: Attraction'.
Rationale	The prior scrutiny faced by the Australian red meat processing sector over Visa Worker treatment was identified as a key issue for the industry.
Objectives	/ To produce a clear system for Visa Worker treatment that is transparent enough that any signatory to the code is considered to be ethical and fair to Migrant Workers. This includes providing the processing industry with: o Voluntary Code of Conduct which sets minimum requirements on treatment of Migrant Workers and supports government regulatory efforts o The option to demonstrate compliance with the Code o Tools and support needed to communicate development and compliance with the Code to both government and other stakeholders o A Code and Compliance Guide which have been iterated in collaboration with both industry and external stakeholders (government, customers, labour hire providers and industry bodies) o Options of best-practice approach to the implementation and ongoing management of the Code / Create a fit for use Code through consultation and involvement of key stakeholders
Activities and Outputs	/ Desktop analysis of relevant legal, industrial, and industry regulatory frameworks and existing research to inform drafting documents / Consistent consultation with AMPC, AMIC and steering group to test/validate / Consultation with external stakeholders
Potential Outcomes	/ Voluntary Code is adopted by industry / Improved welfare of migrant workers / Increased access to migrant workers

	/	Increased assurances of best practice provided to migrant workers, government regulators and customers
Potential Impacts	/	Reduced cost of compliance and restrictions on migrant workers
	/	An industry led and created Code

Project investment

AMPC invested **$315,646** into the project over the 2021/22 financial year, including project management costs.

Summary of impacts

Table 33 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 33 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Reduced cost/risk of future government regulation**
	/	Reduced cost/risk of customer concerns and reputational damage
	/	Improved access to migrant workers
Environmental	/	NA
Social	/	Reduced risk of worker exploitation
	/	Improved demonstration of social responsibility

Quantification of impacts

Estimated benefits

The Voluntary Code is expected to benefit industry by reducing the risk of government (or customer/market) imposed regulations and restrictions on migrant workers. This pro-active approach allows industry to develop workable and effective standards and procedures which can be readily incorporated into existing compliance auditing processes without duplication. Stakeholders expect that over time the Voluntary Code might be incorporated into existing AUS-MEAT Supplier Ethical Data Exchange (SEDEX) audits.

Table 34 Benefit assumptions

Variable	Assumption	Source/ Explanation
a) Potential annual compliance costs from a regulated, government enforced program aimed to ensuring appropriate management of migrant workers	$15,000 per plant	Assuming separate record keeping processes and audit processes. Annual record keeping: $5,000 Audit preparation: $5,000 Independent audit: $5,000
b) Potential annual compliance costs from voluntary code	$6,000 per plant	Alignment with existing record keeping and audits Annual record keeping: $2,000 Audit preparation: $2,000

Variable		Assumption	Source/ Explanation
			Independent audit: $2,000
c)	Potential annual savings in compliance costs	$9,000 per plant	= a - b
d)	Chance of success	90%	Government (or customers) may still choose to place additional regulatory burden on industry.
e)	Potential annual savings in compliance costs (probability adjusted)	$8,100 per plant	= c x d

Adoption costs

The costs for adopting the Voluntary Code are incorporated into the net benefit assumptions outlined in Table 34 above.

Counterfactual

Under the counterfactual scenario it is assumed that government or customers would likely impose some form of compliance program on industry to ensure best practice in the management of migrant workers.

Attribution

Attribution of benefits was based on the estimated costs incurred by all parties in delivering the outcomes, including past research, future development and extension.

Table 35 Attribution assumptions

Variable		Assumption	Source/ Explanation
d)	Past development	7%	The outcome was influenced by past work by the National Processor Council in highlighting the need for a pro-active approach. This development effort is valued at $50,000.
e)	Future Development promotion and extension	51%	The Stage 2 project has a budget of around $250,000. Some additional development and advocacy work may be required by AMPC, AMIC, AUS-MEAT and other industry bodies before the Voluntary Code becomes fully implemented. In addition, the Voluntary Code will require an ongoing review. The estimated cost is $400,000.
f)	Attribution of remaining benefits to project	42%	=100 – a – b

Note: Subject to rounding error

Adoption

The Stage 2 Project is expected to be complete by the end of 2022, after which time the Voluntary Code will need to be finalised and approved, before being communicated to industry, government and customers. This analysis has assumed that adoption will begin in 2023. Based on consultation, uptake amongst processors is expected to be strong, particularly if compliance can be integrated with existing AUS-MEAT audits. Adoption is expected to peak at 80% of processors before declining beyond 2030 as compliance requirements and programs are likely to change.

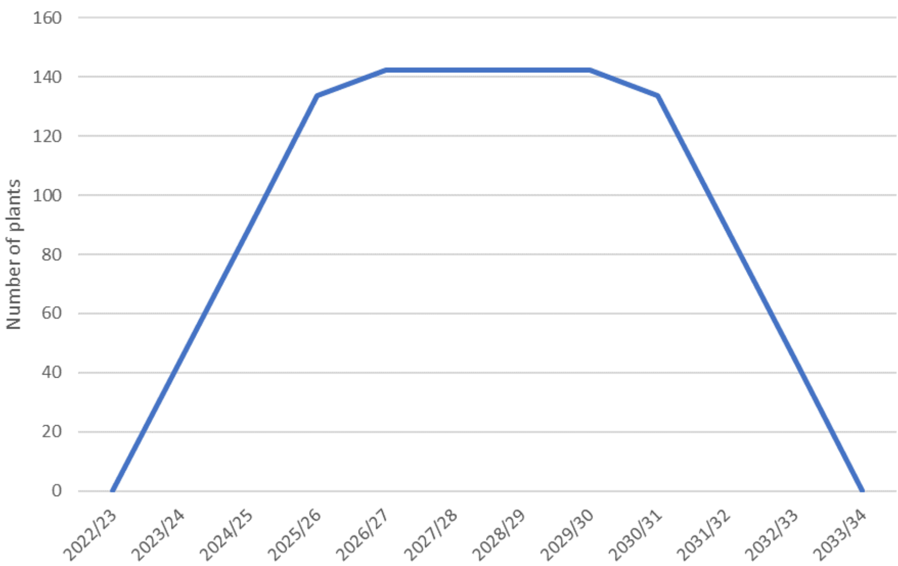

Figure 8 Projected adoption of the Voluntary Code of Conduct for the Management of Migrant Workers

Results

Table 36 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2021/22 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to current dollars using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2021/22) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $2.57 m and a favourable Benefit Cost Ratio of 9 modelled over 30 years.

Table 36 Investment criteria for total investment in Project 2022-1048 ($m)

Year	0	5	10	15	20	25	30
PV Benefits	$-	$1.21	$2.80	$2.89	$2.89	$2.89	$2.89
PV Costs	$0.32	$0.32	$0.32	$0.32	$0.32	$0.32	$0.32
NPV	-$0.32	$0.89	$2.48	$2.57	$2.57	$2.57	$2.57
BCR	-	3.8	8.7	9.0	9.0	9.0	9.0
IRR	NA	49%	60%	60%	60%	60%	60%
MIRR	-100%	21%	22%	18%	15%	13%	12%

The flow of total undiscounted costs and benefits from the project is presented below.

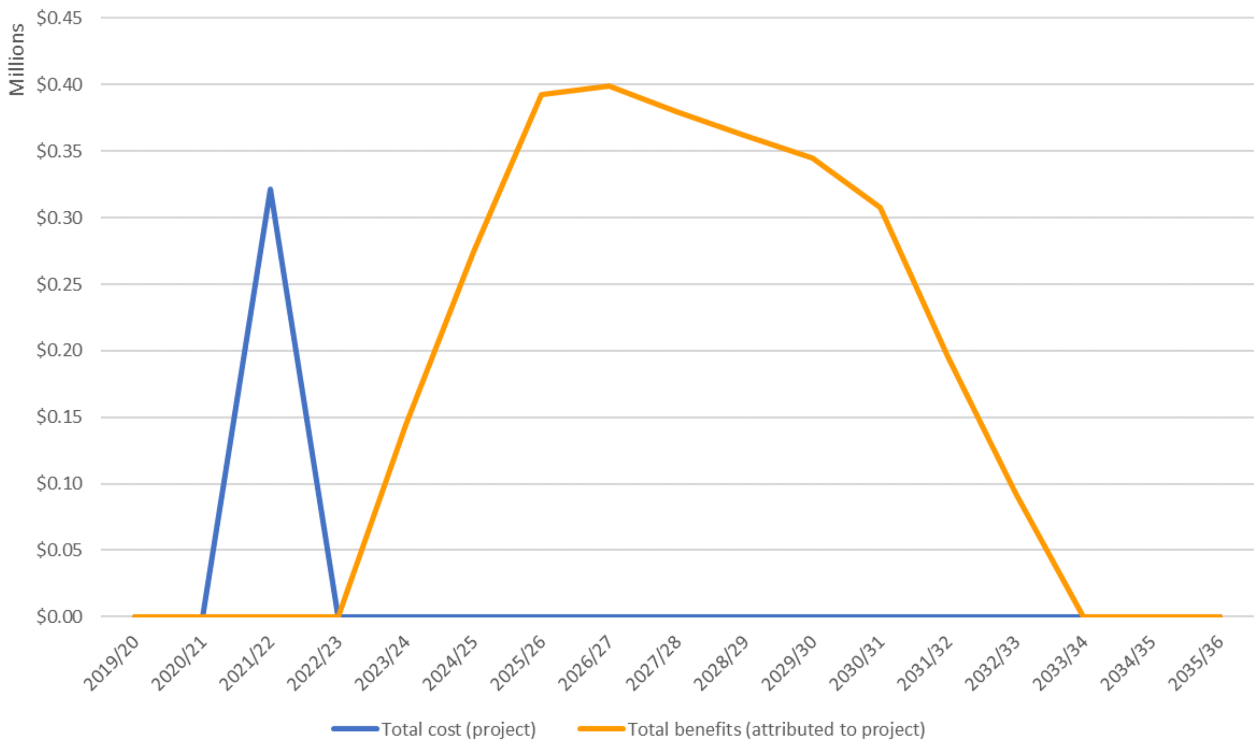

Figure 9 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 37 below.

