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Adoption of grape and wine R&D outputs: Who, what and why?



FINAL REPORT to

AUSTRALIAN GRAPE AND WINE AUTHORITY

Project Number: **DPI 1201**

Principal Investigator: **Megan Hill**

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Adoption of grape and wine R&D outputs: Who, what and why?

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Authors

Megan Hill
Department of Economic Development, Jobs, Transport and Resources, Private Bag 1, Tatura, Vic, 3616

Sandy Hathaway
Felix Consulting, 4 Rosella Close, Flagstaff Hill, SA, 5159

Roger Wilkinson
Department of Economic Development, Jobs, Transport and Resources, Warrnambool, Vic, 3280

Neil Barr
Department of Economic Development, Jobs, Transport and Resources, Bendigo, 3551

Geoff Cowey
Australian Wine Research Institute, PO Box 197, Glen Osmond, SA, 5064

Mark Krstic
Australian Wine Research Institute, Level 1 West, 262-276 Lorimer St, Port Melbourne, Vic, 3207.

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Abstract

Extensive interview and survey data was collected and analysed using the Technology Acceptance Model (TAM2) to identify the drivers of adoption for two vineyard and two winery technologies. Perceived usefulness was a key driver for all of these technologies, with business scale and outlook (i.e. if the business was expanding, staying steady or contracting in size), attitudes to productivity, social norms and grower or winemaker age also emerging as important. It was found that grapegrowers and winemakers sought and used more sources of information when considering high involvement, important or risky technologies, than when considering more routine, low involvement technologies. Networks of other grapegrowers and winemakers were found to be key sources of information and a strong influence on the decision making and adoption of technology. A framework that ties these results and concepts together to guide the design of an extension strategy is presented.

Executive summary

Background

The success of Australia's wine industry is largely underpinned by its investment in research and development (R&D) and its willingness and ability to innovate and adopt new technologies, products and processes resulting from this investment. In an increasingly complex and competitive business and market environment, R&D remains crucial.

Ensuring Australian grapegrowers & winemakers are aware of the latest R&D outcomes is essential. Actively disseminating information via Targeted extension activities have been found to increase interest and encourage uptake of new technologies and practices, referred to as 'adoption'.

In order to target extension to increase adoption, a number of questions must be answered:

- Which grapegrowers and winemakers adopt or are likely to adopt technologies? **(Who?)**
- What vineyard and winery technologies are being adopted? **(What?)**
- What are the drivers of adoption of these technologies? **(Why?)**

Another important consideration in designing extension activities is the information-seeking behaviour related to decision-making about adoption. That is, where do grapegrowers and winemakers seek information when making decisions about adopting new technologies and practices?

While there are many opinions on these topics, this project sought to identify some facts pertinent to grapegrowers and winemakers through exhaustive data collection, analysis and use of a proven adoption framework.

The study

The research project was undertaken as several separate pieces of work including:

1. **Literature review** (part E of report)
   A review of previous research to understand key drivers for adoption and select the most suitable model to mimic adoption in the Australian grape and wine industry
2. **Qualitative analysis** (part A)
   Interviews conducted with a range of grapegrowers and winemakers to test the model and collect data on information-seeking behaviour
3. **Quantitative survey** (Part B)
   A phone/online survey to collect more specific information to answer the research questions, followed by data analysis and interpretation.
4. **Design and evaluation of an extension strategy** (Part C)
   Using project results to create a process to inform the evaluation or design of extension strategies.
5. **Workshop report** (Part D)
   The outcomes of a workshop conducted with research collaborators and industry representatives to discuss newly developed model.

Results

This project found the Technology Acceptance Model (TAM2) (Venkatesh and Davis 2000) was the most suitable model to describe and predict drivers of technical adoption and behavior change for the Australian grape and wine industry.

A small number of case study technologies were selected to test the robustness of the model. A case study approach enables some examples related to a topic, in this case adoption of technologies in the wine industry, to be studied in depth. The case study technologies selected were included soil moisture monitoring systems and new chemical sprays (fungicides) in vineyards, and cross-flow filtration systems and novel yeasts in wineries.

A total of 81 face-to-face interviews were conducted with grapegrowers, winemakers and R&D managers from 12 Australian wine regions for the qualitative research component (part A) of the study. Survey data was collected from 1066 winemaker and grapegrower respondents from all winegrowing states in Australia for the quantitative component (part B).

Results from the survey indicated:

- 33% had adopted soil moisture monitoring systems,
- 66% had adopted or trialled new chemical (fungicide) sprays,
- 41% had purchased, leased, trialled or had their wine filtered using a cross-flow filtration system, and
- 60% had used novel yeasts at least twice.

Who is adopting technologies?

- Grapegrowers and winemakers who described their business as 'expanding' often purchased new technology to assist or support their expansion process. Businesses that were 'steady ' in size tended to mainly adopt technologies that were not capital intensive and would provide quantifiable short- to medium-term benefits such as reducing costs, increasing quality or increasing efficiency. Grapegrowers and winemakers whose businesses were 'contracting' had not been purchasing much, if any technology, and reported that they were reducing staff numbers and had little access to financial resources. These results show that there is merit in identifying market segments based on business outlook.
- Of the survey respondents 16% of the grapegrowers and 31% of the winemakers said their businesses had expanded in the last five years, with 13% and 40% respectively predicting they would continue to expand over the next five years. Tasmania had the highest proportion of expanding vineyards and wineries. The majority of respondents with expanding businesses also said that increasing productivity was important to them and that they felt they were likely to achieve this (the 'confident' group).
- 71% of the grapegrowers and 53% of the winemakers said their businesses had remained steady in size while 13% of the grapegrowers and 16% winemakers said their businesses had contracted over the last five years.
- For both grapegrower and winemaker respondents there was a strong relationship between age, business outlook and attitudes to productivity, with a higher percentage of younger people (under 34 years old) likely to have expanding businesses and be confident of increasing productivity.

What is being adopted?

During the interviews, grapegrowers were specifically asked about adoption of soil moisture monitoring systems and new chemical sprays. In addition to these, other vineyard technologies mentioned by respondents as being adopted included alternative varieties, equipment related to precision viticulture, application of compost/mulch, pruning techniques and canopy management, machine harvesters incorporating new features or technologies such as wire lifting or fruit sorting capabilities, smartphone apps (weather and irrigation), changes to spray equipment, cane pruning machines and plant tissue analysis.

