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Issues relevant to the adoption of technology in the meat processing industry

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Executive summary

Significant investment has been made into research, development and facilitated adoption of various technologies in meat processing, however there remains significant challenges in relation to effective commercialisation, adoption and uptake of these outcomes.

The aim of this project was to establish the extent to which the drivers and barriers are associated with meat processors' technology adoption practices and their knowledge and attitudes in relation to technology uptake.

Responses came from 102 people from 63 processor organisations.

All respondents reported adopting some new technology in the past two years with the most frequent categories of adoption being OH&S, Processing, and Environmental. Fewer than 50% of respondents had adopted new technology in Yards, Chilling/Freezing, and packing with very low adoption in Offal and Rendering.

Apart from Internet searches, equipment providers (salespeople, brochures and enquiries) were the main source of information about new technology while conventions, both local and overseas were the least used.

Only 34% of respondents indicated that they had a formal model for evaluating adoption of new technology. When asked about the term of cost recovery that they would require, most indicated that two or three years would be required.

More that 80% of respondents regarded as important barriers: availability of spare parts, the time for cost recovery, downtime if/when there is a breakdown, high capital cost, payback period is too long, given the risk, equipment may not physically fit into plant and equipment support and maintenance costs. In addition, 88.4% considered that OH&S hazard costs of manual tasks are not clear or sufficiently onerous.

Being a leader in technology advancement was considered to be an important reason for adoption by only 42.1% of respondents. On the other hand over 90% of respondents rated reduction in production costs, reduction in labour costs and processing efficiency and yield improvements as important or very important.

When asked to list the top three potentially most useful technologies that they were aware of, respondents gave a wide range of responses. Robotics in a range of areas was the most commonly cited *specific* technology but more respondents cited a wide range of applications for new machinery of an unspecified nature. Environmental innovations of various kinds were also cited often.

When asked to list the incentives that they would need to adopt new technology, respondents overwhelmingly cited cost savings and improved returns as the main incentive. Labour incentives, OH&S improvements and safety considerations were also cited fairly frequently, but at only at a quarter of the frequency of cost savings.

To describe adopters, several characteristics were found to correlate with history of, and intention to, adopt technology. These were: Being an information source, Others' expectations about the respondent being information source, Beliefs about impediments to adoption and Positive attitudes to adoption. Degree of control over decision-making did not correlate with adoption.

Size of the organisation was not correlated with either “Beliefs about impediments to adoption” or whether or not the respondent gave advice to others, but did show a small correlation with “Positive attitudes to adoption”.

Three groups of processors were identified: High adopters/high advisors, Low adopters/low advisors and High adopters/low advisors. There was no systematic relationship between group membership and role in the organisation with the possible exception of some plant managers having little advisory role and engineers and operations managers tending to have strong advisory roles. Not surprisingly, the larger organisations generally provided the early adopters/high advisors.

Overall, the factors that independently predicted adoption were: Size of the organization, Low concerns about the possible barriers, Positive attitudes to adoption, tending to give advice to others and being expected to provide advice by others.

On the basis of these results and follow-up interviews, several suggestions for actions were made:

The business case for MLA funding new technology needs to factor in:

- the costs of plant changes.
- careful analysis of on-site expertise required to run and maintain the plant.
- viability of its implementation in rural and remote areas, particularly in terms of workforce requirements.
- not only the on-site expertise required, but also the cost and practicality of training the local workforce to reach the required level of expertise.

Proactive strategies to assist with implementation could include:

- assisting Mintrac to develop on site training for employees to adapt to automated technologies
- consider investment in a flexible design for a plant with infrastructure (power, water, drainage, etc.) in some sort of modular form that permits easy adaptation.
- consider the development of an integrated implementation strategy that would provide an framework comprising HR and training needs, infrastructure needs and capital works that could be adapted for any particular new technology.
- establishment of a consultant network to provide independent evaluation of processing plants.

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Background

Significant investment has been made into research, development and facilitated adoption of various technologies in meat processing, however there remain significant challenges in relation to effective commercialisation, adoption and uptake of these outcomes.

At present, we do not have a good understanding about why some innovations are adopted and why innovation adoption behaviours vary. Studies of agricultural technology adoption (e.g. Abdulai & Huffman, 2005; Besley & Case, 1993) observe that the diffusion of new technologies varies significantly across geographical locations and time. In particular, it is unclear why some seemingly profitable technologies are not adopted. For example, research suggests that new technologies on farms are usually introduced either as a consequence of farmers' own experimentation or through formal sector intervention. While earlier theoretical work has emphasized the importance of contextual factors such as size, financial constraints or physical proximity to innovation adopters, more recent literature has increasingly focused on the capacity to engage in complex decision-making behaviours (Abdulai & Huffman, 2005). The underlying question relates to how contextual factors, attitudes and beliefs and decision-making behaviours interact.

Two important theoretical concepts that underpin an understanding of these decision processes is the information available to decision makers, how they obtain this information and how their beliefs influence their decisions.

Objective information is available to meat processors via producer communications, industry forums and communications from MLA and AMPC. However, an individual's understanding of available technology and its efficacy may be filtered informally through contact with other individuals. These may be other processors, colleagues or broader contacts. This particular process of diffusion of information characterises those who provide the information as opinion leaders (Katz and Lazarsfeld, 1955, Rogers, 2003). It may be useful to identify the characteristics of opinion leaders in the meat processing industry.

An approach to the understanding of the psychological processes that drive human behaviour is the Theory of Planned Behaviour (Ajzen and Fishbein, 2005). This theory basically asserts that the proximal determinants of people's behaviour are their beliefs about the behaviour and its consequences, the expectations of relevant others and the degree of control that they believe themselves to have. In the context of adoption of innovation, these three factors would translate into a person's beliefs about the consequences of adopting, their beliefs colleagues' expectations and the extent to which they believe that they have the genuine discretion to adopt a technology. It may be useful to assess these factors in adoption decisions in the meat processing industry.

Therefore, the factors associated with adoption of new technologies in the meat processing industry fall into several broad categories:

1. Knowledge about the new technology;
2. Perceived cost/benefit, including time and effort;
3. Perceived barriers to adoption;
4. Attitudes and beliefs about uptake of the technology, beliefs about peer opinions and perceived degree of control of the adoption behaviour (cf Ajzen and Fishbein 2005: Theory of Planned Behaviour);
5. Differences in beliefs between owners/CEOs and engineers;
6. Nature of the organisation (family owned or corporate) and its impact on decision processes

7. Early/late adopter characteristics of the meat processor (cf Rogers 2003, Diffusion of Innovations);
8. Network of processors and the communication amongst them (cf Rogers 2003r, Diffusion of Innovations);
9. The presence of opinion leaders from whom processors seek information/take advice (Katz and Lazarsfeld, 1955; Rogers , 2003).

These categories needed to be systematically investigated. The questions that needed to be addressed were:

1. What is the relationship between each factor and willingness for or actual adoption of innovation?
2. Does any factor represent a hurdle that will inhibit adoption of innovation regardless of the other issues?
3. What strategies to facilitate uptake are possible?

It is with the above information that better decision-making can be undertaken by funding organisations with regards to investment and delivery in this area.

It is generally recognised that there is a need for better education/extension of outcomes, such that processors can make more informed decisions regarding the uptake of technology. This includes quantification of both the "barriers" and the "benefits". It is considered that through more targeted communication on the barriers to and benefits for uptake, other challenges, including the process by which industry decides whether or not to "adopt" a technology may be overcome. For instance, processors may simply discount the benefits and focus on the "bottom line" (e.g. machine purchase) without full recognition of the broader (more futuristic) paybacks. It may be in some instances, that the future gains might include enhanced yields (over time e.g. better micro controls, better cuts/boning/outputs), enhanced labour savings (over time e.g. absenteeism saved, training saved, advancement in learning, modernising the workplace and cultural changes), additional developments (e.g. the ability to "add on other technologies for continual improvement).

It is also recognised that detailed analysis of the "barriers" to uptake would lend itself to an enhanced ability to establish targeted strategies to either overcome these challenges with providers and processors and/or address these challenges in terms of more defined adoption approaches. It is also important to understand "drivers" for uptake. Where the drivers directly conflict with the barriers, it will be crucial, for any successful adoption/commercialisation strategy, to determine the views and how these might be changed, the variation in these views and where in industry these apply (e.g. large vs medium, sheep vs beef).