Table 37 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		2.57	9.00	12%
Adjusted discount rate				
	0%	$3.39	11.55	8%
	10%	$1.99	7.19	16%
Adjusted potential benefits				
	+20%	$3.15	10.80	13%
	-20%	$1.99	7.20	11%

The accuracy of the assessment is highly dependent on both the extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and the level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions). Presented below is an assessment of coverage and confidence ratings for this project.

Table 38 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	Medium	The analysis was based on a potential reduction in compliance costs, however additional benefits may be realised by participants having improved access to labour as a result of compliance with the code.
Confidence in assumptions	Medium	The analysis relied on assumed compliance costs for both the Voluntary Code and a potential regulated government program. In both cases compliance costs are unknown as programs are yet to be implemented.

Conclusions

Project *2022-1048: Developing a Voluntary Code of Conduct for the Management of Migrant Workers (Stage 1)* aimed to develop a Voluntary Code of Conduct accompanied by a set of best practice guidelines for the management of migrant workers in the Australian red meat processing industry. The project was initiated in response to the National Processor Council identifying a pressing need for industry to develop a consistent and pro-active approach to Migrant Worker management in anticipation of potential further scrutiny on the sector.

Once Stage 2 is completed, the Voluntary Code is expected to benefit industry by reducing the risk of government (or customer/market) imposed regulations and restrictions on migrant workers. The Voluntary Code was developed to include workable and effective standards and procedures which can be readily incorporated into existing compliance auditing processes without duplication. Stakeholders expect that over time the Voluntary Code might be incorporated into existing AUS-MEAT Supplier Ethical Data Exchange (SEDEX) audits.

Based on the adopted assumptions this analysis has estimated the project investment will likely deliver a positive economic benefit (BCR 9.0). This investment return remained positive under all scenarios modelled.

References

KPMG (2022) *Developing a Voluntary Code of Conduct for the Management of Migrant Workers (Stage 1)*, prepared for AMPC.

Acknowledgements

Consultations undertaken with Amanda Carter (AMPC) and Eleanor Sondergeld (KPMG)

8.6 Appendix F: 2022-1093 Business Plan for a Red Meat Industry Knowledge Hub

Background

A previous study (*Modernising Training in the Red Meat Sector,* KPMG) found the industry has a "fragmented training landscape", characterised by duplication and inefficiencies, with participants having difficulty finding available information and resources. This study recommended the development of a consolidated and centralised "knowledge hub" for delivering training, sharing knowledge and facilitating collaboration. This opportunity was further explored through a subsequent Business Case.

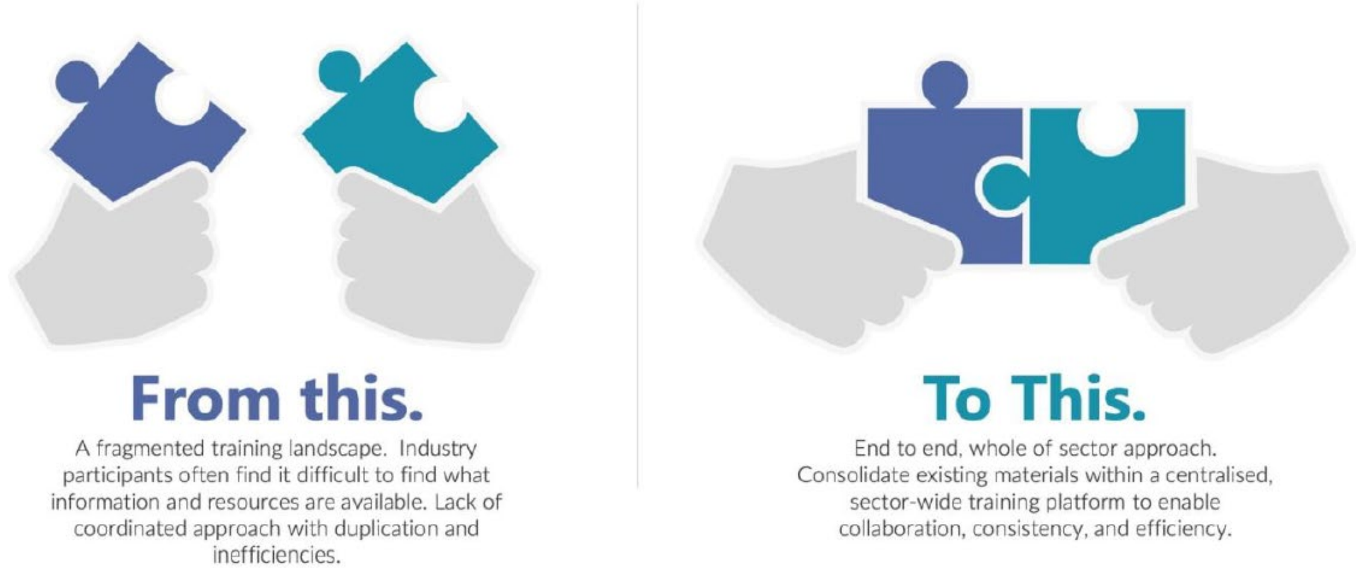

Figure 10 Identified problem and opportunity (KPMG)

Description of the project

This report outlines a business model detailing the financial feasibility of the industry hub under a range of assumptions and scenarios. The business model details both the financial and strategic operations of the Hub.

Table 39 Project description and logic

Project Details	Project title: 2022-1093 Business Plan for a Red Meat Industry Knowledge Hub Organisation: Response Research Pty Ltd Date: March 2022
Rationale	/ The opportunity to develop a centralised Red Meat Industry Knowledge Hub required further investigation to inform future investment decisions
Objectives	/ To provide a business plan to determine the feasibility of funding the Red Meat Industry Knowledge Hub. There was an identified need for the Hub in past research papers completed.
Activities and Outputs	/ This business plan covered: / Strategies for set up, operations, technology, intellectual property and marketing and communications

	/	Financials, including; establishment costs, licensing costs, development costs, cost recovery and financial projections
	/	Operation plan
Potential Outcomes	/	The business plan increases the feasibility of creating the knowledge hub
	/	Increasing the accessibility, quality and scope of training resources available to sector members
	/	More workforce upskilling efficiently and at scale
	/	Create a forum for collaboration, share learnings and equip the workforce to continue being fit for market
Potential Impacts	/	Reduced training costs and increased knowledge sharing
	/	Increased staff retention
	/	Reduced resources from in-person training
	/	Increased knowledge sharing and collaboration

Project investment

AMPC invested **$33,000** into the project over the 2021/22 financial year, including project management costs.

Summary of impacts

Table 40 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 40 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Reduced training costs and increased knowledge sharing**
	/	**Increased staff retention**
Environmental	/	Reduced resources from in-person training
Social	/	Increased knowledge sharing and collaboration

Quantification of impacts

Estimated benefits

The Business Plan estimated the cost of developing the Knowledge Hub at just over $2m over two years, after this point the service would likely operate on a subscription basis, with revenue received via the following:

- Access fee: a $50 fee per person to join the platform and access free content and networks
- Course fees: additional $250 fee to access industry-built courses required as part of a typical induction process.

The above estimated prices provide a general guide to the benefits delivered to users of the platform.

Table 41 Benefit assumptions

Variable	Assumption	Source/ Explanation
a) Annual benefit per subscriber	$100	It was assumed that each subscriber would obtain $100 in value (double the subscription fee) each year, through access to information, knowledge and networking. Benefits include time savings and efficiencies in facilitating faster research and connections. Noting that some staff subscribed to the platform may use it on a daily or weekly basis, while others may not utilise it beyond the initial induction.
b) Additional staff retention benefit per subscriber	$50	Identifying career pathways and opportunities through the knowledge hub will likely increase staff retention rates and therefore reduce plant costs associated with recruitment and training. The analysis conservatively assumed a 1% increase in retention rate, reducing recruitment and training costs (estimated at $5,000 per person) by $50 per annum.
c) Benefit per course delivered	$500	Avoided cost of induction training traditionally delivered independently by each plant on a weekly or fortnightly basis, to small groups of new starters. Removing this requirement would free up staff and company resources in planning and delivering training.

Adoption costs

The above potential benefits will be offset by the proposed subscription costs for the service, outlined below.

Table 42 Adoption cost assumptions

Variable	Assumption	Source/ Explanation
Subscriber fee	$50 per person	Business Plan
Course fee	$250 per course	Business Plan

Counterfactual

Under the counterfactual scenario the Knowledge Hub Business Plan would not have been completed and the concept not developed at this time. Training and information sharing would continue to be delivered in a less centralised way, with more duplication and inefficiencies.

Attribution

Attribution of benefits was based on the estimated costs incurred by all parties in delivering the outcomes, including past research, future development and extension.

Table 43 Attribution assumptions

Variable	Assumption	Source/ Explanation
a) Past research	36%	Past efforts have contributed to developing the case for a knowledge hub including the past AMPC Project (*Modernising Training in the Red Meat Sector*) and efforts by Response Research to develop the concept to the Business Planning stage. This previous investment is estimated at $1m.
b) Future Development	63%	If the concept proceeds to development, an estimated cost of $2.1M will be incurred over the first two years before the platform would be launched.
c) Promotion and extension	NA	Promotion and extension costs are assumed to be covered by the subscription revenue (adoption costs outlined above).
d) Attribution of remaining benefits to project	1.15%	=100 – a – b - c

Note: Subject to rounding error

Adoption

The Business Plan modelled an expected uptake from meat processors and staff following establishment of the Knowledge Hub (peaking at 97 processors). This analysis has adopted a somewhat more conservative estimate of adoption rate, 20% below the business case estimates (peaking at 78 processors). Adoption rate was also tested in the sensitivity analysis.

Table 44 Projected adoption following establishment of the Knowledge Hub (Business Plan)

Years following establishment	1	2	3	4	5	6	7	8	9
Participating plants	6	18	34	54	78	78	78	78	78
Access members	1,120	4,120	8,120	13,120	14,320	14,320	14,320	14,320	14,320
Courses delivered	336	2,060	5,684	10,496	12,888	12,888	12,888	12,888	12,888

Results

Table 45 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2021/22 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to current dollars using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2021/22) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $0.25M and a favourable Benefit Cost Ratio of 8.7.