Winemakers were asked specifically about cross-flow filtration and novel yeasts. In addition to these, other winery technologies mentioned in the qualitative interviews included flotation, energy efficiency technologies and practices (i.e. automatic temperature control systems), alternative grape varieties, near-infrared spectrometry and berry-sorting tables at the winery.

Why were these technologies adopted?

- The 'perceived usefulness' of the technology to the grapegrower or winemaker was the key driver of intention to adopt and in turn actual adoption behaviour of all the case study technologies. For the more expensive and complex technologies, 'perceived usefulness' was found to be related to business scale and outlook (i.e. expanding, remaining steady or contracting) and was influenced by the decision-maker's motivation and capacity to invest.
- Dimensions of perceived usefulness of a technology included whether it could be used to increase productivity, sustain competitive advantage, increase workplace safety or generate knowledge. Technologies were found to be easy to use if they did not require significant changes to vineyard or winery infrastructure, were easy to maintain and if the owner or staff did not need to develop new skills or knowledge to operate them. These dimensions and their priority varied depending on the individual technology.
- Business scale emerged as a significant influence on the adoption of soil moisture monitoring systems and cross-flow filtration with the larger businesses being more likely to adopt these more expensive and complex technologies. Scale was not a significant influence in the case of new chemical sprays and novel yeasts.
- A number of contextual factors were also found to influence adoption of technology – such as the region, site characteristics, competitive strategy of the business and characteristics of the business decision-maker.
- Social norms – i.e. the opinion of other people considered important or knowledgeable – was a driver for adoption of all of the technologies considered, while the influences of decision control, ease of use, experience and innovative factor varied.
- The Technology Acceptance Model 2 (TAM2) was found to provide a solid basis for understanding the adoption of technology in the Australian wine industry, with all the original variables being found to be relevant, except 'image'. However, it was less effective at predicting actual adoption than the intention to adopt. Suggestions have been made on how to improve the explanatory and predictive power of this model for the wine industry, and an alternative approach for data analysis presented.

Where do grapegrowers and winemakers seek information?

- It was found that a range of sources of information is used when considering adopting a new technology. The more important or risky the decision, the more information collected and sources used.
- Most grapegrowers and winemakers have an extensive network which they use to obtain practical, trustworthy, independent information, especially in regard to new technologies.
- Grapegrowers and winemakers value information sources that provide them with credible, trustworthy, relevant information from knowledgeable, accessible sources.
- Grapegrowers and winemakers generally follow a structured process of decision-making leading to the purchase of new technology, which includes information-seeking at every stage.
- Corporate vineyards or wineries were found to differ from private (family-owned) businesses in their information-seeking, as they usually had access to specialised R&D advice and considerable information resources within the organisation.

The implications of these results are discussed and a framework for extension program design and evaluation is presented in this report.

Recommendations

1. The 'market, message, means of communication' framework be used to guide thinking and the wine sector's data collection for extension design and evaluation.
2. Market segmentation can provide practical insight into target markets and messages that will be effective to support adoption of a technology. It is recommended that this approach be replicated on additional technologies, products and practices, which would:
   - Enable the data collection and analysis process to be refined and streamlined
   - Build an understanding of the dimensions of perceived usefulness and ease of use for a larger range of innovations. These will be useful to enhance researcher and extension provider understanding of the range of considerations that lead to something being considered useful or otherwise
   - Inform predictions of market size and composition for existing technologies, enabling extension efforts to be designed and targeted and effective evaluation to be conducted
   - Provide data on current grapegrower and winemaker needs to inform predictions of their future needs and preferences in regard to emerging innovations. There are marketing tools (e.g. focus groups) and processes (e.g. forecasting) available to support this objective.
3. The TAM2 be modified for use in the wine industry to include the variables:

- business outlook
- business scale (size)
- age of the decision maker
- frequency of contact with peers
- price of the technology.

4. Identify opinion leaders in key areas of viticultural production and winemaking and explore opportunities to encourage adoption with this group. A targeted extension strategy should be considered for this group.
5. The range and size of extension provider networks in the Australian wine industry be identified and mapped to show where and why flows are most effective and efficient, and to enable gaps in information flow (e.g. regional or topic-specific) to be identified.

Contributions

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- The Australian Wine Research Institute
- Wine Grape Grapegrowers Australia
- The University of Melbourne

Background

Many models, theories and opinions exist on extension design and delivery. However, extension designers and practitioners have no systematic, logical approach to guide them through the processes of collecting relevant data, identifying where their efforts will be most effective and designing an extension strategy.

In an increasingly complex and competitive business and market environment, R&D remains crucial. Actively disseminating R&D outcomes and related information via targeted extension activities have been found to increase interest and encourage uptake of new technologies and practices, referred to as 'adoption'. Hence the value any R&D investment is optimised through effective extension design.

Towards that aim this project uses methods and tools from a range of disciplines to explore the following questions:

- Which grapegrowers and winemakers adopt or are likely to adopt technologies? **(Who?)**
- What vineyard and winery technologies are being adopted? **(What?)**
- What are the drivers of adoption of these technologies? **(Why?)**

Another important consideration in designing extension activities is information-seeking behaviour related to decision-making about adoption. That is where do grapegrowers and winemakers seek information about technologies when making decisions about adopting new technologies and practices? This question was also addressed in the project.

Who? Market segmentation

Market research is any organised effort to gather information about target markets or customers. The 'market' is the population of actual or potential users (Assael 1998). Market segmentation involves using this information to identify groups within a population based on commonalities in needs or processes (Quester *et al.* 2010). Understanding who is in the market, ie the market segments likely to adopt the desired technology, information, product or practice change, is the first step in designing an effective extension and communication strategy (Schiffman *et al.* 2014, Quester *et al.* 2010).

Kaine (2004) suggested that grapegrowers adopt a technology based on their 'farm context': the combination of biophysical and financial resources of the farm, and the skills of the farmer. Therefore he suggests that identifying the key aspects of the farm context, and the associated benefits sought through adoption should enable the potential market for a technology to be identified and market segments designed.

A study of the farm household and business context of Victorian farmers (Wilkinson *et al.* 2011) revealed that farmers can usefully be segmented according to their attitudes towards productivity growth and which of three phases of their business they are in: growing, maintaining or phasing down. Individuals in the different segments were found to vary in their interest in and intentions towards adoption of R&D outputs, as well as availability of resources for adoption.

The combination of these concepts should yield useful insights into the potential market for a new technology.