A priori, it was considered that drivers for uptake might include the following:

- Numbers of personnel on floor (and costs)
- OHS
- Consistency of operation
- Consistency of product
- Hygiene
- Training
- Availability of skilled labour
- Increasing production
- Processing efficiency and yield improvements

- Changing specifications (customers etc.)
- Previous experience
- Increased flexibility to respond to market changes/customer specs
- Inventory management
- Reduction in waste/product not meeting specs
- Being a leader in technology advancement

Similarly, possible barriers to uptake (including but not only relating to purchase costs) might include the following:

- Space on the floor
- Training (to operate the technology)
- Maintenance (operation of the technology)
- Cost or perceived cost
- Keeping the same throughput
- Access to capability / providers
- Other competing priorities in the business
- The time for cost recovery
- Downtime if/when there is a breakdown
- Previous experiences with technology and/or automation
- Decreased flexibility to respond to market changes/customer specifications
- Gaining customer acceptance
- Product specification/requirements (e.g. specific requirements, service kills, cut specifications, packaging specifications, over the hooks)
- Unreliable prototypes;
- Equipment is very expensive, high capital cost
- Cost benefit analysis are not always trusted to apply broadly/specifically;
- Payback period is too long, given perceived risk;
- Equipment may not physically fit into plant, high installation costs;
- Issues with “retrofitting”
- Equipment specifications may not fit plant requirements;
- Equipment support and maintenance costs are a concern;
- Capability and training issues with staff;
- Awareness and educational issues (sustainable business change)
- Perception (or realisation) of unsuccessful installations at other sites;
- Labour availability can be managed in other ways than via automation;
- OH&S hazard costs of manual tasks are not clear or sufficiently onerous to many plant decision makers;

The aim of this project was, therefore, to establish the extent to which these drivers and barriers are associated with meat processors’ technology adoption practices and their knowledge and attitudes in relation to technology uptake.

Method

Originally it was planned to conduct a series of focus group discussions with processors to identify the relevant topics to be addressed in a survey that would be administered to the meat processing industry. Despite several attempts to convene focus groups at times when processor meetings were being held already, it proved not to be possible because of competing demands on their time. As a result, face-to-face meetings were conducted with three individual processors who had agreed to participate and with an industry consultant as well as with AMPC personnel. The discussions were confidential and semi-structured, based on the topics given in Table 1.

Table 1. Topics covered in the preliminary interviews

What new technology is available for meat processors?
How much do you know about it? What is available?
Do you think there is adequate dissemination of information?
What is your view on the use of new technology in meat processing?
How could this be improved?
What is good about available new technology?
What is bad about available new technology?
Is there a need for change/improvement? Why?
To what extent do you think that the traditional approaches are best?
Who would you get advice from or whose opinion would you value in deciding about new technology?
What determines whether or not you uptake new technology?
What are the disincentives? (Probe if necessary in regard to cost/benefits)
What incentives would you want?
What are the barriers to uptake?
If you were to give advice on improving uptake, what advice would that be?
What do you think about the current level of industry investment in new technology (OK, more needed, less needed)
Do you know what the current level of uptake is (ask for an example)?
How would you improve uptake?
What are relevant plant/commercial factors?
Any relevance of species slaughtered?
Anything else?

On the basis of these discussions, a draft questionnaire was developed. This was further refined following discussion with AMPC and an industry consultant. The final questionnaire is given in Appendix 1.

AMPC sent letters to all processors that were on its contact list to inform them about the project and to seek their cooperation in completing the survey. The letter is given in Appendix 2. I-View, a market and social research data collection agency, was contracted to conduct the survey and they signed a confidentiality agreement with AMPC. Subsequently, AMPC provided I-View, with the contact list and the questionnaire. A total of 102 questionnaires were completed.

Results.

Sample characteristics.

Responses came from 102 people from 63 organisations. Respondents were predominantly male (97%). Role in the organisation is given in Table 2. The most common roles were CEO (22), Operations manager (17), Plant manager (17) and Engineer/Maintenance (18).

The “Other” category comprised I.T. manager/CIO (2), Q A manager, General manager, Owner/Proprietor/Principal (4), Retail ready services manager, Production manager, Finance, Executive assistant, Projects and business improvements manager, Engineering manager, Production control and planning, Managing director, Director(3) and Fitter.

Table 2. Role of respondents in their organisation

	Frequency	Percent
CEO	22	21.6
Group operations manager	17	16.7
Plant manager	17	16.7
Environmental manager	1	1.0
Sales	5	4.9
Engineer/Maintenance	18	17.6
Innovation manager	2	2.0
Other	20	19.6
Total	102	100.0

Almost 60% of respondents said that their organisation has a project manager to implement plant upgrades.

Respondents came mainly from Qld and WA (Table 3).

Table 3. Numbers of respondents by State.

	State	Number	%
	NSW	14	13.7
	Vic	3	2.9
	Qld	40	39.2
	SA	11	10.8
	WA	24	23.5
	Total	92	90.2
Missing		10	9.8
Total		102	100.0

The length of time that respondents had worked in the organisation varied widely and was distributed from two years to 60 years. Most (79%) had worked in the organisation for 25 years or less. Nevertheless, only 11.9% had worked in the organisation for five years or less.

Annual turnover is given in Table 4. Some organisations operated from several sites, so these data refer to turnover at each site rather than the entire organisation

Table 4. Annual turnover of organisation (site) in which respondents worked.

Annual turnover	Frequency	Percentage
Less than $5 million	15	14.7
$5.1 - $50 million	24	23.5
$50 - $500 million	30	29.4
Greater than $500 million	15	14.7
Refused	5	4.9
Don't Know	13	12.7
Total	102	100.0

Of those who gave a response (n=84), 18% were small operators, 28.5% medium sized and the remainder (53.5%) were large.

Adoption behaviour

All respondents reported adopting some new technology in the past two years (Table 5) with the most frequent categories of adoption being OH&S, Processing, and Environmental. Fewer than 50% of respondents had adopted new technology in Yards, Chilling/Freezing, and packing with very low adoption in Offal and Rendering.

Table 5. Reported percentage uptake of new technology in the past two years

In which of these categories, have you adopted new technology in the past two years? (percentages)	Yes
Yards	40.2
Processing	67.6
Chilling/freezing	44.1
Boning	50.0
Packing	45.1
Offal	22.5
Rendering	24.5
Environmental	61.8
OH&S	72.5
None of these	10.8

Table 6 Likelihood of uptake of new technology in the future

How likely are you to adopt possible new technologies in the following categories? (percentages)	Highly unlikely	Unlikely	Likely	Highly Likely	Don't know
- Yards	1.0	19.6	39.2	40.2	0.0
- Processing	2.0	4.9	42.2	51.0	0.0
- Chilling/freezing	2.9	9.8	40.2	47.1	0.0
- Boning	6.9	16.7	29.4	44.1	2.9
- Packing	7.8	12.7	34.3	40.2	4.9
- Offal	3.9	14.7	46.1	31.4	3.9
- Rendering	16.7	18.6	20.6	35.3	8.8
- Environmental	2.0	7.8	37.3	52.9	0.0
- OH&S	1.0	3.9	32.4	61.8	1.0

Likelihood of uptake in the future is reported in Table 6. Generally, 80% or more of respondents indicated that they were likely or very likely adopt new technology in the future in all categories except rendering where 56% indicated this.

Correlations between past adoption and likelihood of future adoption showed that only for Processing, Boning, and Packing was there a moderate relationship between past adoption and likelihood of future adoption (Table 7).

Table 7. Correlations between past uptake of technology and future likelihood in each category.

Plant category	r
- Yards	.11
- Processing	.34**
- Chilling/freezing	.15
- Boning	.38**
- Packing	.28*
- Offal	.20
- Rendering	.22*
- Environmental	.13
- OH&S	-.22

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Adoption processes

Seventy eight percent of respondents indicated that there was adequate information available on new technology.

Respondents were asked to identify sources of information about new technology. Apart from Internet searches (80.4%), equipment providers were the main source: salespeople (81.4%), brochures (75.5%) and enquiries (76.5%). Conventions, both local (53.9%) and overseas (35.3%) were the least used sources (Table 8).

Table 8. Where do you find out about new technology?

Internet searches	80.4%
Ask equipment providers	76.5%
Industry meetings/functions	67.6%
Local meat convention	53.9%
Overseas meat convention	35.3%
Equipment provider sales people	81.4%
Sales brochures	75.5%
From someone in my organisation	76.5%
Don’t Know	2.0%
Other:	7.8%
Attend meat industry conferences	
Department of Industry emails	
Industry material sent to me by either hardcopy or email	
Other food industries and materials handling such as exhibitions.	
Through other processors	
Word of mouth	

Respondents were also asked how they would identify a need for new technology. As can be seen in Table 9, most indicated that they would use all of the selected methods: respond to marketing information, constantly review plant operation, take advice from other processors and respond to a market opportunity.