Table 45 Investment criteria for total investment in Project 2020-1093 ($m)

Year	0	5	10	15	20	25	30
PV Benefits	$-	$0.03	$0.22	$0.29	$0.29	$0.29	$0.29
PV Costs	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03
NPV	-$0.03	-$0.00	$0.19	$0.25	$0.25	$0.25	$0.25
BCR	-	0.9	6.7	8.7	8.7	8.7	8.7
IRR	NA	3%	32%	34%	34%	34%	34%
MIRR	-100%	4%	20%	18%	15%	13%	12%

The flow of total undiscounted costs and benefits from the project is presented below.

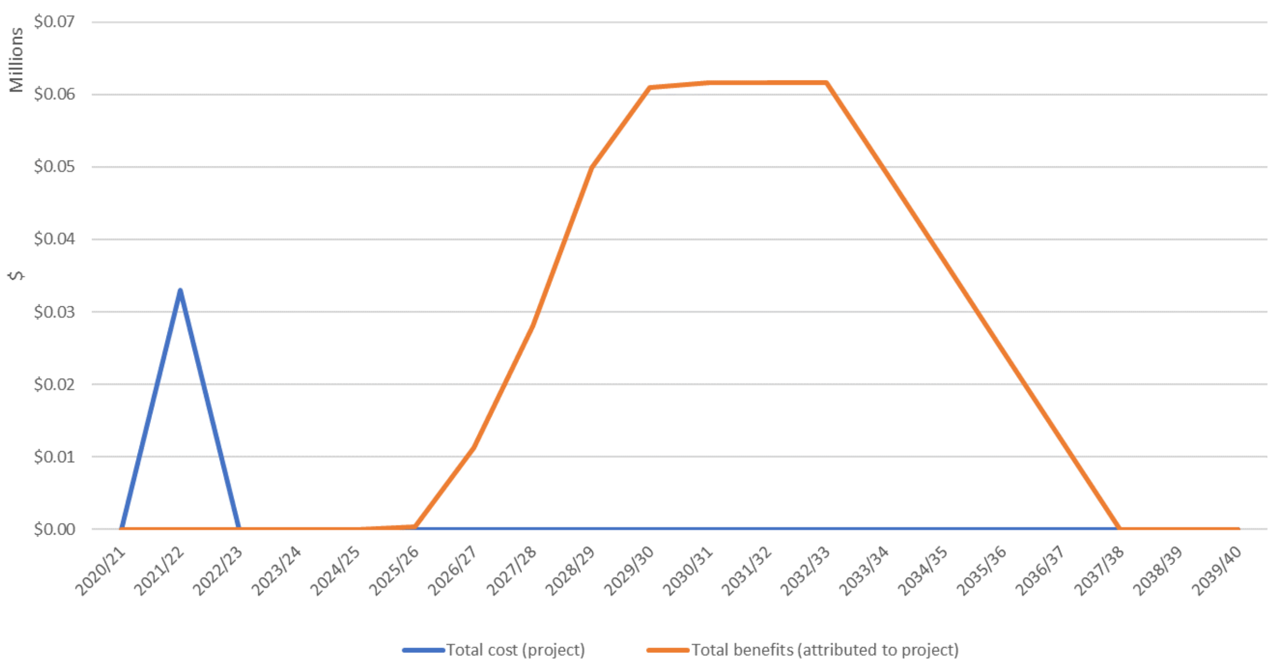

Figure 11 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 46 below.

Table 46 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		$0.25	8.7	12%
Adjusted discount rate				
	0%	$0.39	13.0	8%
	10%	$0.16	6.0	16%
Adjusted benefits per user				
	+20%	$0.35	11. 58	13%
	-20%	$0.16	5.9	11%
Processor adoption rate				
	+20%	$0.31	10.4	12%
	-20%	$0.20	6.9	11%

The accuracy of the assessment is highly dependent on both the extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and the level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions). Presented below is an assessment of coverage and confidence ratings for this project.

Table 47 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	High	The analysis covers the primary expected benefits from the Knowledge Hub, being the savings in induction course delivery and value of knowledge sharing.
Confidence in assumptions	Medium	The Business Plan includes indicative pricing for services and projected uptake, informed by consultation with processors. Therefore these assumptions are considered a reasonable indicator of future value and uptake. However there are risks and challenges in delivering the concept as per the Business Plan.

Conclusions

Project *2022-1093 Business Plan for a Red Meat Industry Knowledge Hub* explored the feasibility and business model for a proposed central industry hub delivering training and knowledge sharing. The relatively small investment into the Business Plan is likely to contribute to future benefits if/when the knowledge hub is established, particularly through reduced training costs associated with employee inductions.

Based on the adopted assumptions this analysis has estimated the project investment will likely deliver a positive economic benefit (BCR 8.7). This investment return remained positive under all scenarios modelled.

References

Response Research, (2022), *Red Meat Industry Knowledge Hub: Business Plan,* prepared for AMPC.

Acknowledgements

Consultations undertaken with Amanda Carter (AMPC, 10/6/2022) and report author Roderick Glass (Response Research,29/6/2022)

8.7 Appendix G: 2020-1066 Augmented Reality for the Development of Remote Auditing

Background

Previous R&D has demonstrated potential benefits from the use of smart-glasses in meat processing plants, particularly for undertaking virtual inspections. Smart-glasses have the potential to reduce the need for in-person inspections and the associated labour and travel costs. The COVID-19 pandemic also highlighted biosecurity risks associated with having additional inspectors on site and often travelling between plants. Further, there is an ongoing need to improve compliance and quality control within plants.

Description of the project

This project trialled the in-plant use of smart glasses and additional accessories in remote inspection and verification activities. 22 processors and auditing authorities were invited to trial the technology performing a range of tasks, and recording their experiences and results.

Figure 12 Smart Glasses being trialled

Table 48 Project description and logic

Project Details	Project title: 2020-1066 Augmented Reality for the Development of Remote Auditing Organisation: Bondi Labs Date: June 2021
Rationale	The process of in-person inspections and verification activities can be costly and logistically difficult – putting pressure on the viability of abattoir operations. By creating a remote solution which allows for decreased travel costs and logistics, abattoirs will benefit significantly.
Objectives	/ Explore the possibilities for increased efficiency through the use of smart glasses and additional accessories in remote inspection and verification activities / Implement hardware and software to the processing industries to conduct their own pilots of this technology
Activities and Outputs	To reach its objectives, this project: / Researched the problem scope, needs of the system and the users requiring a solution / Designed solutions whilst including stakeholders to ensure a thorough approach / Developed the necessary software with end-use flexibility in mind / Help test and rollout the product

Potential Outcomes	/	Implementation of the smart glasses within the industry
	/	Remote auditing
Potential Impacts	/	Increased staff productivity and reduced compliance costs
	/	Reduced resources and carbon emissions from auditor travelling
	/	Reduced staff/visitor risk of Covid-19 and other diseases

Project investment

AMPC invested **$435,606** into the project over the 2021/22 financial year, including project management costs.

Summary of impacts

Table 49 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 49 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Increased staff productivity and reduced compliance costs**
Environmental	/	Reduced resources and carbon emissions from auditor travelling
Social	/	Reduced staff/visitor risk of Covid-19 and other diseases

Quantification of impacts

Estimated benefits

Of the 22 processors and auditing authorities who signed on to the trial, a total of 9 completed the trial, 8 partially completed the trial, while 5 decided to drop out.

The project report identified and quantified the likely benefits from the adoption of smart-glasses in a typical processing plant, including increased staff productivity, reduced travel costs, increased quality/quantity of inspections, faster response to incidents as well as reduced impacts from Covid-19 disruptions.

Table 50 below shows the benefit assumption adopted for this analysis.

Table 50 Net benefit assumptions

Variable	Assumption	Source/ Explanation
Estimated annual costs per plant from adopting smart glasses		
a) Device	$3,250	Elixar Pack 1 RealWear HMT- 1 device + accessories. Project Report suggested a 3 year life, however this analysis assumed 1 year only with high usage in busy abattoir environment.
b) Licence Services	$1,250	25 users, 12 months
c) Staff training and facilitation	$1,200	IT check, equipment training, a pre-flight, checklist, staff train the trainer (23 hours * 1 FTE)

Variable	Assumption	Source/ Explanation
d) Data, connectivity and miscellaneous costs	$5,000	Additional costs to ensure connectivity and functionality
e) Training and contingency	$20,000	Additional costs associated with training staff and having contingency arrangements
f) Total costs	$$30,700	Sum of costs
Estimated annual benefits per plant from adopting smart glasses		
g) More productive work	$4,000	10% reduction in travel time (as per Project Report)
h) Higher quality output	$3,000	10% increase in completed inspections. Improving quality and reducing risk (as per Project Report)
i) Improved resource utilisation	$70,000	20% increase in employee utilisation. Saving costs on new hires (as per Project Report)
j) Incident management	$5,000	5% increase in incident management response time (as per Project Report)
k) Biosecurity benefits	$40,000	The Project Report estimated benefits of $80,000 in reducing Covid-19 costs, based on an 80% reduction in visitor guests on-site plus an additional 20% in staff utilisation. This analysis assumed a reduced benefit of 40,000 per annum in post Covid environment.
l) Total benefits	$122,000	Sum of benefits
Net annual benefit	$91,300	Total benefits minus costs
Chance of success	80%	The innovation will need to be approved by regulators and commercial partners for use in auditing. Some restrictions may limit potential benefits.
Net annual benefit (probability adjusted)	$74,773	= Net annual benefit x chance of success

Adoption costs

Adoption costs are accounted for in Table 50 above.

Counterfactual

Under the counterfactual scenario the adoption of smart-glasses technology within the Australian meat processing sector is likely to be considerably slower. This analysis has assumed adoption would be delayed by 3 years.

Attribution

Attribution of benefits was based on the estimated costs incurred by all parties in delivering the outcomes, including past research, future development and extension.