Why? What are the drivers of adoption?

An extensive range of models and theories has been developed and published that seek to describe and predict people's adoption of technology. To answer the research question: '*Why are technologies adopted?*' an adoption model needed to be selected that was most suited to understanding the process of

adoption of the case study technologies. A review of the main models conducted at the start of the project[1] indicated that the most suitable model to use in the project was the Technology Acceptance Model 2 (TAM2) (Venkatesh and Davis, 2000).

The original TAM (Davis, 1993) proposed that a person will adopt a technology largely based on two key beliefs about the technology: its perceived usefulness, and its perceived ease of use. TAM2 proposes that these beliefs are supplemented by the influence of social norms and mediated by constraints on their capacity to adopt (Venkatesh and Davis, 2000). TAM2 has previously been used to study the adoption of technologies in agriculture (Adrian, 2005, Folorunso, 2008), which was one of the criteria leading to its selection for use in the project.

Where do grapegrowers and winemakers seek information?

From the literature it is clear that people actively seek information to reduce uncertainty and risk, or to 'make sense' of something (Case, 2007). When making a purchase decision people often seek information to inform that decision. The more important or risky the purchase is to them the more information they seek, from more sources (Assael 1998). This was also demonstrated to be the case with the purchase of agricultural technologies and products (Hill and Kaine, 2011). Therefore when considering a purchase of technology that is potentially risky, it is logical that grapegrowers and winemakers would seek information before making a decision. In this project, interview and survey information was collected on where this information was sought.

It has also been proposed that people have an 'information source horizon' which describes 'the ways information sources are mapped in preference order in an imaginary field' (Savolainen, 2008). That is, all the places or sources an individual knows about and may use to obtain information. Barry and Schamber, (1998) found that the sources are selected depending on where in the decision-making process the person is up to and the perceived attributes of the source, called their 'source criteria' (e.g. how trustworthy, accessible etc). This project examined where sources of extension information were placed on the information source horizons of a small number of grapegrowers and winemakers, identified the source criteria for some extension methods, and examined whether corporate businesses use different sources of information compared with private (family-owned) operations.

This project has provided insights that will enable extension providers to better understand the market for R&D outputs, and how to best identify and meet the information needs of the target audience and set adoption targets.

[1] Review of Selected Adoption Theories – Rowbottom (2013) unpublished –see report part E

Project aims and performance targets

Project objectives

The original objectives of this project were:

- **Stage 1: Segmentation study on wine and grape growing industries.**

  The identification and description of market segments, based on winemakers' and grapegrowers' business aspirations and capacity to invest in the adoption of R&D outputs.

- **Stage 2: To determine the market for a range of R&D outputs.**

  Identification of the specific R&D outputs which are, or will be, relevant to the grapegrowers and winemakers in each of the segments previously described. GWRDC and project collaborators will be consulted when selecting the R&D outputs to be studied in greater depth.

- **Stage 3: Prediction of extension tools that will be effective in achieving adoption outcomes.**

  The identification of the extension tools that have, and will be most effective in supporting the adoption of various types of R&D outputs (selected in Stage 2). Theory suggests this will depend on the complexity, trialability and riskiness of adopting the R&D output (Hill and Kaine 2011).

- **Stage 4: Design adoption strategies and guidelines.**

  Project findings will be consolidated and used to underpin the design of adoption strategies and extension design guidelines, incorporating:

  - A 'route to change'
  - The fit of the technology with farming systems and the enabling environment
  - The intention and worldview of grapegrowers and wine makers
  - Integration of new technologies with existing ones
  - The practical aspects of applying innovation in the commercial world.

During the project, these objectives evolved to become:

Stage 1- Market segmentation on business outlook

Business and attitudinal information was collected on grapegrowers and winemakers, to enable market segments to be described in relation to who has adequate resources and desire to increase the size or productivity of their business, and hence the market for various R&D outputs to be identified, along with estimates of market size. This answers the question W*ho is likely to adopt technologies?*

Stage 2- Drivers of adoption for specific R&D outputs

The next stage was to identify the key drivers of adoption for the case study technologies. This enabled the identification of drivers of adoption for emerging R&D outputs.

Stage 3- Grower and winemaker information-seeking behaviour

The next stage was to answer the questions:

- What information-seeking behaviour do grapegrowers and winemakers use when considering adoption of a technology?
- What sources of information were used to inform decision-making in regard to the purchase or adoption of technologies or products?
- Why did grapegrowers and winemakers use different sources?
- What information were they seeking?

Stage 4- Design adoption strategies and guidelines

This stage involved a consideration of the implications of the project results for extension program design. A framework was designed to enable the evaluation of existing extension programs or to design a new extension strategy.

Table 1 lists these stages, research questions, approaches and data or tools used.

Stage	Research questions	Approach	Data/tool
1	Who is adopting, and likely to adopt research technologies?	Market segmentation based on business outlook and attitudes to productivity	Selected literature Interview data Survey data
2	What are the drivers of adoption for the case study technologies?	Select model Test model with industry Run model Moving from intention to adoption	Literature review Interview data Survey data Survey data
3	What information-seeking behaviour do grapegrowers and winemakers use when considering adoption?	Identify sources of information used Study web use and web site selection criteria Describe general information source use	Interview data Survey data Interview data
4	What do the project results tell us about extension design?	Create a framework that could be used for evaluation or design of extension strategy	Project results Selected literature

TABLE 1: STAGE, RESEARCH QUESTIONS, APPROACH AND DATA AND TOOLS USED.

While the objectives of this project remained constant, this research is not reported against the stages listed above, but rather in three discrete parts due to the iterative nature of the work. Each part details the research approach, methods, results, discussion and references. The three parts are:

Part A: The Qualitative Study- this report details the grower and winemaker interviews conducted to test the TAM2 model, and collect data about their information-seeking and decision making.

Part B: The Quantitative Study- this report contains the survey data and results and discussion pertaining to market segments and the key drivers of adoption.

Part C: Designing or evaluating an extension strategy- this report contains information-seeking results and a framework and example of how to design an extension strategy, using soil moisture monitoring systems as an example.

Part D: Adoption strategies workshop – this report is a write-up of the content and outcomes of a workshop conducted to consider the implication and application of the project results to extension program design.

Part E: Literature review -

This project met all the planned outputs and performance targets within the agreed timeframe (extended from the original anticipated deadline).

Table 2 details the performance targets, activities and actual results of this project.