Table 9. How would you identify a need for new technology? (n=102)

	Count
I would see some marketing material for new technology and recognise the need it addresses	80
I constantly review plant operation looking for better methods	91
I would take advice from other processors	87
I would respond to a market opportunity	85
Don't Know	1
Other: Always try keep up to date with the market and lower cost of production Analyse financial drivers Benchmark from each plant facility we have Customer driven Internet searches Look at customer needs, market needs Research Running cost, fertility cost Simple opportunity for task replacement Through the AMPC conferences	10

Drivers for adoption

The attitude questions in section C1 of the survey (Appendix 1) were analysed using Principal Components Analysis (PCA) followed by Varimax rotation to summarise the questions into as few common categories as possible so that further analysis would be simplified (Table 10).

The two components identified were named, based on the questions that were most correlated with them, "Beliefs about impediments to adoption" and "Positive attitudes to adoption". A high score on "Beliefs about impediments to adoption" indicates that the respondent thinks there are many impediments to adoption. A high score on "Positive attitudes to adoption" indicates that the respondent supports adoption. Three questions did not fit well with the two components and were "New technology is often not properly field tested before being sold to processors", "The plant in my organisation is not suited to most of the available new technology" and "My plant is capable of meeting relevant environmental standards for the foreseeable future".

Table 10. Principal components Analysis of attitude questions from Part C1 of the survey.

To what extent do you agree or disagree with the following statements	Component	
	1	2
The economic environment is too uncertain to consider investing in new technology	.72	
Day to day issues are more important than looking for ways of improving production	.70	
My business can't afford to invest in new equipment	.64	

Table 10 (cont.). Principal components Analysis of attitude questions from Part C1 of the survey.

To what extent do you agree or disagree with the following statements	Component	
	1	2
New technology is overrated	.62	
I prefer to continue using established processing methods	.62	
I can't afford the downtime required to install new equipment	.60	
The plant in my organisation is not suited to most of the available new technology	.60	
There is insufficient space at my plant to install new technology	.58	
I don't have the authority to make decisions about adopting new technology	.52	
My labour force is sufficient to maintain production in the foreseeable future	.42	
New technology is often not properly field tested before being sold to processors	.32	
I would consider myself willing to adopt new technology		.71
I would be happy to use my plant to field test new technology		.64
I listen to other senior staff when it comes to considering new technology		.60
I think it is important to continually seek ways to improve plant efficiency		.58
There are few OH&S issues that could be solved by new technology		.57
I am more likely to consider adopting a new technology if I know other processors have done so successfully		.54
I value industry opinion about the best ways to slaughter livestock		.42
I think of myself as a leader in adopting new technology		.41

Component 1 – Beliefs about impediments to adoption
Component 2 – Positive attitudes to adoption.

Table 11. Correlations between attitudes to adoption and past adoption behaviour

In which of these categories, have you adopted new technology in the past two years? -	Beliefs about impediments to adoption	Positive attitudes to adoption
Yards	.01	.27**
Processing	-.25*	.25*
Chilling/freezing	-.25*	.10
Boning	-.37**	.17
Packing	-.27**	.26**
Offal	-.09	.05
Rendering	-.22*	.13
Environmental	-.20*	.37**
OH&S	-.22*	.21*

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Generally there were significant negative relationships between beliefs about impediments to adoption and past adoption (Table 11). In other words, those who thought that there were many impediments to adoption were least likely to have adopted in the past. Adoption of new technology in yards and offal were the exception where there was no relationship. There were fewer significant positive relationships between positive attitudes to adoption and past adoption. Past adoption in chilling/freezing, boning, offal and rendering was unrelated to positive attitudes to adoption.

The single items "New technology is often not properly field tested before being sold to processors", "The plant in my organisation is not suited to most of the available new technology" and "My plant is capable of meeting relevant environmental standards for the foreseeable future" were all significantly correlated with beliefs about impediments to adoption (r=.32**, r=.60** and r=.24* respectively). However positive attitudes to adoption was significantly related only to "My plant is capable of meeting relevant environmental standards for the foreseeable future" (r=.24*).

Cost/benefits of adoption

Only 34% of respondents indicated that they had a formal model for evaluating adoption of new technology. When asked about the term of cost recovery that they would require, most indicated that two or three years would be required. (Table 12).

Table 12. Term of cost recovery required to adopt new technology for non-compliance projects?

	Frequency	Percent
Less than one year	6	5.9
One year	15	14.7
Two years	35	34.3
Three years	30	29.4
More than three years	12	11.8
Don't know	4	3.9
Total	102	100.0

Table 13. What is the relative importance of the following advantages of adopting new technologies? (percentages)

	Not at all important				Very important	Don't know
Improved plant performance	1.0	0.0	4.9	31.4	61.8	1.0
Net cost savings	1.0	2.0	5.9	32.4	58.8	0.0
Improved OH&S	2.0	2.0	5.9	22.5	67.6	0.0
Consistency of product	0.0	2.0	5.9	26.5	64.7	1.0
Better accuracy	2.0	5.9	15.7	34.3	42.2	0.0
Reduced labour costs	0.0	0.0	4.9	22.5	72.5	0.0
Reduced maintenance costs	2.0	3.9	16.7	32.4	45.1	0.0
Reduced required skill level of the workforce	4.9	4.9	31.4	36.3	22.5	0.0

When asked the relative advantages of adoption, around 90% or more respondents rated most considerations as important or very important. The two exceptions were "Better accuracy" and "Reduced maintenance costs" where 76.5% and 77.5% respectively rated these as important or very important (Table 13).

When asked to rate the relative disadvantages of adopting new technologies, the pattern was similar in that for most considerations, between 70% and 80% rated them as important or very important. The one exception was ”Risk of being an early adopter” which only 50% considered to be a disadvantage (Table 14).

Table 14. What is the relative importance of the following disadvantages of adopting new technologies? (percentages)

	Not at all important				Very important	Don’t know
Cost of the technology	1.0	2.0	16.7	23.5	56.9	0.0
Capital infrastructure costs	2.0	2.0	20.6	29.4	46.1	0.0
Ability to maintain it	1.0	6.9	13.7	37.3	41.2	0.0
Backup from providers	0.0	4.9	19.6	29.4	46.1	0.0
Disruption to production when breakdowns occur	1.0	6.9	10.8	16.7	64.7	0.0
Variation in animals makes automation of slaughter difficult	6.9	4.9	15.7	31.4	41.2	0.0
Availability of floor space	2.0	7.8	20.6	28.4	41.2	0.0
Reliability of available technology	1.0	2.0	20.6	36.3	40.2	0.0
Risk of being an early adopter	6.9	9.8	32.4	27.5	22.5	1.0

Respondents were asked to rate the relative importance of barriers to adoption (Table 15). While all of the potential barriers were rated as important or very important by at least 50% of respondents, there were several that more that 80% of respondents regarded as important barriers. These were: availability of spare parts, the time for cost recovery, downtime if/when there is a breakdown, equipment is very expensive - high capital cost, payback period is too long, given the risk, equipment may not physically fit into plant and equipment support and maintenance costs. In addition, 88.4% considered that OH&S hazard costs of manual tasks are not clear or sufficiently onerous. In general about one third rated the other barriers as neither important nor unimportant.

Table 15. How important are the following barriers to your decision whether or not to adopt new technology? (percentages)

	Not at all important				Very important	Don’t know
Concern about untried technology	2.0	7.8	23.5	34.3	32.4	0.0
Concern about in-house skill requirements	3.9	8.8	35.3	31.4	20.6	0.0
Availability of spare parts	1.0	5.9	10.8	38.2	44.1	0.0
Lack of generic spare parts	0.0	6.9	27.5	29.4	36.3	0.0
Major changes to facilities	2.0	11.8	22.5	29.4	34.3	0.0
No available model to properly cost adoption of new technology	3.9	8.8	27.5	26.5	31.4	2.0
Space on the floor	1.0	5.9	26.5	28.4	38.2	0.0
Training (to operate the technology)	1.0	9.8	25.5	36.3	27.5	0.0

Table 15 (cont.). How important are the following barriers to your decision whether or not to adopt new technology? (percentages)