Table 51 Attribution assumptions

Variable	Assumption	Source/ Explanation
a) Past research	59%	Past research has contributed to the outcome through the development of the technology (including applications in other industries). The project also built on a previous research project undertaken by Teys Australia, which used smart-glasses to allow Chinese Authorities to track a consignment through the processing phase. The estimated investment in past research is $3M.
b) Future Development	16%	Widespread adoption is likely to be reliant on future research and development to obtain the support and approval for remote auditing, from government regulators and commercial parties. AMPC is planning to advance some of these objectives through a follow-up project. The estimated cost of future development is $1M.
c) Promotion and extension	16%	In order to access benefits processors, regulators and commercial parties will need to be educated in how to use the devices, and protocols will need to be established. The estimated cost of future promotion and extension is $1,000,000
d) Attribution of remaining benefits to project	8%	=100 – a – b - c

Note: Subject to rounding error

Adoption

The analysis assumed that augmented reality, with the use of smart glasses, will become adopted by the majority of processing plants in the coming years, however in the absence of the Project demonstrating and progressing the opportunities, adoption would likely be delayed by 4 years.

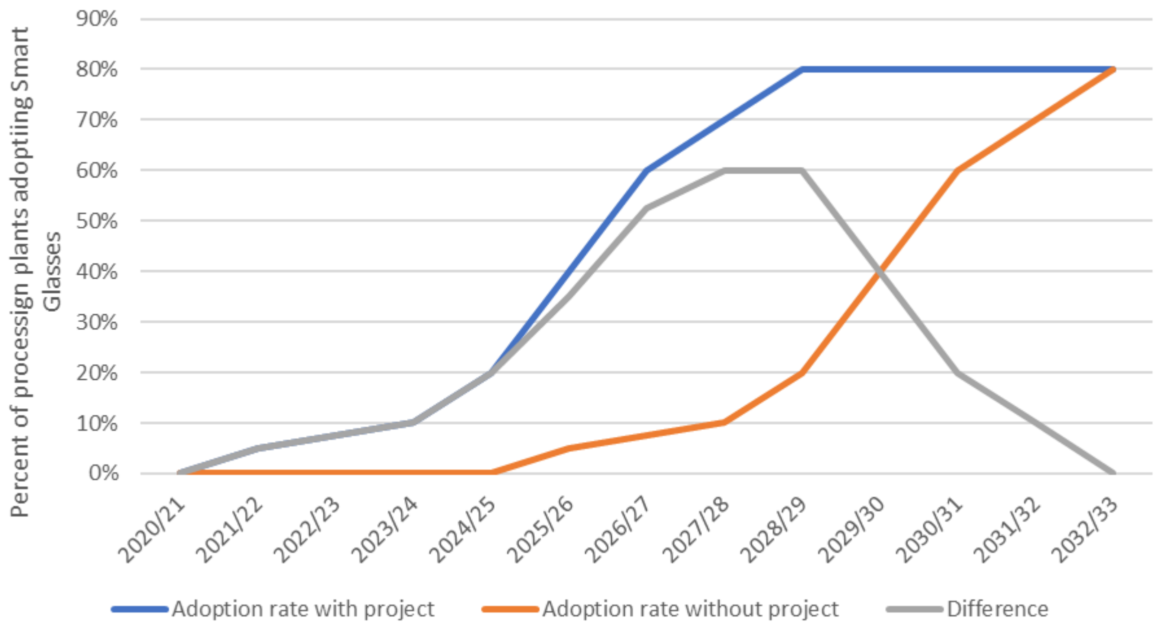

Figure 13 Projected adoption rate of

Results

Table 52 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2021/22 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to current dollars using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2021/22) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $2.14M and a favourable Benefit Cost Ratio of 5.9.

Table 52 Investment criteria for total investment in Project 2020-1066 ($m)

Year	0	5	10	15	20	25	30
PV Benefits	$0.13	$1.63	$2.57	$2.57	$2.57	$2.57	$2.57
PV Costs	$0.44	$0.44	$0.44	$0.44	$0.44	$0.44	$0.44
NPV	-$0.31	$1.19	$2.14	$2.14	$2.14	$2.14	$2.14
BCR	0.3	3.7	5.9	5.9	5.9	5.9	5.9
IRR	-79%	48%	54%	54%	54%	54%	54%
MIRR	-30%	23%	20%	16%	14%	12%	11%

The flow of total undiscounted costs and benefits from the project is presented below.

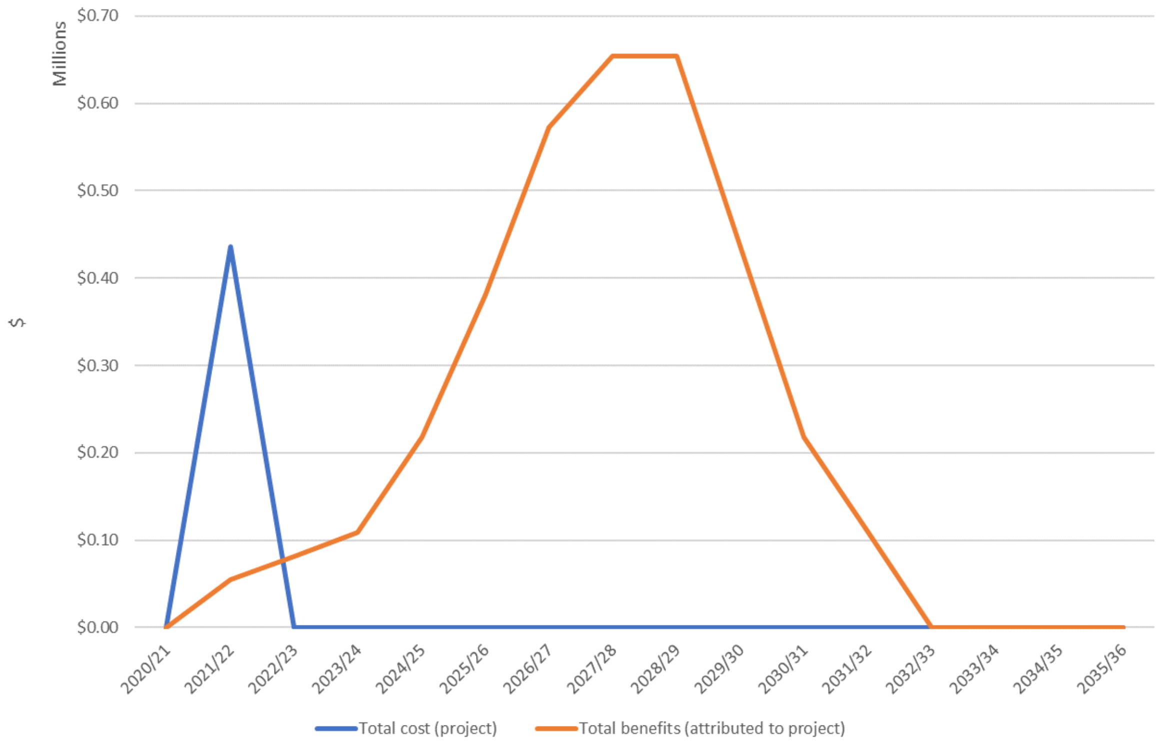

Figure 14 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 53 below.

Table 53 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		$2.14	5.91	54%
Adjusted discount rate				
	0%	$2.80	7.4	52%
	10%	$1.65	4.8	56%
Adjusted potential cost savings from technology use				
	+20%	$2.83	7.5	65%
	-20%	$1.45	4.3	42%

The accuracy of the assessment is highly dependent on both the extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and the level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions). Presented below is an assessment of coverage and confidence ratings for this project.

Table 54 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	High	The analysis includes the primary identified benefits of increased staff productivity, reduced auditing costs and biosecurity risks.
Confidence in assumptions	Medium	Some uncertainty exists around the acceptance of augmented reality and smart glasses for auditing purposes. This makes future adoption more uncertain.

Conclusions

Project *2020-1066: Augmented Reality for the Development of Remote Auditing* explored the possibilities for increased efficiency through the use of smart glasses and additional accessories in remote inspection and verification activities.

Based on the adopted assumptions this analysis has estimated the project investment will likely deliver a positive economic benefit (BCR 5.9) by bringing forward the adoption of this technology. This investment return remained positive under all scenarios modelled.

References

Hall. J, Baxter. G (2021), *Utilisation of Augmented Reality for the Development of Remote Auditing,* prepared for AMPC.

Acknowledgements

Consultations undertaken with (Ann McDonald, 7/6/2022) and Bondi Labs (Josh Hall, Jonathan Marshall, Stu Smith and Graeme Baxter, 14/6/2022)

8.8 Appendix H: 2021-1091: Meat Hygiene Assessment 3 – An Industry Trial

Background

This project continued efforts to improve ways in which the Australian meat industry monitors the microbiological and visual condition of its products, in particular building on the AMPC Projects: *Process control monitoring - is there a better way?* (2017-1068); *Process monitoring for the Australian meat industry – a comparative trial* (AMPC 2018-1070); and *Visual monitoring of carcases and carton meats – a system for the 21st century* (AMPC Project 2019-1066).

This previous work ultimately led to the development of *Meat Hygiene Assessment: Product Monitoring (3rd edition),* which became known as MHA 3, which focusses on food safety (Zero Tolerance (ZT), pathology and contamination-related defects); removing non-food safety (Minor and Manufacturing) defects; retained pre-boning room inspection checks; retained ZTs and pathology as per current definition and ascribed risk-based ratings to individual products.

This project tested MHA 3 within 11 processing plants, over a period of at least 100 days from April-November 2021. The trail and results were overseen by DAWE, SARDI and the Project Reference Panel.

Description of the project

Table 55 Project description and logic

Project Details	This project was carried out by University of Adelaide at a budget of $362,000. It classifies under AMPC's program stream '4. Markets & Market Access: 4.4: Global Competitiveness'.
Rationale	Industry and DAWE recommended a working trial of MHA 3 to test utility within establishments.
Objectives	/ To further explore the current practices in place for MHA and create a framework for a "better way" for process monitoring
Activities and Outputs	/ Established a "better way" for meat hygiene assessments / Trialled MHA 3 and reported on these results
Potential Outcomes	/ The MHA 3 system was considered more "fit for purpose" than MHA 2 with all eleven trial establishments proposing to continue adopting the system
Potential Impacts	/ QC/QA staff time savings estimated at 2 person hours/shift equating to $130/shift

Project investment

AMPC invested **$398,200** into the project over the 2021/22 financial year, including project management costs.