	Performance targets	Activity	Actual results and activities
1	Three meetings and presentation to ensure industry and collaborator engagement	Conduct planning meetings with collaborators and stakeholders	Meetings conducted by March 2013
2	A detailed project plan	Consolidate project planning information	Delivered to AWGA 23rd April 2013
3	Information and update	Report to the national Wine Extension Industry Network	Presented 31st October 2014
4	Data available to guide questionnaire development	Conduct semi-structured interviews with grapegrowers and wine makers	Interviews completed and transcribed by September 2013
5	Questionnaire to collect Stage 1&2 data	Develop and test the questionnaire	Questionnaire piloted and ready to submit by November 2013
6	Industry demographic, attitudinal and R&D output specific data for the wine industry	Data collection	Data collected, cleaned and available March 2015
7	Report of Stage 1&2 market segmentation	Analyse and report data	Data analysed and reported September 2015
8	Report on the effectiveness of extension tools (Stage 3)	Complete collection and analysis of extension tool data	Analysis completed December 2014
9	Workshop	Use “smart design” to start the design of adoption strategies.	Completed in March 2015
10	Guidelines to guide program design and investment	Develop guidelines and recommendations to guide program design and investment	Guidelines finished December 2014
11	Final Report	Write the final report, make presentations to industry and stakeholders on project findings and recommendations	Report submitted December 2014
	Additional outputs- project extension		
8	Drivers at different stages of adoption	Additional and novel data analysis and presentation	Completed and reported October 2014
9	Presentation at international conference	Presentation of project findings at PIM conference, USA	24th October 2014
10	Explore future application and development of findings	Link in with future projects	Currently participating in submissions for ARC linkage funding and DEPI, Melbourne University Innovation seed funding

TABLE 2: PROJECT PERFORMANCE TARGETS AND RESULTS.

Project Report

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Adoption of grape and wine R&D outputs: Who, what and why?



Megan Hill et al.

March 2015

Australian Government
Australian Grape and Wine Authority

Department of Economic Development, Jobs, Transport & Resources
State Government Victoria

Adoption of grape and wine R&D outputs: Who, what and why? Part A: Qualitative analysis



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Executive Summary

Part A of this report describes the 'qualitative' (using data that can be observed but not measured, words for example) research component. Data was collected by interviewing grapegrowers and winemakers to understand their business outlook, where they seek information and which technology/practices have been recently adopted and why

Sixty two grapegrowers and winemakers, from ten Australian wine regions, were interviewed to better understand:

- If business outlook (i.e. if the business was expanding, steady or contracting in scale) influenced the likelihood of R&D outputs such as novel technologies, products and practices
- If the TAM2 model was useful to model the wine industry
- The reasoning behind why some grapegrowers and winemakers adopted technologies, products and practices, while others did not
- where grapegrowers and winemakers seek information from when making adoption decisions

Information-seeking behaviour was explored using several 'case study' technologies, including:

- Viticulture related - soil moisture monitoring systems, new chemical (fungicide) sprays, precision viticulture and alternative grape varieties,
- Winemaking related - novel yeasts and cross-flow filtration.

In summary, qualitative data showed:

- 42% of the grapegrowers or winemakers interviewed described their business as 'expanding' and had purchased new technology to assist or support this process.
- Businesses that were 'maintaining' or 'consolidating' (39% of sample) or 'winding down' (19% of sample) had been purchasing little, if any technology. Some reported that they were reducing staff numbers and had little available finance. Any technologies purchased by these businesses were made to save money (reduced input costs or increased efficiency).
-
- The 'market' for adoption of a technology should be segmented based on business phase and aspirations as these provided a sound indicator of the available resources and motivation of grapegrowers and winemakers to adopt R&D outputs such as new technologies. A number of contextual factors also influenced the adoption of technology. These included (in random order) wine region, biophysical, infrastructure and management systems onsite, business scale and competitive strategy of the vineyard or winery, and the characteristics of their business decision-makers.
- The Technology Acceptance Model 2 (TAM2), a theoretical model used to represent factors influencing adoption, was found to be a useful tool with all the original variables relevant, except 'image'.
- Grapegrowers and winemakers perceived a technology to be useful if it could be used to:
    - increase productivity
    - sustain competitive advantage
    - increase workplace safety, or
    - generate knowledge.
- Technologies were considered easy to use if they:
    - did not require significant changes to vineyard or winery infrastructure,

    - were easy to maintain, and
    - if the owner or staff did not need to develop new skills or knowledge to operate them.
- When seeking information, grapegrowers and winemakers sought information at every stage of the decision-making process leading to the purchase of new technology.. While the decision-making process was structured, the information-seeking process was usually iterative, ad hoc and often opportunistic and/or intuitive. However a number of themes were identified:
    - Most grapegrowers and winemakers have an extensive network which they use to obtain practical, trustworthy, independent information, especially in regard to new technologies
    - Region-specific information is often sought, particularly by grapegrowers
    - A range of types and sources of information are used when considering technology. The more important or risky the decision the more information collected and sources used
    - Grapegrowers and winemakers value information sources that provide them with credible, trustworthy, relevant information from knowledgeable, accessible sources
- Compared with private (family-owned) businesses, grapegrowers and winemakers employed by wine industry corporate companies sought information differently. They usually had access to specialised R&D advice and considerable information from within the organisation.

These findings were used to inform the next, quantitative phase (Part B) of the project, and the development of guidelines to guide the design of extension programs and information to support the adoption of R&D outputs (Part C).

1. Introduction

1.1 Context

This project investigated the target audience for research and development (R&D) outputs in the Australian wine industry and tested the Technology Adoption Model 2 (Venkatesh and Davis 2000) to determine its relevance and if it would be a useful basis for a quantitative study to identify the drivers and barriers to adoption. The project also explored the information-seeking behaviour of grapegrowers and winemakers when making decisions about technology. This work was intended to provide insights to enable people to better understand what makes one R&D output more successful in the market than another, and how to target their extension and communication efforts to be most effective.

1.2 Research basis

Research outputs such as novel technologies or products often reach the market after a development and commercialisation process. Adoption of novel practices may also involve the purchase of some products or use of novel technologies, and involves a cost (i.e. time, development of skills and knowledge, potential risk) and benefits.