	Not at all important				Very important	Don't know
Maintenance (operation of the technology)	1.0	3.9	20.6	34.3	40.2	0.0
Cost or perceived cost	2.0	2.9	23.5	37.3	33.3	1.0
Keeping the same throughout	2.9	7.8	27.5	34.3	25.5	2.0
Access to capability / providers	0.0	5.9	25.5	41.2	26.5	1.0
Other competing priorities in the business	1.0	2.9	29.4	35.3	31.4	0.0
The time for cost recovery	1.0	2.9	13.7	29.4	52.9	0.0
Downtime if/when there is a breakdown	1.0	4.9	8.8	28.4	56.9	0.0
Previous experiences	1.0	9.8	29.4	25.5	33.3	1.0
Decreased flexibility to respond to market changes/customer specifications	2.9	4.9	23.5	36.3	30.4	2.0
Gaining customer acceptance	2.9	9.8	16.7	27.5	40.2	2.9
Unreliable prototypes	2.0	6.9	16.7	32.4	42.2	0.0
Equipment is very expensive, high capital cost	1.0	4.9	10.8	27.5	55.9	0.0
Cost benefit analysis are not always trusted to apply	2.0	6.9	33.3	31.4	26.5	0.0
Payback period is too long, given the risk	4.9	1.0	11.8	33.3	49.0	0.0
Equipment may not physically fit into plant	2.0	6.9	16.7	24.5	49.0	1.0
Issues with "retrofitting"	1.0	11.8	32.4	31.4	22.5	1.0
Equipment specifications may not fit plant requirements	2.0	2.9	30.4	24.5	40.2	0.0
Equipment support and maintenance costs	0.0	2.0	17.6	40.2	40.2	0.0
Perception (or realisation) of unsuccessful installations	1.0	6.9	30.4	27.5	33.3	1.0
Labour availability can be managed in other ways	0.0	7.8	36.3	34.3	19.6	2.0
OH&S hazard costs of manual tasks are not clear or sufficiently onerous	2.0	6.9	10.8	33.3	45.1	2.0
Inflexibility of new technology	1.0	6.9	34.3	27.5	29.4	1.0

Respondents were also asked to rate the relative importance of reasons to consider adopting new technology (Table 16). In general, most of the reasons were regarded as important or very important by more than 80% of respondents. However, being a leader in technology advancement was considered to be important by only 42.1% of respondents. On the other hand over 90% of respondents rated reduction in production costs, reduction in labour costs and processing efficiency and yield improvements as important or very important.

Table 16. What is the relative importance of the following reasons to consider adopting new technologies? (Percentages)

	Not at all important				Very important	Don't know
Reduction of production costs	1.0	1.0	4.9	26.5	66.7	0.0
Meet government regulations	2.0	6.9	8.8	23.5	57.8	1.0
Environmental concerns	2.0	2.0	9.8	34.3	51.0	1.0
OH&S concerns	1.0	2.9	7.8	17.6	70.6	0.0
Reduce labour costs	0.0	1.0	4.9	40.2	53.9	0.0
Improve consistency of operation	0.0	1.0	14.7	32.4	52.0	0.0
Improve consistency of product	0.0	2.0	9.8	31.4	56.9	0.0
Improve hygiene	1.0	2.9	5.9	25.5	63.7	1.0
Reduce need for skilled labour	0.0	2.9	12.7	44.1	40.2	0.0
Increasing production	1.0	2.0	6.9	34.3	55.9	0.0
Processing efficiency and yield improvements	1.0	1.0	4.9	24.5	65.7	2.9
Changing specifications (customers etc)	2.9	6.9	17.6	37.3	34.3	1.0
Increase flexibility to respond to market changes/customer specs	1.0	5.9	12.7	47.1	32.4	1.0
Inventory management	2.9	8.8	21.6	29.4	36.3	1.0
Reduction in waste/product not meeting specs	2.0	5.9	7.8	32.4	51.0	1.0
Being a leader in technology advancement	10.8	9.8	36.3	22.5	19.6	1.0
Greater flexibility of new technology	2.0	2.9	21.6	41.2	31.4	1.0
Market access	5.9	1.0	12.7	27.5	52.0	1.0
Increase shelf life	1.0	2.9	11.8	25.5	57.8	1.0

Current beliefs about available technology

When asked to list the top three potentially most useful technologies that they were aware of, respondents gave a wide range of responses. These are summarised in Table 17. Robotics in a range of areas was the most commonly cited *specific* technology but more respondents cited a wide range of applications for new machinery of an unspecified nature. Environmental innovations of various kinds were also cited often.

Table 17. Potentially most useful available technology.

Robotics	General robotics and automation	23
	Robotics in cutting	11
	Robotics in boning	5
	Robotics in freezing/chilling	2
	Robotics in packing	12
	Other robotics	4
Subtotal robotics		57

Table 17 (cont.). Potentially most useful available technology

New machines/equipment or improvement to machinery/equipment	New machinery/equipment in cutting	7
	New machinery/equipment in boning	8
	New machinery/equipment in hide removal	4
	New machinery/equipment in freezing/chilling	14
	New machinery/equipment for lifting	5
	New machinery/equipment for scanning	2
	New machinery/equipment for packing	6
	Other new machines/equipment	15
Subtotal new machines/equipment		61
Environmental innovations	Energy efficiency	13
	Biogas	6
	Water saving	4
	Treatments	8
	Other environmental innovations	5
Subtotal environmental innovations		36
Computers and electronics		15
New procedures and practices		18
Innovations in meat safety/quality		13
Innovations for restraining and stunning		3
Animal welfare		2
Innovations and improvements in chilling/freezing		9
Innovations and improvements in boning		8
Innovations and improvements in cutting		3
Innovations and improvements for packing		2
Miscellaneous innovations and improvements		18
TOTAL		245

Table 18. Incentives cited for the adoption of new technology.

Cost, savings and returns	83
Labour incentives	19
Increases productivity	12
Financial assistance	8
Other assistance with implementation	6
OH&S improvements	22
Safety considerations	16
Increases ease and efficiency	12
Product improvements	8
Food safety considerations	7
Matters of reliability	9
Necessity	5
Ease of implementation and maintenance	12
Environmental considerations	4
Other	22
Total suggested incentives	245

When asked to list the incentives that they would need to adopt new technology, respondents overwhelmingly cited cost savings and improved returns as the main incentive (Table 18). Labour incentives, OH&S improvements and safety considerations were also cited fairly frequently, but at only at a quarter of the frequency of cost savings.

Respondents were also asked to indicate up to three examples of technology that they had adopted over the past three years. The responses are summarised in Table 19. New machinery of various types was the most common category and these were spread fairly evenly across the plant. The next most common categories were robotics and environmental innovations.

Table 19. Examples of new technology adopted in the past three years

Robotics	General robotics	7
	Robotics in cutting and boning	10
	Robotics in packing	5
	Other robotics	6
Subtotal robotics		28
New machinery/equipment	New machinery/equipment in cutting	9
	New machinery/equipment in boning	8
	New machinery/equipment in processing	4
	New machinery/equipment in freezing/chilling	7
	New machinery/equipment for lifting	5
	New machinery/equipment for packing	10
	Other new machinery/equipment	22
Subtotal new machinery/equipment		65
Environmental innovations	Energy efficiency	10
	Treatment	12
	Water saving	4
	Other environmental innovations	3
Subtotal environmental innovations		29
Computers and electronics		11
New procedures and practices		23
Innovations in restraining and stunning		4
Innovations and improvements in chilling/freezing		13
Innovations and improvements in boning and cutting		5
Innovations and improvements in packing		3
Innovations for meat safety/quality		15
Misc. innovations and improvements		13
Total		230

Drivers for uptake

To determine the factors associated with past technology uptake and likelihood of uptake in the future, regression analyses were conducted. “Positive attitudes to adoption”, “Beliefs about impediments to adoption”, “Being an information source”, “Others expectations about the respondent being information source” and “Degree of control over decision-making” were the independent (predictor) variables. Because size of the organisation (measured in terms of turnover; QA7, Appendix 1) may be a determinant of adoption, this was entered as a first step, followed by the remaining variables, using forward stepwise regression.

The correlations between the independent variables and the technology uptake variables are given in Table 20. All of the independent variables, with the exception of "Degree of control over decision making" correlated significantly with both actual uptake over the previous two years and likelihood of uptake in the future.

Table 20. Correlations between the independent variables and the technology uptake variables

	Actual uptake in the past two years	Likelihood of adoption in the future
Being an information source	.48**	.38**
Others' expectations about the respondent being information source	.23**	.24**
Degree of control over decision making	-.02	-.06
Beliefs about impediments to adoption	-.34**	-.21*
Positive attitudes to adoption	.32**	.41**

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Size of the organisation measured in terms of annual turnover was not correlated with either "Beliefs about impediments to adoption" or whether or not the respondent gave advice to others, but did show a small correlation with "Positive attitudes to adoption" ($r=.20$, $p<.05$).

To establish the relative importance of these variables, separate stepwise regressions were conducted for each of the uptake variables (Tables 21 and 22).