Summary of impacts

Table 56 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 56 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Staff time savings**
Environmental	/	Potential for reduced resources and waste from testing
Social	/	Potential for improved food safety

Quantification of impacts

Estimated benefits

The Project report cites unanimous agreement by plant staff that MHA 3 was less time-consuming but produced more targeted and actionable data. The time-savings allowed QC/QA staff to "proactively monitor potential trends, undertake investigations to improve the system and interact with other departments (for example, the slaughter floor)".

One participant quantified the potential benefits from implementing MHA 3 (compared to MHA 2), suggesting a saving of approximately 2 hours per shift at a cost of $65/hour. Assuming there are 250 work days/shifts per year, this equates to a potential saving in the order of $32,500 per year for a single establishment. Consultation suggests this was a conservative estimate which may increase with larger sized plants.

Table 50 below shows the benefit assumptions adopted for this analysis.

Table 57 Net benefit assumptions

Variable	Assumption	Source/ Explanation
a) Hours saved (or re-allocated per shift)	2	Project report
b) Cost of labour	$65	Project report, QA/QC staff
c) Shifts per year	250	Project report
Estimated annual benefits per plant from adopting MHA3	$32,500	= a x b x c

Adoption costs

Consultation suggested plants may incur minor costs to change from MHA2 to MHA3, including in-house training of staff and changing of forms and processes. The analysis has assumed costs of $5,000 per plant.

Counterfactual

Without the project being completed MHA3 would have remained developed but not sufficiently tested to validate the accuracy and benefits. DAWE would have likely remained cautious about approving the change without evidence from the trial. This analysis has assumed the adoption of MHA3 would be delayed by 5 years compared to the project case.

Attribution

Attribution of benefits was based on the estimated costs incurred by all parties in delivering the outcomes, including past research, future development and extension.

Table 58 Attribution assumptions

Variable	Assumption	Source/ Explanation
a) Past research	38%	A range of past projects and developments have contributed to the development of MHA3, including *Process control monitoring - is there a better way? (2017-1068); Process monitoring for the Australian meat industry – a comparative trial (AMPC 2018-1070); and Visual monitoring of carcases and carton meats – a system for the 21st century (AMPC Project 2019-1066).* The estimated investment in past research is $0.4M.
b) Future Development promotion and extension	26%	Before implementation the industry will likely require some additional data analysis, risk categorisation and training. The estimated cost is estimated at $300,000M.
c) Attribution of remaining benefits to project	36%	=100 – a – b

Note: Subject to rounding error

Adoption

MHA3 is expected to be rapidly implemented in the coming years, with 80% of plants adopting the revised version and enjoying cost savings. As discussed above, in the absence of the project it was assumed adoption would be delayed by 5 years.

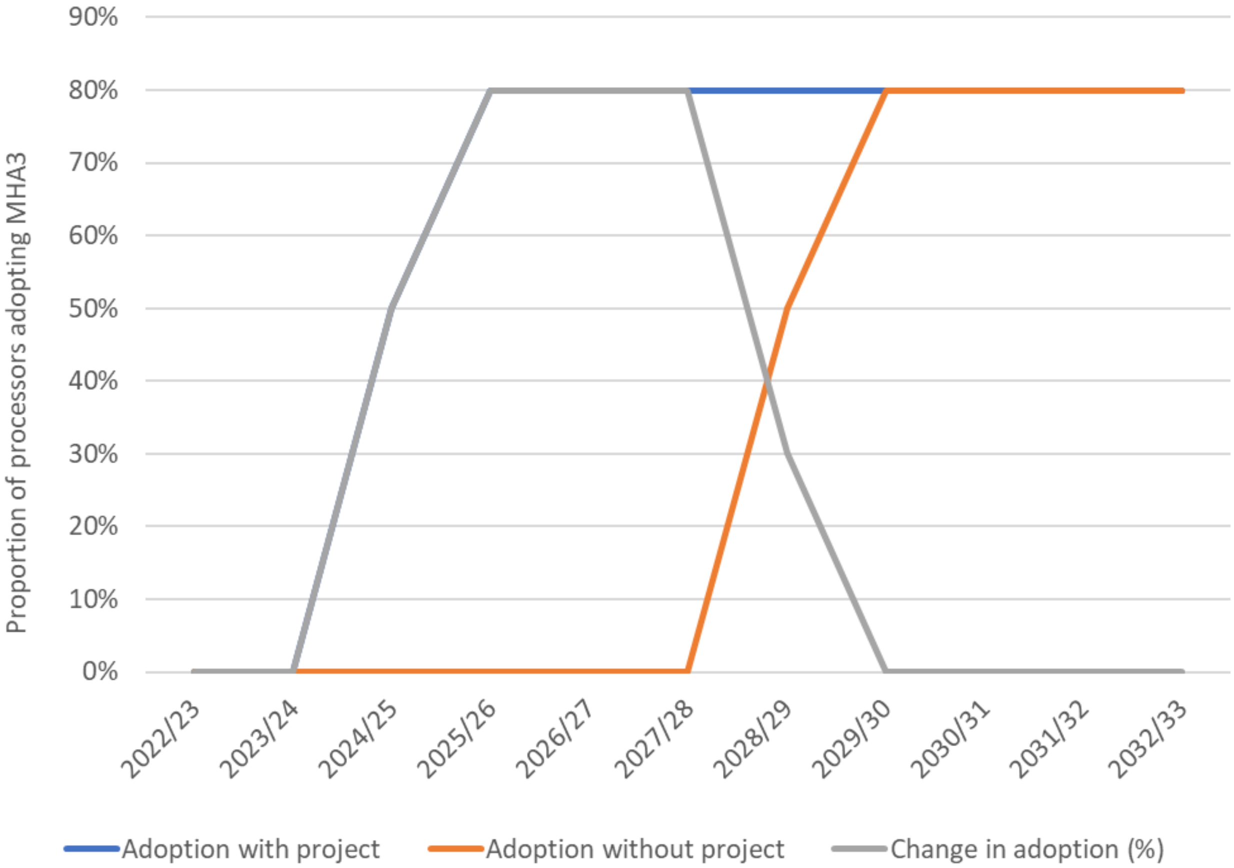

Figure 15 Projected adoption of MHA3

Results

Table 59 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2021/22 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to current dollars using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2021/22) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $4.38m and a favourable Benefit Cost Ratio of 11.8 modelled over 30 years.

Table 59 Investment criteria for total investment in Project 2021-1091 ($m)

Year	0	5	10	15	20	25	30
PV Benefits	$0	$3.25	$4.79	$4.79	$4.79	$4.79	$4.79
PV Costs	$0.41	$0.41	$0.41	$0.41	$0.41	$0.41	$0.41
NPV	-$0.41	$2.85	$4.38	$4.38	$4.38	$4.38	$4.38
BCR	0	8.0	11.8	11.8	11.8	11.8	11.8
IRR	NA	76%	82%	82%	82%	82%	82%
MIRR	-100%	32%	25%	19%	16%	14%	13%

The flow of total undiscounted costs and benefits from the project is presented below.

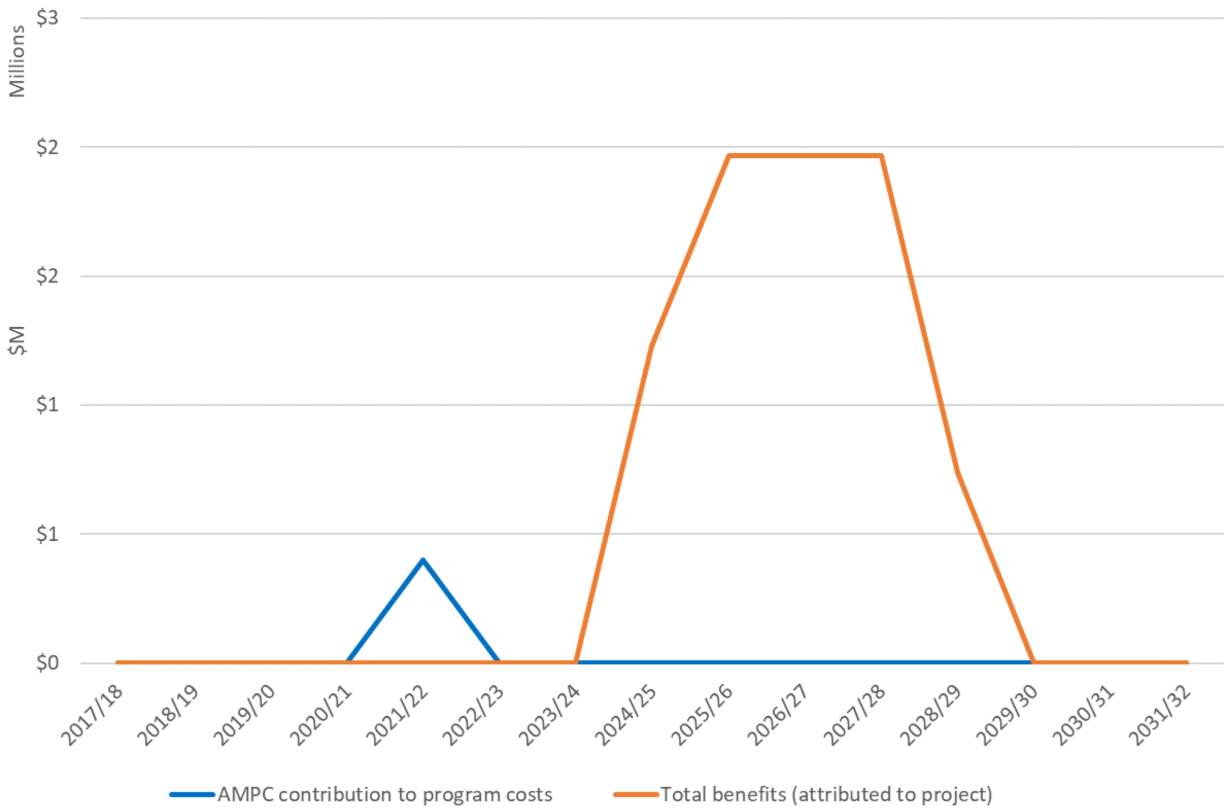

Figure 16 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 60 below.