Kaine (2004) suggested that grapegrowers purchase and adopt technology based on their 'farm context' – this is the combination of biophysical and financial resources of the farm, and the skills of the farmer. Identifying the key aspects of the farm context should enable the potential market for a technology to be identified and market segments designed. More recently, Wilkinson *et al.* (2011) divided Victorian farmers into market segments based on their business phase (e.g. expanding, phasing down, etc) and the farmers' aspirations for their farm's future productivity. It was found that:

- 16% of the farmers wish to grow their farm business and are interested in, and have the resources to adopt R&D outputs that enable them to manage larger farms more efficiently and productively.
- 32% aim to increase the productivity of their farms, through adopting R&D outputs that will enable them to use their existing resources more efficiently.
- 14% are interested in increasing their productivity but do not have the resources to make major investments; they will be interested in R&D innovations that are cheap to adopt and provide rapid returns.
- 38% of the farmers are phasing down or selling out of farming. This is independent of property size, but rather is determined by age and personal or family circumstances. This group are unlikely to be interested or able to adopt R&D innovations that require a significant investment of time, money or energy.

Wilkinson *et al.* (2011) found age and capacity to invest to be the key factors that influenced where the farmers were placed within this segmentation. Kaine (2004) reported that a technology must be relevant and provide a benefit in each unique farm context or enterprise in order to be adopted. In addition, this work found the phase of the business provides valuable insight into winemaker and grapegrower motivation and ability to adopt. The combination of these concepts should yield a more accurate estimate of a potential market for a technology.

An extensive range of models has been published that seek to describe and predict people's adoption of technology. Rowbottom and Hill (2013) conducted a review of these models and assessed them against a number of criteria to determine their suitability for use in this project.

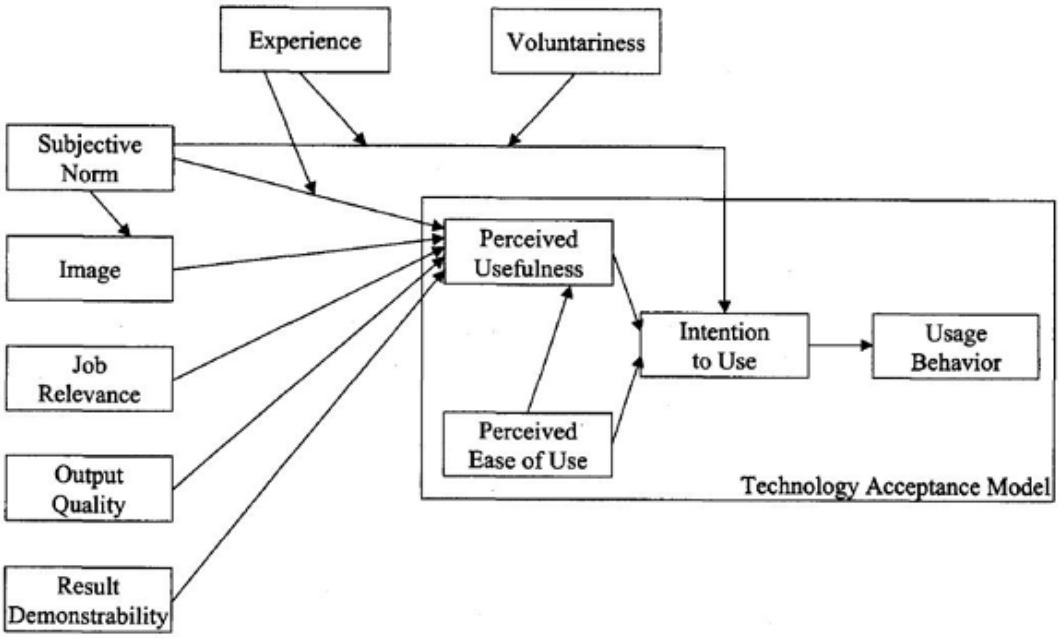
The criteria used were in selecting a model was that the model must:

1. Be amenable to phone survey techniques for data collection
2. Be simple enough to be tested using a practical sample size (ie: <1000 samples)
3. Include the majority of the key concepts considered to influence adoption (eg: social norms, etc.)
4. Have predictive power
5. Have been used successfully on agricultural and agribusiness technologies.

Of the models examined, the Technology Acceptance Model 2 (TAM2) (Venkatesh and Davis, 2000) was identified as the most suitable. The original TAM (Davis, 1993) proposes that a person will adopt a technology largely based on two key beliefs about the technology: its perceived usefulness, and its perceived ease of use. TAM2 (see Figure 1 below) proposes that these beliefs then influence people's intention to use the technology and in turn usage behaviour, while perceived usefulness is determined by a number of factors (variables) including job relevance and result demonstrability (Venkatesh and Davis, 2000).

As TAM2 has been previously used to study the adoption of technologies in agriculture (Adrian, 2005; Folorunso, 2008), it was deemed suitable for use in the wine and grape industry.

FIGURE 1: TECHNOLOGY ACCEPTANCE MODEL (TAM2)



Previous research has identified that when people actively seek information, they aim to reduce uncertainty and risk, or to "make sense" of something (Case, 2007a). When making a purchase decision, people often seek information to inform that decision; the more important or risky the purchase is to them the more information they seek, from more sources (Hill and Kaine, 2011). Therefore when considering a purchase of technology that is potentially risky, it is logical that grapegrowers and winemakers would seek information before making a decision. This study sought to develop some preliminary insights into the following questions:

1. Is the purchase decision-making similar to that used by other consumers considering high involvement (i.e. important and/or risky) purchases?

2. What does this mean for the design and delivery of extension strategies?

It has been proposed that people have an 'information source horizon' which describes "the ways information sources are mapped in preference order in an imaginary field" (Savolainen, 2008). In other words, this concept refers to all the places or sources an individual knows, and may use, to obtain information. An 'information pathway' then describes the sequence in which these sources are actually used when the person is seeking information (Savolainen, 2008). The sources are selected depending on where in the decision-making process the person is located and the perceived attributes of the source (eg: how trustworthy, how accessible, etc. - Barry and Schamber, 1998).

When interviewing grapegrowers and winemakers during this research, questions where asked to ascertain:

1. Where do they (grapegrowers and winemakers) get information to inform their purchase and adoption decisions?

2. What process do they use when deciding whether to purchase technology, equipment or products?

3. Where do corporate grapegrowers and winemakers seek information? Does this differ from non-corporate grapegrowers and winemakers?

2. Method

2.1 Research approach

This component of the project was conducted using a qualitative[1] research approach based on semi-structured interviewing to enable a rich understanding of the range of factors likely to influence adoption of R&D outputs and technologies and associated information-seeking behaviour.