Table 21. Regression predicting actual adoption in the past two years

Model	Beta	t	Sig.
(Constant)		2.64	.01
What is the annual turnover of your organisation?	.19	2.28	.03
Give advice	.34	3.76	.00
Beliefs about impediments to adoption	-.25	-2.93	.00
Positive attitudes to adoption	.19	2.23	.03

Adjusted R^2=.33

Table 22. Regression predicting likelihood of adoption in the future

Model	Beta	t	Sig.
(Constant)		15.53	.00
What is the annual turnover of your organisation?	.23	2.62	.01
Give advice	.29	3.25	.00
Positive attitudes to adoption	.29	3.25	.00

Adjusted R^2=.28

The size of the organisation accounted for a small but significant proportion of the variation in past adoption and likelihood of adoption in the future (R^2 = .05 and .09 respectively) but the other variables made a larger contribution. For both actual adoption and likelihood of adoption, "Positive attitude to adoption" and "Being an information source" were significant predictors. In addition, a low score on "Beliefs about impediments to adoption" was a significant predictor of actual adoption in the past two years, but not likelihood of adoption in the future. However, care needs to be taken in interpreting this latter result because “Beliefs about impediments to adoption” was significantly negatively correlated with likelihood of adoption in the future (see Table 19) but did not appear in the regression equation because the other variables with which “Beliefs about impediments to adoption” was correlated had already accounted for the component of variance in likelihood of adoption in the future.

Adoption leaders

The aim in the following analyses was to attempt to identify those respondents who were targeted by other processors as sources of information on new technology and who had recently provided such information to others and who themselves had adopted new technology.

A two-step cluster analysis was used to identify groups of respondents based on their responses to section C3 and C4 of the survey (see Appendix 1). Section C3 asked what technology had been adopted in the past two years and section C4 asked respondents to indicate the extent to which they were used as a resource by other processors for information about new technology. In order to see if it would be possible to identify those respondents who reported themselves as likely to give advice to others and who had a history of adoption, a two-step cluster analysis was performed and the results are given in Figure 1. Three clusters provided a reasonable fit to the data and the three groups identified were High adopters/high advisors, Low adopters/low advisors and High adopters/low advisors. These clusters were then used to identify the distinguishing characteristics in terms of the organisation and the role within the organisation.

Clusters

Input (Predictor) Importance
1.0 0.8 0.6 0.4 0.2 0.0

Cluster	1	2	3
Label	High adopter/High advice	Low adoptr/low advice	High adopter/high advice
Description	Opinion leaders and early adopters	Non-adopters	Followers and early adopters
Size	52.9% (54)	24.5% (25)	22.5% (23)
Inputs	Likely to adopt 31.09	Likely to adopt 21.12	Likely to adopt 30.09
	Give advice 7.20	Give advice 3.76	Give advice 2.96
	Actual adoption 5.98	Actual adoption 2.12	Actual adoption 3.13

Figure 1. Two-step cluster analysis of adoption characteristics of respondents.

As can be seen in Table 23, there is no systematic relationship between cluster and role in the organisation with the possible exception of some plant managers having little advisory role and engineers and operations managers tending to have strong advisory roles.

Table 23. Distribution of roles within clusters

	Main role in the organisation							
	CEO	Group operations manager	Plant manager	Environmental manager	Sales	Engineer/ Maintenance	Innovation manager	Other
High adopters /high advisors	8	10	9	1	3	12	2	9
Low adopters /low advisors	10	3	1	0	2	3	0	6
High adopters /low advisors	4	4	7	0	0	3	0	5

Table 24 illustrates the relationship between clusters and size of the organisation in terms of turnover. There is a clear trend for the larger organisations to provide the early adopters/high advisors.

Table 24. Distribution of organisation turnover within clusters

	Annual turnover					
	Less than $5 million	$5.1 - $50 million	$50 - $500 million	Greater than $500 million	Refused	Don't Know
High adopters/high advisors	3	12	20	11	5	3
Low adopters/low advisors	10	6	4	1	0	4
High adopters/low advisors	2	6	6	3	0	6

The characteristics of the individuals within clusters were investigated by comparing the three clusters in terms of "Beliefs about impediments to adoption" and "Positive attitudes to adoption". For both variables there were significant differences between clusters ($F_{2, 101}$=6.87, p<.01 and $F_{2, 101}$=9.55, p<.01 respectively) with high adopters/high advisors being more positive.

Table 24. Mean belief scores within clusters

		N	Mean	Std. Error
Beliefs about impediments to adoption	High adopters/high advisors	54	-.31	.14
	Low adopters/low advisors	25	.57	.18
	High adopters/low advisors	23	.11	.17
	Total	102	.00	.10
Positive attitudes to adoption	High adopters/high advisors	54	.36	.13
	Low adopters/low advisors	25	-.69	.17
	High adopters/low advisors	23	-.10	.18
	Total	102	.00	.10

It should be noted that the belief/attitude scores are standardised from the PCA analysis. The High adopters/high advisors had the lowest scores on “Beliefs about impediments to adoption” and the highest scores on “Positive attitudes to adoption” while the Low adopters/low advisors were the opposite. The High adopters/low advisors fell in the middle.

In summary, and not surprisingly, the High adopters/high advisors are characterised as coming from the larger organisations and having strong positive attitudes to adoption and an absence of beliefs about impediments to adoption. This group might be regarded as probable early adopters.

Figure 1 contains a summary of the independent relationships amongst the variables as a structural model (AMOS v22). The single arrows represent the proposed direction of the relationships and the values on the arrows indicate the strength of the relationships as regression coefficients.

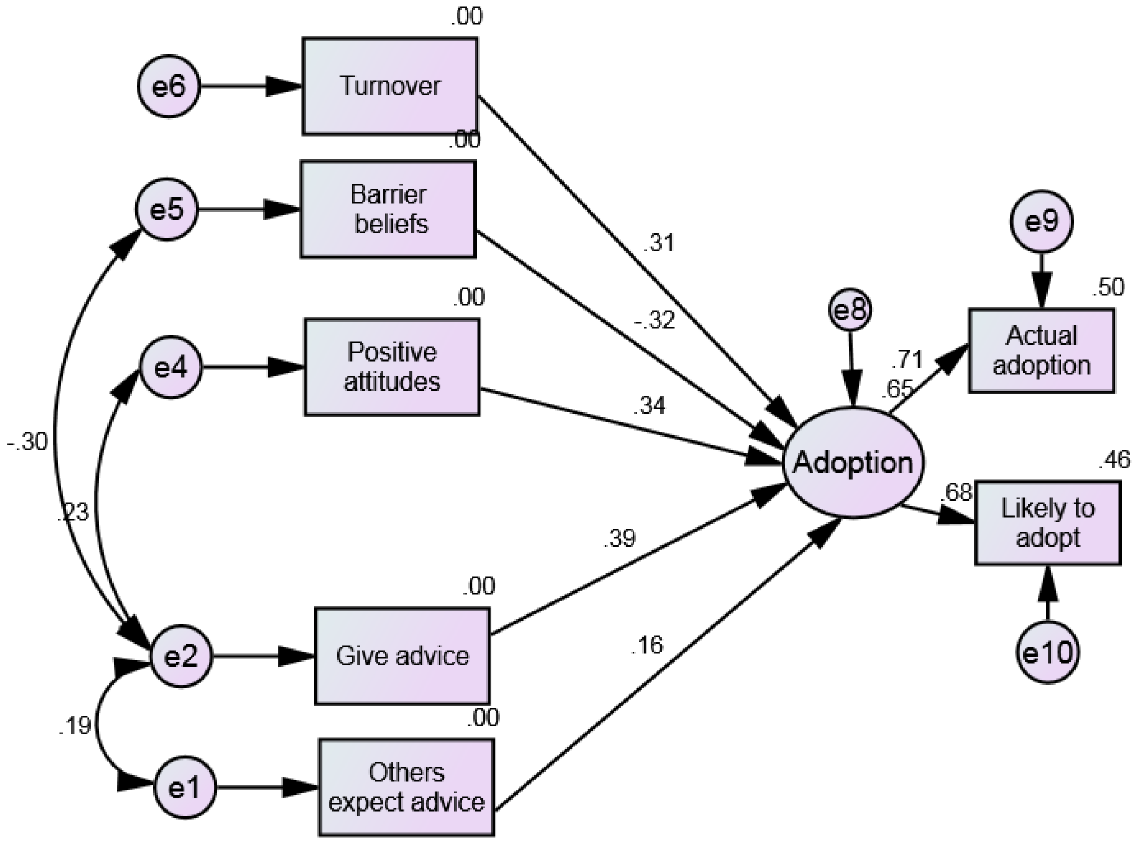

Figure 1. A structural model of the relationships between processor characteristics and adoption of technology (CMIN/DF=1.098, RMSEA=.031), total R^2=.65

Note: Adoption is a latent variable comprising both past and future adoption.