Table 60 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		4.38	11.81	13%
Adjusted discount rate				
	0%	$5.35	14.18	8%
	10%	$3.63	9.95	17%
Adjusted potential benefits				
	+20%	$5.52	14.60	14%
	-20%	$3.25	9.02	12%

The accuracy of the assessment is highly dependent on both the extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and the level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions). Presented below is an assessment of coverage and confidence ratings for this project.

Table 61 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	High	The analysis covered the main benefit being the efficiency gains in implementing MHA 3 without compromising the accuracy of the analysis. Other benefits may include improved food safety and staff retention.
Confidence in assumptions	Medium	MHA 3 has now been well tested and broad implementation is almost certain. The potential benefits were quantified in the study, however only by one establishment (considered conservative). Broader contributions would have provided a more robust analysis.

Conclusions

Project *2021-1091 Meat Hygiene Assessment 3 – An Industry Trial* continued efforts to improve ways in which the Australian meat industry monitors the microbiological and visual condition of its products. The revised Meat Hygiene Assessment (MHA3) was tested within 11 processing plants and returned favourable results, including potential savings in staff time.

Based on the adopted assumptions this analysis has estimated the project investment will likely deliver a positive economic benefit (BCR 11.81). This investment return remained positive under all scenarios modelled.

References

AMPC Project (2017-1068) *Process control monitoring - is there a better way?* prepared for AMPC.

AMPC Project (2018-1070) *Process monitoring for the Australian meat industry – a comparative trial,* prepared for AMPC.

AMPC Project (2019-1066) *Visual monitoring of carcases and carton meats – a system for the 21st century,* prepared for AMPC.

Project (2021-1091) *Meat Hygiene Assessment 3 – An Industry Trial,* prepared for AMPC.

Acknowledgements

Consultations undertaken with Amanda Carter (AMPC) and Jessica Jolly (University of Adelaide).

8.9 Appendix I: 2021-1131 Review of traceability outcomes from electronic tagging of sheep- implications for small stock processors outside Victoria

Background

Livestock traceability plays an important role in reducing the spread of exotic animal disease outbreaks, thus reducing the costs associated with livestock disposal and disruption to export markets. The use of Electronic Identification Devices (EIDs) for sheep and goats has been mandated in Victoria however remains voluntary in other states and territories where mob-based tagging is typically used. However, the adoption of individual animal identification is likely to be progressed in the coming years, with SAFEMEAT, representing the relevant industry and governments, agreeing in principle to phase in mandatory digital/electronic identification from 2021 to 2025. Despite the agreement there remains some uncertainty about when and how implementation will occur, and the implications for meat processors.

Description of the project

This project assessed the success of the Victorian model to determine its potential for adoption by other states and territories.

Table 62 Project description and logic

Project Details	Project title: 2021-1131 Review of traceability outcomes from electronic tagging of sheep- implications for small stock processors outside Victoria Researcher: Bill O'Halloran Date: June 2021
Rationale	The Victorian model of EID based NLIS is being pressured for adoption in other states and territories.
Objectives	The objectives of this project are to: / Evaluate the Victorian EID system versus the current national mob-based system / To determine the perception of processors in Victoria and nationally / Define why other states have not adopted EIDs yet / Document equipment required and the likely cost of installing the new system / Define the benefits to process and producers under the new system / Discuss the downsides of implementation of the new systems
Activities and Outputs	/ A desktop review of evaluation of the Victorian EID / A telephone survey/discussion with processors outside Victoria, equipment suppliers and Victorian DPI staff to gain a good understanding of the current state of the system and ability to apply it elsewhere.
Potential Outcomes	/ Progress towards the adoption of mandatory electronic tagging of sheep and goats, through increased understanding of opportunities and limitations of the current mob-based system.
Potential Impacts	/ Reduced costs for sheepmeat processors transitioning to mandatory electronic tagging / Reduced economic and social costs associated with exotic disease outbreaks.

Project investment

AMPC invested **$21,120** into the project over the 2021/22 financial year, including project management costs.

Summary of impacts

Table 63 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 63 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/ **Reduced costs for sheepmeat processors transitioning to mandatory electronic tagging** / Reduced economic costs associated with exotic disease outbreaks
Environmental	
Social	/ Reduced social costs associated with exotic animal disease outbreaks

Quantification of impacts

Estimated benefits

Reduced costs for sheepmeat processors transitioning to mandatory electronic tagging

The Project Report outlines the experiences of Victorian sheepmeat processors in transitioning from mob-based traceability to mandatory electronic tagging, providing learnings and direction for processors outside Victoria which will likely be required to implement similar changes in the coming years.

The study identified the following challenges and benefits which could help improve implementation in other jurisdictions. The study found that EID equipment installation issues in abattoirs can be overcome quickly and effectively in most cases. The benefit to processors of implementing an EID system differed depending on whether they aimed to simply comply with NLIS requirements or to record carcass data along the chain for use in improved processing efficiency.

Table 64 Identified challenges and benefits for sheepmeat processors implementing electronic tag reading

Challenges	Benefits
○ Electro-magnetic interference (noise) ○ Lack of space adjacent to the chain for location of readers, crowding of carcasses on sections of the chain, reducing manoeuvrability and making reading of individual tags difficult.	○ Improved ability to differentiate suppliers within mixed saleyard lots. ○ Improved ability to differentiate suppliers and individual carcasses within supplier mobs. ○ Ability to do the same within mixed saleyard lots. ○ Recording the disease status of individual carcasses and the property of origin electronically at evisceration. ○ Improved feedback to producers on disease status of their flock. ○ Touch pad or other similar system at inspection, carcass EID could be uploaded automatically to AQIS and NRS. ○ Improved disease prevention in Australian flocks. ○ Using data measured along the chain to inform boning room decisions. ○ Better information on stock source – can reduce the need for trim. ○ With carcass yield feedback to producers, they can adjust genetics used.

The study recommended that states outside Victoria should seek to form a national position on the mandatory use of EID in sheep and goats. It was also recommended that states should collaborate to provide consolidated input into each state-based Regulatory Impact Statements (RIS), including a combined and thorough estimate of the implementation costs, to assist in making the case for Government assistance.

The above findings and recommendations will likely help sheepmeat processors to reduce the cost burden and maximise potential benefits from implementing EID systems. Benefits could be achieved through increased knowledge to overcoming potential challenges and maximise benefits, as well as increased likelihood of accessing government assistance to support changes.

The above benefits were modelled as a potential reduction in the implementation costs for an EID system.

Table 65 Benefit assumptions

Variable	Assumption	Source/ Explanation
a) Cost of EID panel reader	$35,00	Project report suggested range between $20,000 and $50,000 per plant
b) Cost of EID hardware and software per plant	$100,000	Project report suggested range between $50,000 and $250,000 depending on the size of the plant.
c) Total cost	$135,000	= a + b
Cost reduction attributable to the study		
d) Potential cost reduction from improved planning and technology choices	(5%) $6,750	Assume the study findings will avoid plants making incorrect and costly decisions when planning to implement EID hardware and software, i.e. plants will be more likely to implement the optimal system to suit their plant needs and maximise additional data benefits. Assume 5% of costs avoided (or 1 in 20 plants avoiding having to re-implement different systems), equals $6,750 per plant.
e) Increased government funding assistance (%)	$2,000	The study recommended that states outside Victoria should collaborate to provide consolidated input into each state-based Regulatory Impact Statements (RIS), including a combined and thorough estimate of the implementation costs, to assist in making the case for Government assistance (as was provided to Victorian processors during implementation).Assume this consolidated approach increases the likelihood of plants receiving government assistance via a $40,000 grant by 5% = $2,000 benefit per plant
f) Cost reduction attributable to the study ($)	$8,750	= d + e

<u>Reduced economic costs associated with exotic disease outbreaks</u>

An additional, unquantified benefit from the project was to help inform and progress the adoption of mandatory electronic tagging of sheep and goats, thereby reducing the risk and economic cost of an exotic disease incursion.

Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) modelling projects a widespread FMD outbreak in Australia would have an estimated direct economic impact of around $80 billion. disrupting livestock production and export markets for up to 10 years. The speed with which infected or potentially infected animals can be traced and isolated is a key determinant of the size, duration and cost of the outbreak. The Traceability of sheep and goats is considered particularly important in controlling FMD which can be widely spread by sub-clinically infected animals (Matthews 2011).

Based on the findings of the of the project (and other studies completed) it can be conservatively assumed that electronic tags provide around 97% traceability against Australia's National Livestock Traceability Performance Standards (NLTPS) compared to mob based tags which provide around 70% traceability against the NLTPS. Improved traceability would help contain potential outbreaks and reduce the economic cost. Previous analysis by Buetre et al.

(2013) found that smaller outbreaks isolated and contained within a single state would cost around 10-12% of the size of a large multi-state outbreak.

Adoption costs

Adoption costs are accounted for in the benefit assumptions above.

Counterfactual

Under the counterfactual scenario states outside Victoria will consider and likely implement mandatory EID policies, however processors would have less information about the consequences (challenges and opportunities) for their business. The processing sector would be less likely to collaborate across state boundaries, providing consolidated input into RIS's and seeking funding assistance.

Attribution

The modelled benefits are entirely attributable to the project investment.

Adoption

There are an estimated 49 small stock processing plants in Australia (AMPC Annual Report 20/21). Assuming the distribution of plants follows the distribution of sheep numbers, approximately 75% of these plants (37 plants) would be located outside Victoria. These plants are likely to be required to implement EID systems in the coming years.