Semi-structured interviews utilise a set of questions which can be asked in any order and may include adding extra questions to clarify a point or to explore an issue (Sarantakos, 1993). This technique is particularly useful for the exploration of perceptions and opinions because it allows the interviewee to respond to broad questions or statements with limited direction and provides opportunities for the interviewer to elicit further information if required (Sarantakos, 1993).

Interview questions were developed based on project team and collaborator experience, with questions being asked about several themes, including:

- The phase of the business (expansion, phasing down, etc.)
- Business contextual factors (i.e. size, product, competitive strategy, history, changes in the last five years)
- Drivers of adoption (taken from TAM2) – specifically: perceived usefulness of the case study technologies, their ease of use and benefits sought
- Interviewee's information-seeking behaviour (i.e. where did they seek information, why did they use those sources)

Each interviewee was interviewed face-to-face by two project team members. Each interview ranged from 60 to 90 minutes. Audio from each interview was recorded and later transcribed in full.

[1] Qualitative data is that which is observed or describes something - eg the process of making a decision. Quantitative data can be expressed as a number i.e. age, income, size of property.

2.2 Technologies discussed

A small number of 'case study' technologies[2,3] were used in the interviews as examples for discussion. The case study technologies were selected after consultation with stakeholders from AGWA and members of the project team (from DEPI and AWRI) and selected if they were:

- distinguishable from other technologies
- in the market for at least one year to enable industry time to adopt them
- relevant to much of industry (so a sizable sample of adopters could be studied)
- relatively new to the market so people could remember their adoption/purchase decision-making
- significantly different in cost and risk (complexity of decision).

For winemakers the case study technologies were:

- novel yeasts
- cross-flow filtration.

For grapegrowers the technologies selected were:

- soil moisture monitoring,
- new chemical (fungicide) sprays.

These technologies, and others raised by interviewees during the interviews, are described in Tables 2 and 3 (page 9 and 10).

2.3 Sample selection

Interviewees were recruited from ten wine regions across South Australia, Victoria, NSW, Western Australia and Tasmania. The wine regions covered included eight cool to temperate wine regions (mean January temperature <19-20.9°C), and two regions in warm (mean January temperature 21-22.9°C) and hot wine regions (mean January temperature >23° C)[4] . The extensive study area was chosen to provide a good representative sample of the wine industry across Australia including a cross-section of climatic types and a mix of grape and wine production methods.

Data was collected from grapegrowing and winemaking businesses representing a mixture of enterprise sizes and types (i.e. family and corporate – see Table 1 on page 8). The sample was selected using the extensive database of industry contacts held by the AWRI (Australian Wine Research Institute) and informal networks of Wine Grape Grapegrowers Australia (WGGA). Both organisations were involved in collecting data during the project. Regional associations in each target area were also contacted as a way of recruiting interviewees.

Potential interviewees identified were contacted personally by phone or email to confirm their interest in participating. Project background information was sent out to each interviewee in advance.

2.4 Data analysis and presentation

Interview transcripts were analysed in several ways including manual coding, sorting of data using an online qualitative data analysis program (Dedoose) and summarising and interpreting data in tables. To begin with, open coding was used to search for concepts in the data and then common and outlying themes were developed using a 'mind-mapping' process (Sarantakos, 1993). Some interviewee quotes have been included in the results section to illustrate the findings.

[2] Instead of "R&D output" the term "technology" was used to describe novel equipment or products, as this term was more familiar to the growers and winemakers interviewed.

[3] Knowledge-based R&D outputs (ie change of management or winemaking practice) were not explicitly studied in this project, although of course the adoption of a novel technology or product often involves some accumulation of knowledge and some change of practice.

[4] Definitions taken from Dry and Coombe (2005)

3. Results

3.1 Participant description

A total of 65 face-to-face interviews were conducted between January and August 2013. Data from three interviews was removed due to integrity issues with the data (interviews 6, 15 and 52). Of the 62 interviewees in the remaining data set, 31 interviewees were winemakers, 13 grapegrowers, 14 viticulturists (working for corporate or group owned vineyards in advisory roles) and four Research and Development (R&D) managers. The sample comprised a range of business types including family-owned (n = 43), small group or corporate owned (n = 9) and large corporate owned businesses (n = 10). Family or group-owned wineries comprised most of the sample in the Riverland, Goulburn Valley, Margaret River and Swan Valley wine regions. People from large corporate wine businesses were interviewed in the McLaren Vale and Barossa regions of South Australia, small and large corporate wine businesses in the Griffith region, and some small corporate businesses in the Tasmanian and Griffith samples (Table 1). The sample set was not designed to be a statistically representative sample, but indicative of the range of grapegrowing and winemaking businesses in the Australian wine industry.

TABLE 1 PARTICIPANT/BUSINESS DESCRIPTION

Wine Region	Sample size (interview #)	Sample description
McLaren Vale**, SA	5 (# 1 – 5)	Mixture of family and large corporate, mostly winemakers, winery tonnage range from 30 to 20,000 t.
Barossa**, SA	5 (# 7 – 11)	Mostly large corporate, mixture R&D managers, winemakers and viticulturist, winery tonnage range from 120 to 40,000 t.
Riverland ***, SA	9 (# 21 – 29)	All family-owned, mainly grapegrowers and one winemaker and viticulturist, vineyard area range from 18 to 1417 ha.
Yarra Valley*, Vic	7 (# 12 - 19)	Mixture of family and small corporates, mixture of winemakers and grapegrowers and viticulturists, winery tonnage range from 100 to 3,500 t.
Goulburn Valley and surrounds**, Vic	5 (# 30 – 33, 20)	All family-owned, three winemakers, one viticulturist, and one winemaker/grower. winery tonnage range from 20 to 1,800 t.
Mornington*, Vic	5 (# 34 – 38)	Mixture of family and large corporates, mixture winemakers and viticulturists, vineyard size range from 28 to 70 ha.
Riverina***, NSW	10 (# 39 – 48)	Mixture of all business structures, four winemakers, three grapegrowers, two viticulturists, one R&D manager, winery tonnage range from 200 to 175,000 t.
Margaret River*, WA	4 (# 49 – 53)	All family-owned, mixture grower and winemaker and viticulturist, winery tonnage range from 700 to 4,000 t.
Swan Valley***, WA	4 (# 54 – 57)	All family-owned, mostly winemakers, winery tonnage range from 10 to 7,000 t.
Tasmania*	8 (# 58 - 65)	Mixture of family-owned and small corporate, mostly winemakers and one viticulturist. Small wineries (from 3 to 5 t), one very small vineyard and one large vineyard (60 ha).
TOTAL	**62**	

* Cool- temperate climate, ** warm climate, *** hot climate

3.2 Technologies discussed

The interviewees were asked about a number of technologies, including the case study technologies, during each interview (see section 2.2). Not all the interviewees had experience with all technologies. Tables 2 and 3 summarise the technologies discussed by winemakers and grapegrowers respectively. Interviewed viticulturists and R&D managers provided comments on all technologies.