Follow-up interviews

Follow up interviews were carried out with meat processors and one manufacturer. Out of 10 meat processors that were identified for follow-up interviews, five were available. The criteria for identifying processors for interview were plant size, past history of adoption of technology and intentions to take up technology in the future. It was not possible to obtain interviews with processors covering all combinations of these factors. Although the interviews were semi-structured and covered a range of issues, the responses consistently focused on the barriers to adoption of new technology. The themes from these interviews are described below.

One of the common themes to emerge here was the capital cost of plant modifications to accommodate new technology. While old plants are particularly problematic in this respect, even in a medium plant when it was rebuilt 10 years ago, it was purpose built with little flexibility. This impacts on both past adoption and the likelihood of future adoption.

However, manufacturers often factor these matters into their costings, and plant modifications may represent 10% or less of the final cost. Further, this issue remains a barrier even when MLA is providing co-funding.

One of the areas where those interviewed consistently reported up-to-date technology was in waste management, particularly water management. This was driven, in part, by EPA requirements but also, in the big plants, by requirements of the big retailers such as Burger King, McDonalds, etc.). For example, McDonalds currently require the following:

- Maximise water use efficiencies and eliminate the release of wastes and by-products into the environment via water;
- Minimise the release of harmful by-products into the atmosphere;
- Maximise energy use efficiency and use ecologically sustainable renewable sources when feasible;
- Minimise waste production, maximise recycling, and ensure proper handling and disposal of solid waste;
- Maintain soil health by controlling erosion and improving the structure and fertility;
- Preserve natural habitats for native species and protection of biodiversity; and
- Minimise the use of chemical pest management inputs that impact human, animal, and environmental health.

However, these customer-driven requirements are not relevant in plants that supply other markets, so the way in which customer requirements drive adoption of technology is highly variable across plants.

Several of the plants, large, medium and small, that provided interviews indicated that they had a policy of ethical production. While this impacted on their policies of environmental management, it also was reflected, especially in the small and medium plants, in engagement with the local community. This was reflected in a commitment to provide employment opportunities, providing local sponsorships and a commitment to help the disadvantaged.

In the larger plants interviewed, there was a clear policy to be on the lookout for new technology. There was usually a designated person whose responsibility it was to coordinate adoption. In the medium to small plants, no such role existed. A couple of those interviewed in these small plants indicated that they were never contacted by MLA to update them, or to discuss their needs.

Several interviewees reported that it is in the area of robotics and other high-tech innovations that there is resistance. In the case where the technology was complex and involved automation or robotics, several indicated that this technology was too complex. Some technologies prove to be “too hard” to use in practice. For example when simple errors occur, the person on the plant may not have sufficient insight to troubleshoot – e.g. knowing what interlocks are in place or understanding reset procedures, etc. Implementation strategies need to explicitly factor in exception management.

Then, recruitment becomes a problem – there is a need for an electrician with PLC knowledge, for example or a need to identify to recruit plant workers who are literate enough and amenable to relevant technical training in addition to the usual skills required on the chain. This is in the context of plant workers having to be flexible enough to work at various parts of the plant to meet daily shift requirements. Equipment suppliers try to ensure that the remedial action to be taken when a plant exception occurs is as intuitive as possible, but this does not appear to extend as far as displays or spoken messages that actually describe the fault and the action to be taken.

Recruitment in general is seen as a problem and this is emphasised if skilled labour is needed. Industry image problems and geographical location often means that recruitment of suitable employees is difficult. Further, if local external support is needed to deal with a technical problem that requires a fast remedial response, relevant technicians may not be available locally and serious production delays may ensue. Remote fault finding and correction is generally available to deal with fault finding and, in many cases, correction, but this did not seem to alleviate processors' concerns about dealing with faults at their plants. Certainly, if something is "broken" remote faultfinding may identify the problem, but cannot resolve it.

A further problem arises when the technology requires a degree of operator-machine interaction. One interviewee reported a case where an operator forgot to scan the ID of several animals, which then had to be rectified after several animals had commenced processing. The codes were subsequently entered manually out-of-order which then had a cascade effect along the chain. Clearly appropriate interlocks were not in place to prevent this.

Some plants, especially medium sized plants and those that do not export, may not be at capacity and therefore do not have much incentive for new technology. Expansion would mainly entail things such as a new cold room, a rendering plant and water/waste management and perhaps solar power.

The manufacturer interviewed, indicated that when a test site has been trialled successfully (with MLA funding support), volume orders for other plants, even within the same organisation, do not occur. One of the reasons for this is the variability in the criteria for evaluating the success of the technology between plants. For example, one plant may have safety as the highest priority outcome while another has speed or accuracy. A given piece of technology may address one of the processor's requirements one but not necessarily the others.

One interviewee from a medium sized plant considered new technology to be good, but could not justify it at his plant. This interviewee also thought it best for the meat processing industry to have many medium plants and fewer large plants to reduce long distance livestock transport and to use local labour. He held the ethical belief that plants should employ in the local community.

Discussion

This report provides a snapshot of current industry uptake of technology, predictions of future uptake, ways in which they obtain information about available technology and the perceived drivers and barriers for adoption. In terms of future uptake, when respondents were asked the open-ended question to name the three potentially most useful technologies, “new machinery” was the most common response followed by a range of robotic applications. These two classes of response may overlap, but may also indicate that respondents are looking at machinery updates rather than specifically at automation/robotics. Nevertheless, about half of the respondents mentioned robotics and about half also mentioned new machinery. An indication of a bias towards new machinery is that about 60% of respondents reported having adopted new machinery in the past three years but only half as many reported adopting robotics. The main incentive overwhelmingly was cost savings (mentioned by about 80% of respondents with about 20% mentioning each of OH&S improvements and labour savings).

It might be useful in the future to explore this further to determine if the resistance to adoption is biased against robotics and the possible reasons for this.

Arguably, there are two classes of drivers and barriers to adoption. The first class comprises the subjective (psychological) barriers that my include aversion to change, aversion to risk, lack of decision making power, scepticism, etc. and the psychological drivers such as being an early adopter or wanting to anticipate change and deal with it. The second comprises the objective barriers that may include cost, amortisation period, market issues, etc. and the objective drivers including cost-benefit, compliance with customer or regulatory demands, etc. In fact, the same issues may be either objective or subjective barriers depending on the accuracy of the decision makers’ knowledge base. This, in turn, depends, in part, on the attitudes of the decision maker and, in part, on the reliability of the knowledge base from which he or she is making decisions.

Any discussion of incentives and barriers is in the context that there was a high prevalence of uptake in technology over the previous two years. In fact, all respondents reported uptake over the previous two years. However, the extent to which genuinely *new* technology (that is, proven prototype technology in which MLA had invested) is represented in these responses is not known. This report was conducted on a confidential basis with respondent identity not known to the researcher, however, it may be possible for MLA to include actual adoption of MLA funded technology in the database. It would be useful in the future to look at these data in the context of this discussion. It may be that the resistance to the implementation of new technologies may be biased towards those more “experimental” technologies that MLA has invested in. Discussions with a producer and a consultant do suggest that there is a particular resistance to this class of new technology. In fact, only 16.8% of respondents rated the risk of being an early adopter as being of relatively low importance whereas 50% considered it to be relatively high importance. This is also reflected in the fact that 74.6% of respondents considered “unreliable prototypes” as an important barrier to adoption. Further, 66.7% of respondents considered untried technology as an important barrier. Having said that, most of the identified potential barriers were considered important by more than 60% of respondents, which suggests a general wariness about adoption.

Nevertheless, the results from this study do provide some information that increases our understanding of incentives and barriers as well as the way in which decision makers receive their information.

Subjective barriers and incentives.

The main human factors that were associated with past adoption and likelihood of future adoption were (in order of importance) being an information source, having relatively little concern about the possible reasons for not adopting technology (cf Table 10), a relatively positive attitude to adoption (cf Table 10) and believing that others would expect them to be innovative. The degree of perceived control of adoption decisions was not associated with either actual past adoption or likelihood of future adoption. When these variables were put into a regression equation, they accounted for 28% of the variation in past adoption and 20% of the variation in likelihood of future adoption over and above the effect of organisation size.

A closer analysis of the beliefs that contributed to beliefs about impediments to adoption included "The economic environment is too uncertain…", "Day to day issues are more important…" and "New technology is overrated". The beliefs that form this questionnaire are mainly judgements about external factors and a conservative approach generally (cf Table 10).

On the other hand, the beliefs that contributed a positive attitude to adoption included "I consider myself willing to adopt new technology" and "I think it is important to continually seek ways to improve plant efficiency" (cf Table 10). These beliefs are consistent with being an early adopter.