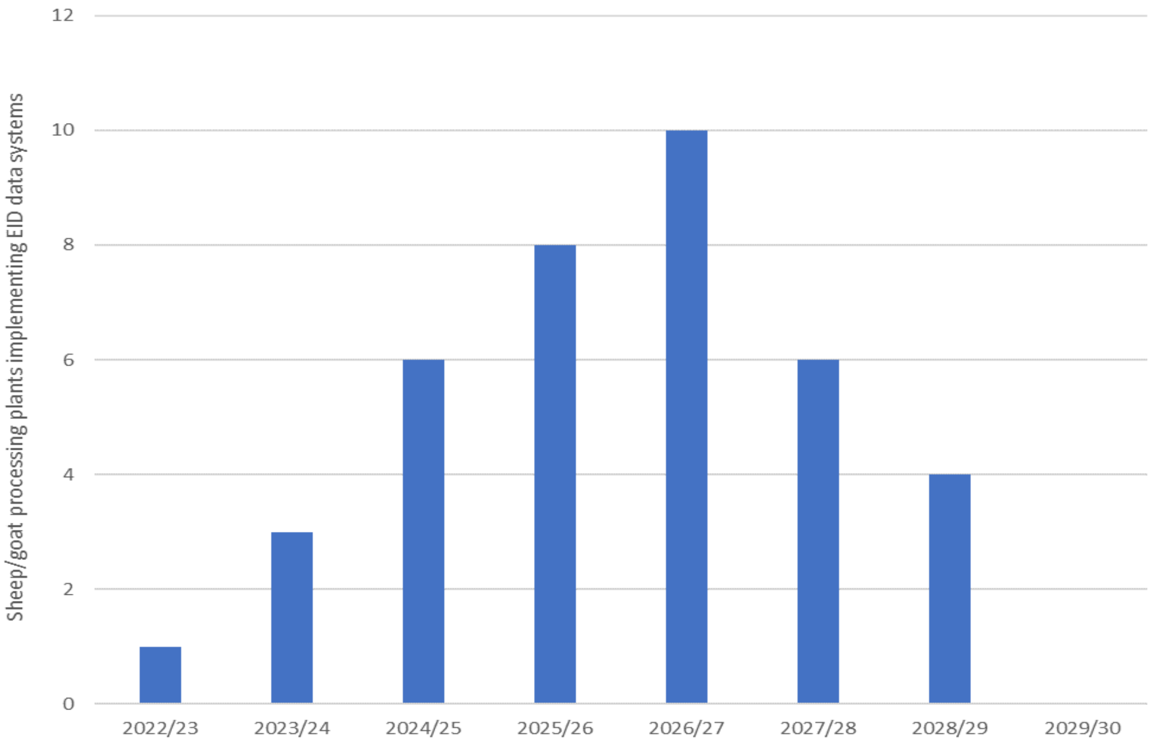

Figure 17 Projected adoption of sheep/goat EID systems in processors outside Victoria

Results

Table 66 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2021/22 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to current dollars using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2021/22) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $0.27 and a favourable Benefit Cost Ratio of 12.7.

Table 66 Investment criteria for total investment in Project 2020-1131 ($m)

Year	0	5	10	15	20	25	30
PV Benefits	$0.01	$0.24	$0.27	$0.27	$0.27	$0.27	$0.27
PV Costs	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02
NPV	-$0.01	$0.22	$0.25	$0.25	$0.25	$0.25	$0.25
BCR	0.4	11.5	12.7	12.7	12.7	12.7	12.7
IRR	-59%	114%	114%	114%	114%	114%	114%
MIRR	-17%	38%	26%	20%	17%	15%	13%

The flow of total undiscounted costs and benefits from the project is presented below.

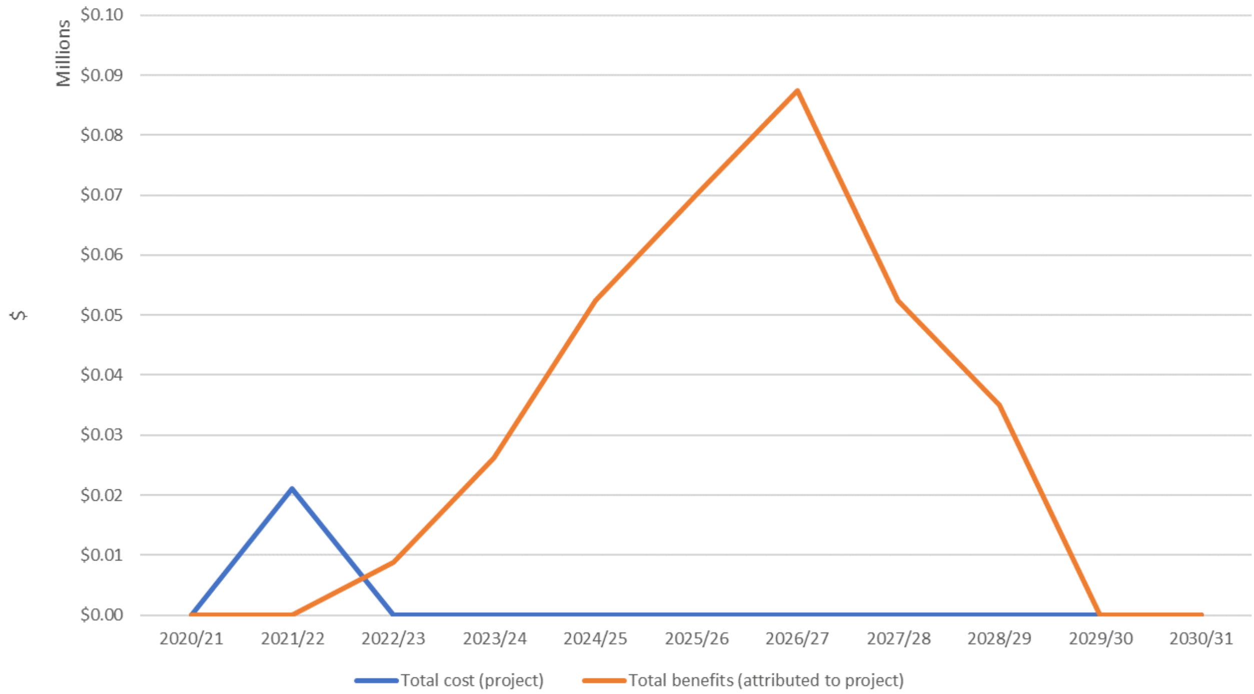

Figure 18 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 67 below.

Table 67 Sensitivity analysis

Changes to Key Variables	NPV ($M)	BCR	MIRR
Standard assumption	$0.25	12.7	13%

Adjusted discount rate				
	0%	$0.31	15.7	8%
	10%	$0.20	10.4	18%
Adjusted potential benefits				
	+20%	$0.30	11.7	13%
	-20%	$0.19	7.8	12%

The accuracy of the assessment is highly dependent on both the extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and the level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions). Presented below is an assessment of coverage and confidence ratings for this project.

Table 68 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	Medium	The analysis included immediate benefits from more efficient implementation of EID systems, however did not account for the potential reduction in risks associated with exotic disease incursions.
Confidence in assumptions	Medium	The analysis relied on generally well established estimates of EID implementation costs and expected future uptake given current SAFEMEAT policy.

Conclusions

Project *2021-113 Review of traceability outcomes from electronic tagging of sheep- implications for small stock processors outside Victoria* assessed the success of the Victorian model of mandatory electronic tagging of sheep and goats to determine its potential for adoption by other states and territories. The study identified a range of learnings which should help processors in other states more smoothly implement systems if/when they are required.

Based on the adopted assumptions this analysis has estimated the project investment will likely deliver a positive economic benefit (BCR 12.7). This investment return remained positive under all scenarios modelled.

References

Buetre, B., Wicks, S., Kruger, H., Millist, N., Yainshet, A., Garner, G., Duncan, A., Abdalla, A., Trestrail, C., Hatt, M., Thompson, L.J. & Symes, M. (2013). *Potential socio-economic impacts of an outbreak of foot-and mouth-disease in Australia*. Research by the ABARES. Canberra, Australia.

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MLA Project V.ISC.2021, *Integrity System 2025 Strategy – Ex Ante Impact Assessment*, GHD Pty. Ltd. 2021

Acknowledgements

Consultations undertaken with Ann McDonald (AMPC) and Bill O'Halloran (CSIRO)

8.10 Appendix J: 2021-1172: Traceability – Primal to Steak/Steak to Primal - Stage 2

Background

The meat industry has identified that providing the consumer with traceability options has potential to be a value add along with contributing to the provenance narrative to ensure market share. Previous focus has been on farm to carcase and carcase to primal however the following supply chain for primal to steak has lacked traceability. With increased development of affordable blockchain technology, there is an opportunity for premium products to provide consumers the option of traceability, helping to validate provenance and other attributes contributing to product integrity. It is estimated that fraud and counterfeiting cost the Australian meat and live animals sector $272 million with a specific threat to premium products such as wagyu (McLeod 2017).

UNOVA is a Belgian based company which operates blockchain infrastructure and software platforms for enabling consumer tracing of supply chain data. Following an AMPC operated innovation competition and initial support to a number of potential technologies (Stage 1), UNOVA were selected by AMPC to develop and pilot a cost-effective and robust primal to steak, and steak to primal, traceability and anti-counterfeit system (stage 2). If progressed to stage 3, UNOVA will apply the technology to a host Australian supply chain.

Description of the project

Table 69 Project description and logic

Project Details	This project was carried out by UNOVA at a budget of $249,726. It classifies under AMPC's program stream '5. Product and Process Integrity: 5.1: Traceability'.
Rationale	Industry identified this project would help ensure that products are being proactive in meeting consumer expectations. Although in the short term there may be a premium placed on this technology being implemented, it is also a way of securing current market share.
Objectives	/ Establish an affordable solution to traceability of primal to steak and steak to primal through the whole supply chain visible to the consumer on a conceptual basis / To propose solutions and prototype code to establish protocols for identifying, on a risk percentage basis, the likelihood of a counterfeit product
Activities and Outputs	/ Development and demonstration of an affordable and effective traceability system for the steak to primal/primal to steak stage of the supply chain. Including the software and hardware necessary for proper implementation / Development of counterfeit detection functionalities within UNOVA's current systems
Potential Outcomes	/ Development of an effective primal to steak/steak to primal traceability system that can be used by consumers / Potential for value adding of premium products and protection against fraud. / Showing proactiveness in ensuring consumer trust and social license to operate
Potential Impacts	/ Price premiums for blockchain validated products / Increased market incentive to reduce environmental impact / Improved social licence

Project investment

AMPC invested **$274,699** into the project over the 2021/22 financial year, including project management costs.

Summary of impacts

Table 70 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 70 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Price premiums for blockchain validated products**
Environmental	/	Increased market incentive to reduce environmental
Social	/	Improved social licence

Quantification of impacts

Estimated benefits

The Project establishes a potential blockchain solution for primal to steak, and steak to primal, traceability. If implemented this solution will deliver benefits to industry via price premiums, particularly for higher value cuts. A recent study (Lin et. al. 2022) found that "blockchain-based traceability exhibits a statistically significant influence on consumers' overall utility. Consumers are willing to pay approximately US$0.60 per pound for blockchain traceable beef compared to beef supported with a regular digital traceability system". This equates to approximately AUD$1.89 per kg. The analysis has assumed that approximately 50% of this premium would be captured by the Australian industry.