Table 2 shows that, in addition to the selected case study technologies (novel yeasts and cross-flow filtration), winemakers also discussed flotation, business technologies, alternative varieties and wine composition-testing equipment. The vineyard technologies most commonly discussed were: soil moisture monitoring, new chemical sprays, alternative varieties, precision viticulture and composting (Table 3).

TABLE 2 SUMMARY OF WINEMAKING TECHNOLOGIES DISCUSSED BY INTERVIEWEES

Technology	Description of technologies	Number of mentions
Novel yeasts	AWRI has been developing a range of novel yeasts which have been commercialised and available to industry. The project focussed on co-ferment yeasts to accentuate Sauvignon Blanc flavours.	22
Cross-flow filtration	A high-volume, automated, relatively expensive filtration system that pumps liquid along thin tubes with ceramic filters. Cross-flow does continuous rather than batch run filtration which is quick and efficient.	19
Wine flotation	A separating technique where gas is pumped through white grape must so that the solids (skins, seeds) float to the surface. Processing and fermentation becomes quicker and cheaper than using refrigerated settling of solids.	9
Business/service technologies	Changing a marketing strategy. For example choosing to focus on a higher value niche product.	9
Energy efficiency/energy audit	Changes made to reduce energy use and cost. Often involves an audit of current energy use and devising a way to use off-peak electricity, alternative energy source (solar), etc.	8
New/alternative varieties	Wine made using varieties that are novel to Australia, hence 'alternative' (e.g. Vermentino or Mencia).	7
Near infrared spectrometry	An instrument, used to test a range of juice and wine compositional characteristics such as alcohol, baume, pH, etc. (eg: OenoFoss spectrometer)	7
Automatic temperature control system	Refrigeration and temperature control systems on wine tanks used to better manage temperature during fermentation to influence wine quality and energy use.	4
Fruit sorting table	A large table with a mounted camera and laser sorter used to sort harvested grapes and reject imperfect berries and MOG (matter other than grapes). This aims to increase wine quality.	4
Others	Other technologies mentioned in interviews included: barrel cleaning, frozen bacteria, basket press, nitrogen technologies, bottling lines, crusher, screw caps, waste water system and oxygen analysis.	

TABLE 3 SUMMARY OF VINEYARD/VITICULTURAL TECHNOLOGIES DISCUSSED BY INTERVIEWEES

Technology	Description of technology	Number of mentions
Soil moisture monitoring	Sensors installed into the soil to monitor soil water content or soil matric tension to inform irrigation management. Several technologies exist including gypsum blocks, capacitance probes, tensiometers, etc.	18
New chemical sprays	Agrochemicals with the product names of Legend, Prodigy, Revus, Samurai, Vivando, Talendo, Custodia. These chemicals have been available in Australia for up to five years, are made by a range of companies and are used to manage vineyard diseases.	17
New/alternative grape varieties	Growing varieties of wine grapes (e.g. 'Mataro', 'Savagnin', 'Vermentino', 'Fiano', 'Negro amaro', 'Nero d'Avola', 'Vermentino', 'Mencia') grown in similar, or warmer climates in Europe, but new to Australia.	13
Precision viticulture	Information collected and used to inform management decisions including: plant cell density mapping, vigour mapping, yield mapping, EM 38 soil survey, use of GPS equipment/machinery, etc.	13
Compost/mulch	Use of organic materials to form a surface mulch or to incorporate into soil to increase organic matter of vineyard soils.	11
Pruning / canopy management	Manipulating vine growth through pruning and canopy manipulation to improve fruit quality by influencing vine vigour or managing fungal disease.	8
Machine harvesting	Newly released mechanical harvester (eg: Pellenc 'Selectiv') with ability to pick and sort grape berries resulting in less MOG	5
Apps (weather & irrigation)	Smartphone and tablet apps that provide information to assist in decision-making, often related to irrigation, weather, spraying, etc.	5
Others	Other technologies mentioned included: drip irrigation, improvements in spray equipment, cane pruning machines and tissue analysis.	

3.3 Business phase and the adoption of technology

The current phase of the business (e.g. expanding or contracting) was found to have a large bearing on the capacity and motivation of the owners and staff to adopt technology. The business phase for each interviewee is shown in Table 4. Five people who were contacted declined to be interviewed. These people were selling or contracting their business and said they were not interested in talking about technology at this stage.

TABLE 4. SUMMARY OF BUSINESS PHASE AS DESCRIBED BY INTERVIEWEES

Business phase	Interviewee #	Total number
Expanding	3, 8, 16, 17, 21, 24, 25, 28, 31, 34, 35, 36, 37, 40, 43, 53, 55, 56, 58, 60, 62	21
Expanding to a limited point	1, 2, 5, 14, 23,	5
Maintaining/ consolidating	4, 7, 10, 11, 19, 22, 26, 27, 29, 30, 38, 41, 42, 44, 46, 48, 49, 50, 51, 54, 57, 59, 63, 64	24
Contracting/ winding down	9, 12, 13, 18, 20, 32, 33, 39, 45, 47, 61, 65	12
Total		**62**

3.3.1 Expanding the business

Businesses in an expansion phase are likely to adopt new technologies to support their expansion

Of the total sample, 42% described their business as 'expanding' or 'expanding to a limited point'. These people were predominantly winemakers, with only four grapegrowers saying they were expanding their businesses. There were no significant patterns of expansion in particular regions – there were all types of business phases in each region. Those looking to expand included a mixture of family-owned, small corporate and large corporate businesses. It is important to note that 'expanding' can also mean rebuilding after an earlier consolidation phase. The businesses that were expanding were doing so in several ways including increasing their assets and infrastructure, expanding into new markets and/or increasing their capacity to do contract processing and bottling.