When respondents were classified into adopter categories, there was no simple relationship between role in the organisation and category of adopter but high adopter/high advisors tended to come from the larger organisations. There are several possible reasons for this: large organisations may have better capital resources, be better informed, have better processes for evaluating new technology and have specific individuals available to scope new technology. Not surprisingly, this high adopter/high advisor group showed less concern about impediments to adoption and more positive attitudes to adoption than did the other respondents.

Objective barriers and incentives

Despite the fact that cost/benefit was the highest priority criterion for adoption, only 34% of respondents indicated that they had a formal model for evaluating the cost/benefits of new technology. However, equipment suppliers do have such models and can, and do, demonstrate the cost/benefits of adoption. Often the supplier will provide a plant-specific analysis of cost/benefits that includes the cost of any infrastructure changes.

This mismatch between what appears to objective data on benefits and a reluctance to adopt needs further analysis. Although costs/labour savings may provide a clear incentive for adoption, there are other objective criteria that reduce the viability of adoption. The first and most obvious is the capacity for any organisation to invest. During the course of the follow-up interviews, it became clear that most final decisions for large-scale investment are made at the board level. The priorities for investment will include a range of remedial and proactive elements. Some interviewees indicated that dealing with environmental issues, or need to expand took precedence. Some interviewees also cited lack of economic pressure to improve efficiency. Certainly, because often the benefits of automation may be improved yield and plant throughput rather than saving in labour costs, there may be few benefits to the processor particularly if they are doing service kills. Several respondents reported the downtime and cost of making substantial building changes as a barrier. The data from the questionnaire provides support for these individual reports. Table 15 lists the potential barriers and 85% of respondents cited downtime as a key issue for example. High capital cost was cited as quite important by over 80% of respondents.

When these kinds of reported barriers were raised with an equipment supplier, the supplier indicated that the organisation explicitly addresses all of the major issues when quoting on a job. Despite this, processors may not accept the quote. This can still occur even when very generous guarantees and financing arrangements are made available.

Sources of information.

The other key piece of data relevant to adoption is the sources and kinds of information that are available to processors. The most reported responses to the question “Where do you find out about new technology?” indicated that many were reliant on equipment suppliers and the Internet. For example, 76% asked equipment suppliers, 81% obtained information from sales people and 76% used sales brochures. Of those methods that involved actual information-seeking, 80% did Internet searches and 68% attended industry functions. While other sources were used by up to 50% of respondents, there is a clear reliance by many on suppliers for information. Given that there is widespread wariness about adoption, it is likely that processors would be sceptical about supplier claims about cost/benefits, performance, etc. of the technology. In the follow-up interviews, at least one interviewee reported never being contacted by MLA or AMPC. While such reports need to be regarded with some caution, it would seem that processors do not access much in the way of independent sources for information on new technology.

Conclusions

Taken together, the results from this survey suggest that the meat processing industry in general, and decision makers in particular, have a broad reluctance to adopt technology and to believe that the reported benefits of adoption apply to their particular plant. Part of the reasons relate to specific attitudes to adoption and part to scepticism about its benefits. It is a truly complex picture because there is interplay between the psychological factors identified, industry investment priorities that are based on a range of considerations (some of which are philosophical, some customer-driven or regulatory as well as those that are cost or labour related) and the availability of dispassionate advice and information.

To deal with this, a culture change within the industry is indicated. The effectiveness of change strategies is proportional to the extent to which the intervention is tailored to individual needs. Broad-brush campaigns by mass communications, social media, brochures and the like will have an incremental effect over a fairly long time frame at best. At the other extreme, personalised assessments of individual plants and joint problem solving sessions by an independent advisor are more likely to have an immediate impact. This latter method permits the identified psychological and structural barriers to be addressed specifically. The specific attitudes (both negative [i.e. barriers] and positive) that have been identified in this study should be targeted along with the knowledge base that underpins these attitudes.

Finally, one of the drivers for undertaking the foregoing analysis was to assist MLA in making technology investment decisions into the future. MLA has a model to evaluate particular investment outcomes, and a process to track adoption in the industry over time. Given the very high reported uptake in technology that processors reported in this study, it may well be that MLA’s investment strategy has, by diffusion, been successful. The climate for adoption may have changed positively even if it is not reflected in the uptake of a particular technology in which MLA has invested.

Recommendations

The main recommendations stemming from this the results of this survey relate to a careful evaluation of possible indirect benefits of MLA’s investment strategy and consideration of strategies for providing processors with dispassionate and specific information on possible technology adoption in their plants.

While it is beyond the scope of this report to provide the details of such a strategy, points to consider may include:

The business case for MLA funding new technology needs to factor in:

- the costs of plant changes.
- careful analysis of on-site expertise required to run and maintain the plant.
- viability of its implementation in rural and remote areas, particularly in terms of workforce requirements.
- not only the on-site expertise required, but also the practicality and cost of training the local workforce to reach the required level of expertise.

Proactive strategies to assist with implementation could include:

- assisting Mintrac to develop on site training for employees to adapt to automated technologies
- consider investment in a flexible design for a plant with infrastructure (power, water, drainage, etc.) in some sort of modular form that permits easy adaptation.
- consider the development of an integrated implementation strategy that would provide an framework comprising HR and training needs, infrastructure needs and capital works that could be adapted for any particular new technology.
- establishment of a consultant network to provide independent evaluation of processing plants on a regular basis and to advise on possible improvements in technology.

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Appendix 1. Meat processor adoption of innovation questionnaire.

Adoption of innovation in meat processing

Thank you for agreeing to complete this survey. Your input is most valuable.

All information you provide will remain confidential. We will not collect any information that might identify you or your organization. Your identity will be anonymous and your responses will be referred to by code number only.

The survey is totally confidential

- The survey results will **only** be reported for groups so individual responses **cannot** be identified

How to answer the questions

- There are no "right" or "wrong" answers to any of the questions, just answer what is true for you
- Some questions require you to nominate or tick a box corresponding to the best answer for you. Others require you to nominate or circle a number that most closely represents your opinion, while others require you to tell the researcher or write your answer in the space provided.

If you have any questions about this research, please contact Professor Grahame Coleman (Ph 0417304596) or by email Grahame.Coleman@ipublish.org.au.

Section A: Questions about you and your organisation

This section contains questions about you and your organisation. Your individual responses will remain **strictly confidential**. Only summary results for the entire sample will be used.

For each question, please ***select*** *the response that best answers the question for you.*

A1. **Are you?** (tick)

1 ☐ Male

2 ☐ Female

A2. How long have you worked at your present organisation? (write) _________ years

A3. How long do you intend to stay at your present organisation? (write) _________ years

A4. What state are you located in (Tick as many as is appropriate)?

State	Tick
NSW	☐ 1
NT	☐ 2
Qld	☐ 3
SA	☐ 4
Tas	☐ 5
Vic	☐ 5
WA	☐ 7

A5. What is your role in the organisation? (tick)

Role	Tick
CEO	☐ 1
Group operations manager	☐ 2
Plant manager	☐ 3
Environmental manager	☐ 4
Sales	☐ 5
Engineer/Maintenance	☐ 6
Innovation manager	☐ 7

Other (please describe)	

A6. **Do you have a project manager to implement plant upgrades?**

1 ☐ Yes

2 ☐ No

A7. What is *the annual turnover of your organisation*? (tick)

Income range	**Tick**
Less than $5 million	☐ 1
$5.1 - $50 million	☐ 2
$50 - $500 million	☐ 3
Greater than $500 million	☐ 4

A8. What type(s) and numbers per day of animal(s) do you slaughter (tick as many as appropriate)? If you have more than one plant, choose the largest.

1 ☐ Sheep Numbers/day _____ Num ☐ Cattle

2 ☐ Cattle Numbers/day _____ ☐ Sheep

3 ☐ Other (write) _________________

_______________ Numbers/day _____

Section B:	**Questions about adoption of new technology**

This section contains questions about adoption of new technology in your organisation. Tick as many answers as is appropriate.

B1. How would you identify a need for new technology?

	Tick
Someone in the organisation would identify the need	☐ 1
I would see a problem and look for a solution	☐ 2

I would see some marketing material for new technology and recognise the need it addresses	☐ 3
I constantly review plant operation looking for better methods	☐ 4
I would take advice from other processors	☐ 5
Would respond to a market opportunity	☐ 6
Other (please describe)	☐ 7

B2. Where do you find out about new technology?

	Tick
Internet searches	☐ 1
Ask equipment providers	☐ 2
Industry meetings/functions	☐ 3
Local meat convention	☐ 4
Overseas meat convention	☐ 5
Equipment provider sales people	☐ 6
Sales brochures	☐ 7
From someone in my organisation	☐ 8
Other (please describe)	☐ 9

B3. Thinking plant-wide, list the top three examples of the potentially most useful available technology that you are aware of:

1	
2	
3	

B4. Do you think there is adequate information available on new technology? ☐ Yes ☐ No

B5. List the top three incentives that you would require to adopt new technology:

1	
2	
3	

For each question, please **tick** the box that most closely represents your opinion.