Table 71 Benefit assumptions

Variable	Assumption	Source/ Explanation
a) Additional premium from blockchain validation of beef	$1.89 / kg	Lin et. al. 2022
b) Estimated proportion of premium captured by Australian processors	50%	Remaining premium captured by overseas importers and retailers
c) Estimated premium captured by Australian processors	$0.94 / kg	= a x b
d) Adoption costs (% of benefits captured)	30%	Estimated $0.28 per kg, accounting for additional hardware, software, processes and supply chain organisation and communications (discussed in more detail below)
e) Estimated net premium captured by processors	$0.66 / kg	= c * (1-d)

Adoption costs

The cost to use the UNOVA platform are expected to be minimal (currently estimated at €0.002/cut), however processors would likely incur much higher costs to enable blockchain traceability. The project report identified a need for participating processors to operate a range of software and hardware including:

- Signing up to a central "on-boarding platform" to manage blockchain functions
- Installing a "company node" on a local server

- Hardware including for each line a scanner, scale, screen, printer and server

Implementing this process is likely to reduce the efficiency of boning and packaging operations. While additional costs will be incurred to communicate to downstream customers on how to use the functionality.

In the absence of quantified costs for the above, this analysis has assumed that adoption costs erode the potential price premium by 30% (approximately $0.28 per kg).

Counterfactual

Under the counterfactual scenario AMPC would not have progressed the Stage 2 project with UNOVA, however other investments into blockchain and traceability would have progressed. UNOVA would not have been further developed or implemented into an export supply chain (as proposed for Stage 3). While these specific opportunities would not have been realised, the industry would continue to pursue other technology and means to underpin consumer trust and product integrity.

Attribution

Attribution of benefits was based on the estimated costs incurred by all parties in delivering the outcomes, including past research, future development and extension.

Table 72 Attribution assumptions

Variable	Assumption	Source/ Explanation
a) Past research	39%	The Stage 1 project and previous investment into blockchain applications for Australian red meat. The estimated investment in past research is $600,000
b) Future Development promotion and extension	45%	Stage 3 project (if progressed), including processor effort and input to refine and implement the technology. The estimated cost is estimated at $800,000
c) Attribution of remaining benefits to project	17%	=100 – a – b

Note: Subject to rounding error

Adoption

Blockchain traceability is expected to become more widely adopted in the red meat processing sector, particularly higher value export markets. UNOVA is one of several potential blockchain and software platforms, which may service the global market in the future.

This analysis has conservatively limited adoption to Australia's exports of chilled beef (bone out) to mainland China, assuming that a supply chain trial of the UNOVA system would attract processors to adopt the platform for 10% of this trade volume. Critically UNOVA will be competing with other providers as blockchain technology develops rapidly, therefore adoption is only assumed to occur over a 5 year period from 2024/25 to 2028/29. It is also considered that after this time the premiums associated with blockchain validation may be reduced as the technology becomes more ubiquitous.

Table 73 Estimated market

Variable	Assumption	Source/ Explanation
a) Australian exports of chilled beef (bone out) to mainland China (2020 calendar year)	32,140 tonnes	DAWE
b) Proportion of above exports adopting UNOVA following a successful stage 3 supply chain trial.	10%	GHD estimate, assuming a trial includes a group of several processors participating focussing on high value primal cuts into Chinese supermarkets. Participants continue to adopt UNOVA following the trial.
c) Volume of above exports adopting UNOVA	3,214 tonnes	= a x b

Results

Table 74 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2021/22 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to current dollars using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2021/22) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $1.18 m and a favourable Benefit Cost Ratio of 5.2 modelled over 30 years.

Table 74 Investment criteria for total investment in Project 2021-1172 ($m)

Year	0	5	10	15	20	25	30
PV Benefits	$-	$0.92	$1.46	$1.46	$1.46	$1.46	$1.46
PV Costs	$0.28	$0.28	$0.28	$0.28	$0.28	$0.28	$0.28
NPV	-$0.28	$0.64	$1.18	$1.18	$1.18	$1.18	$1.18
BCR	$-	$3.3	$5.2	$5.2	$5.2	$5.2	$5.2
IRR	NA	42%	50%	50%	50%	50%	50%
MIRR	-100%	19%	18%	14%	12%	11%	10%

The flow of total undiscounted costs and benefits from the project is presented below.

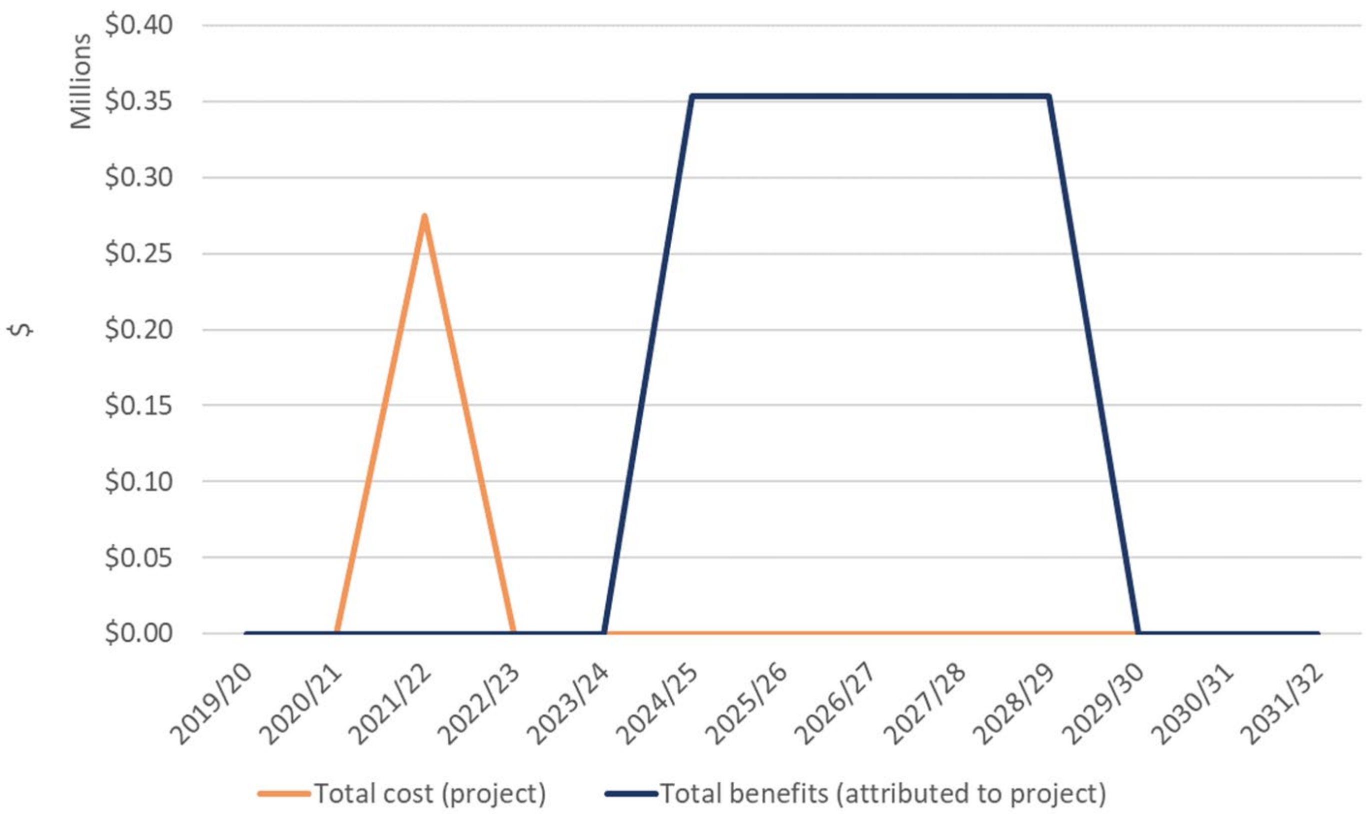

Figure 19 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 75 below.

Table 75 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		1.18	5.21	10%
Adjusted discount rate				
	0%	$1.49	6.31	6%
	10%	$0.94	4.35	15%
Adjusted potential benefits				
	+20%	$1.47	6.25	11%
	-20%	$0.89	4.17	9%

The accuracy of the assessment is highly dependent on both the extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and the level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions). Presented below is an assessment of coverage and confidence ratings for this project.

Table 76 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	Medium	The analysis covers the main expected benefits from the project, being potential price premiums. Benefits could have also been estimated based on reduced counterfeiting/fraud costs and/or improved market access. To avoid double-counting, this analysis assumed these benefits are incorporated into price premiums.
Confidence in assumptions	Low-Medium	The analysis relies on published estimates of price premiums for blockchain validated products in China, however there is considerable uncertainty around the practical application of the technology, adoption costs, potential market coverage and whether price premiums will be sustained into the future. Attribution is also challenging given UNOVA is a global company with broad technology applications.

Conclusions

Project 2021-1172: *Traceability – Primal to Steak/Steak to Primal (Stage 2)* involved the development and piloting of a cost-effective and robust primal to steak, and steak to primal, traceability and anti-counterfeit system (UNOVA). Evidence suggests that Chinese consumers are willing to pay approximately US$0.60 per pound (AUD$1.89/kg) for blockchain traceable beef compared to beef supported with a regular digital traceability (Lin et. al. 2022).

Based on the adopted assumptions this analysis has estimated the project investment will likely deliver a positive economic benefit (BCR 5.2). This investment return remained positive under all scenarios modelled.

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McLoed (2017) *Counting the cost: Lost Australian food and wine export sales due to fraud,* prepared for Food Innovation Australia Ltd.

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Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
1.0	S Hoban	S Madden	S Madden	S Madden	S Madden	23/6/22
2.0	S Hoban	S Madden	S Madden	S Madden	S Madden	7/7/22
3.0	S Hoban	S Madden	S Madden	S Madden	S Madden	28/8/22