B6. Indicate the relative importance of the following advantages of adopting new technologies

	Very important				Not at all important
Improved plant performance					
Net cost savings					
Improved OH&S					
Consistency of product					
Better accuracy					
Reduced labour costs					
Reduced maintenance costs					
Reduced required skill level of the workforce					

B7. Indicate the relative importance of the following disadvantages of adopting new technologies

	Very important				Not at all important
Cost of the technology					
Capital infrastructure costs					
Ability to maintain it					
Backup from providers					
Disruption to production when breakdowns occur					
Variation in animals makes automation of slaughter difficult					
Availability of floor space					
Reliability of available technology					
Risk of being an early adopter					

B8. What term of cost recovery would you require to adopt new technology for non-compliance projects?

1☐ Less than one year

2☐ One year

3☐ Two years

4☐ Three years

5☐ Other (write) ____________Years

B9. Do you have a formal costing model for evaluating innovation? ☐ Yes ☐ No

B10. How important are the following barriers to your decision whether or not to adopt new technology? Please tick the appropriate box.

	Very important				Not at all important
Concern about untried technology					

Concern about in-house skill requirements					
Availability of spare parts					
Lack of generic spare parts					
Major changes to facilities					
No available model to properly cost adoption of new technology					
Space on the floor					
Training (to operate the technology)					
Maintenance (operation of the technology)					
Cost or perceived cost					
Keeping the same throughput					
Access to capability / providers					
Other competing priorities in the business					
The time for cost recovery					
Downtime if/when there is a breakdown					
Previous experiences					
Decreased flexibility to respond to market changes/customer specifications					
Gaining customer acceptance					
Unreliable prototypes					
Equipment is very expensive, high capital cost					
Cost benefit analysis are not always trusted to apply					
Payback period is too long, given the risk					
Equipment may not physically fit into plant					
Issues with "retrofitting"					
Equipment specifications may not fit plant requirements					
Equipment support and maintenance costs					
Perception (or realisation) of unsuccessful installations					
Labour availability can be managed in other ways					
OH&S hazard costs of manual tasks are not clear or sufficiently onerous					
Inflexibility of new technology					

B11. As opposed to the previous question about barriers, now indicate the relative importance of the following reasons to consider adopting new technologies

	Very important				Not at all important
Reduce of production costs					

Meet government regulations					
Environmental concerns					
OH&S concerns					
Reduce labour costs					
Improve consistency of operation					
Improve consistency of product					
Improve hygiene					
Reduce need for skilled labour					
Increasing production					
Processing efficiency and yield improvements					
Changing specifications (customers etc)					
Increase flexibility to respond to market changes/customer specs					
Inventory management					
Reduction in waste/product not meeting specs					
Being a leader in technology advancement					
Greater flexibility of new technology					
Market access					
Increase shelf life					

B12. List up to three examples of technology you have adopted in the past three years:

1	
2	
3	

Section C:	Questions about your opinions about adopting of new technology

This section contains questions about your views about adoption of new technology in your organisation. For each question, please **tick the box** that most closely represents your opinion for each aspect.

C1. For these questions indicate the extent to which you agree or disagree with the following statements:

	Strongly agree				Strongly disagree
I would consider myself willing to adopt new technology					
MLA spends too much on technology R&D					
I am more likely to consider adopting a new technology if I know other processors have done so successfully					
The economic environment is too uncertain to consider investing in new technology					
I don't have the authority to make decisions about adopting new technology					
Day to day issues are more important than looking for ways of improving production					
There is insufficient space at my plant to install new technology					
I value industry opinion about the best ways to slaughter livestock					
New technology is overrated					
New technology is often not properly field tested before being sold to processors					
I think of myself as a leader in adopting new technology					
My business can't afford to invest in new equipment					
MLA spends too much on R&D generally					
My labour force is sufficient to maintain production in the foreseeable future					
I listen to other senior staff when it comes to considering new technology					
I prefer to continue using established processing methods					
Adoption of new technology in my organisation is determined by others					
The plant in my organisation is not suited to most of the available new technology					
AMPC spends too much on technology R&D					
My plant is capable of meeting relevant environmental standards for the foreseeable future					
There are few OH&S issues that could be solved by new technology					
My plant is able to produce high quality product for the foreseeable future					
I think it is important to look for improvements in plant equipment					
I can't afford the downtime required to install new equipment					
I would be happy to use my plant to field test new technology					
AMPC spends too much on R&D generally					
I think it is important to continually seek ways to improve plant efficiency					

C2. In these categories, how likely are you to adopt possible new technologies?

	Highly likely				Highly unlikely
Yards					
Processing					
Chilling/freezing					
Boning					
Packing					
Offal					
Rendering					
Environmental					
OH&S					

. In which of these categories, have you adopted new technology in the past two years?

Yards	
Processing	
Chilling/freezing	
Boning	
Packing	
Offal	
Rendering	
Environmental	
OH&S	

C4. A few final questions

During the last six months, how many processors from other plants have you told about new meat processing technology?	1= none	2 = 1 processor	3 =2 processos	4=3 processos	5 = more than 3 processors
Compared with processors from other plants, how likely are you to be asked about new meat processing technology?	1=very likely	2=likely	3=fairly likely	4=not very likely	5=not at all likely
My co-workers think I should be a source of information about about new meat processing technology?	1 = strongly agree	agree	3=neither agree nor disagree	disagree	5=strongly disagree
I'm not informed enough about farm new meat processing technology to be telling other people about it	1 = strongly agree	agree	3=neither agree nor disagree	disagree	5=strongly disagree
I don't have enough time to be telling other people about new meat processing technology	1 = strongly agree	agree	3=neither agree nor disagree	disagree	5=strongly disagree
Other plant operators think I should be a source of information about about new meat processing technology?	1 = strongly agree	agree	3=neither agree nor disagree	disagree	5=strongly disagree

Appendix 2. Letter sent to producers to enlist their support.

AUSTRALIAN MEAT PROCESSOR CORPORATION

T (02) 9436 0042 F (02) 9436 0343 E AMPC@AMPC.COM.AU WWW.AMPC.COM.AU

Suite 205, Level 2, 460 Pacific Highway, St Leonards, NSW 2065 | PO Box 11, St Leonards, NSW 1590.

AMPC

27/08/2013

Dear AMPC Member,

RE: Your participation in an AMPC project investigating the identification of barriers to the adoption of technology (focus on automation) in the meat processing industry

We seek your participation in an AMPC technology project investigating key barriers to the uptake of technology (focus on automation) in the meat processing industry.

Background to the project

As you are aware, significant investment has been made into research, development and facilitated adoption of various technologies, however there remains significant challenges in relation to effective commercialisation, adoption and uptake of these outcomes in industry.

It is recognised that current rates of adoption for automated solutions in red meat processing are too low to realise expected productivity improvements necessary to maintain productivity into the future, given the pressures on labour and other challenges. Therefore, there is a need to analyse possible "barriers to adoption and uptake" in order to enhance commercialisation and the realisation of outcomes to industry in the future.

To date, many processors have indicated a range of challenges in relation to technology adoption such as: Space on the floor; Training (to operate the technology); Maintenance (operation of the technology); Cost or perceived cost; Keeping the same throughput; Access to capability / providers; and Payback period being too long given perceived risk. But there remain other barriers which need quantification in order to enhance the current strategy for uptake and adoption.

It is recognised that detailed analysis of the "barriers" to uptake would lend itself to an enhanced ability by MLA and AMPC (with processors and technology providers) to develop and implement a more targeted approach and to inform the construct and delivery of funding programs in this area.

Phase 1 now completed

AMPC has engaged Professor Grahame Coleman (of Melbourne University) to undertake this study. Throughout Phase 1 of the project Professor Coleman has been working with a small advisory committee of stakeholders (AMPC members and R&D providers) to develop a targeted questionnaire to capture wider industry input into the project. This survey is now ready for wider distribution.

We seek your participation in Phase 2 – Capturing broader industry views and data

AMPC now seeks your participation in Phase 2 of the project. You will be contacted by an independent data collection company *Iview Pty Ltd* who will assist you to complete the questionnaire (to be provided by Iview) via a telephone interview.

The survey is totally confidential

All information you provide will remain confidential. We will not report any information that might identify you or your organization. Your identity will be anonymous and your responses will be referred to by code number only. The survey results will only be reported for groups so individual responses cannot be identified. We may contact you at a future time to seek your agreement to participate in a more detailed discussion.

ABN 67 082 373 448