Below are two examples of quotes[5] which support these conclusions:

> *'We are expanding the winery as well so we've just purchased a new tank this year, which is being made at the moment. We have increased production quite a bit each year for the last few years, except for anomalies like 2011 and a little bit less in 2009 because of the smoke. We're putting in new vessels and new pumps and looking with a view to 12 to 24 months, actually buying another press as well' [#16].*

> *'We've put a new big winery in. We've bought a new press, we've bought one new tank and more barrels to go with it' [#17].*

3.3.2 Maintaining/consolidating or contracting/winding down the business

Businesses that are not expanding were restricted in their resources, including finances and labour, and hence less likely to adopt new technologies

Those businesses 'maintaining' or 'consolidating' comprised 39% of the sample. This portion of the sample included a mixture of winemakers, grapegrowers and viticulturists with a range of different business models. Again, there were no region-specific patterns.

19% of interviewees described their business as 'contracting' or 'winding down' but there were no trends regarding business model. Consolidation and contraction was occurring by reducing external labour,

[5] Quotes taken directly from interviews are italicized and followed by the number of the interview (for referencing) in brackets.

reducing costs where possible or increasing production efficiencies (eg: increasing production per hectare). Some interviewees were quite uncertain about their future.

Many of the winemakers and grapegrowers with businesses which were 'maintaining' or 'winding down' said they were not in the position to adopt technologies:

> *'We've had a few retirements (of staff) in the vineyard and haven't replaced them, so we've run down our vineyard resources to a degree so we really need to build those back up to be able to make use of any technology anyway' [#33].*

> *'It's mainly been just existing'…'really I should be replanting but I've just got no capital and my interest bill is pretty high at the moment' [#27].*

> *'That's the big driver at the moment, your return. You can't spend more money'*

> *'We are cutting down on staff numbers and just generally trying to reduce overheads where we can' [#39].*

A number of grapegrowers and winemakers were trialling more cost-effective ways of doing things, including managing with less labour resources:

> *'We are making things more efficient – we are still on flood irrigation improving the system and scaling down so that one person can look after it' [#42].*

> *'Technology for us in process …is aimed at shaving cents off getting from A to B without being deleterious to wine quality' [#8].*

In particular, many winemakers indicated their desire to reduce energy costs given their contribution to winemaking costs.

It was found that even the 'expanding' wineries would still need to give careful consideration to technologies and being cost-effective:

> *'When you're expanding you're trying to keep your eye on the ball with what's going on, but still try to keep these things with limited staff. Trying to really economise that way' [# 62].*

Summary:

- Motivation and capacity to adopt technology is influenced by whether a business is expanding, maintaining or contracting
- Businesses in a 'maintaining', 'consolidating' or 'winding down' phase may not have the resources or capacity to adopt technologies. In many cases, labour resources have been reduced resulting in decreased ability for the business to adopt technologies. On the other hand, the tougher economic conditions have required businesses to being more innovative and efficient to remain profitable.

3.4 Business context

The context, defined as interrelated conditions in which something exists or occurs, plays a large role in determining if a technology is considered useful and is likely to be adopted. Data collected during this project found that the most relevant aspects of context were location (region), especially important for vineyards, business size, competitive strategy and existing technologies.

3.4.1 Regional variations and individual differences

The physical and cultural suitability of a region for a particular technology is a strong driver of adoption

Individual differences between businesses also determine the perceived relevance of a technology and therefore the likelihood of it being adopted

Each region and site has different environmental conditions (eg: climate, soil, irrigation, etc.) which means that technologies may not perform equally, or even be relevant, to all vineyards in all regions.

> *''There's a disconnect sometimes between the research and what you actually can do. Because again, as it is always, it depends where you are and what soil type and structure and what - there are so many variables in viticulture. How do you actually apply what someone else has done to your own patch?' [#4]*

Technologies developed in one part of Australia may not be useable somewhere else.

> *'A few years ago, they [parent company] bought automatic wire lifters for all the vineyards in the company. They tested them in South Australia on vineyards that were flat and had good trellising and they worked quite well. They still use them to this day. But they've never worked here (in Western Australia, it is impossible to use them, because our vineyards are much older with different trellising systems' [#57].*

> *'You never really know that you're going to get the right equipment. I think it depends on the equipment and it depends on your vineyard, and everything is sort of different' [#14].*

3.4.2 Business size

Smaller businesses are less likely to adopt technologies due to:

- *Financial constraints*
- *No economies of scale*
- *Greater risk as there is less capacity to absorb the additional costs of failure*

Smaller businesses may adopt technologies in collaboration with other smaller operations.
Large businesses may find adoption of new technology less risky (compared with small business)

The interviewees included a wide spectrum of businesses from small vineyards and wineries to large corporate-owned vineyards and wineries.

The size of a business often determined which technologies were relevant and feasible to adopt. Smaller vineyards and wineries were found not to have sufficient access to physical or financial resources and could not capture the economies of scale required to make the adoption of some technologies feasible.

For example:

> *'$100,000 investment in cross-flow for a winery our size, yeah, that's a lot of filtration to pay it off' [#17].*

> *'I can't go and buy a two-row sprayer with the amount of country I've got. So if I need a two-row sprayer to make myself more efficient I probably need more vines' [#23].*

Some technologies, such as precision viticulture, were not seen as relevant in small vineyards for one reason or another, for example:

> *'I'm interested in the concept [of precision viticulture] but I'm not convinced that it's appropriate for this size of vineyard…I'd be struggling to justify doing differential anything in it including picking' [#38].*

Larger vineyards and wineries can capture economies of scale. Technologies such as precision viticulture were used to help manage properties once over a certain size:

> *'When you get up over 200 hundred [acres] on your own, you run into management problems. You just can't be over it to keep an eye on it. So that's where probably these tools come into their own to assist' [#42].*

It seems that it is less risky for larger businesses to try technologies because they have more capacity to absorb failures, whereas there is more risk being a smaller business:

> *'Yes it is a risk - anything you do, I think on this level, when we are so small and exposed is risky. I'm nervous every time I lay out a cent in business because we don't have the big corporate back-up that the big people have. We just don't have the funds' [#2]*

3.4.3 Competitive strategy

New technologies have to fit with the competitive strategy or advantage (wine style or price or grape specification) of the business

Competitive advantage depends on the value, or perceived value, that a business can create for its customers. A competitive strategy is the plan that determines how a business creates and sustains its competitive advantage. Technologies will be adopted if they can enhance or create a vineyard or winery's competitive advantage.

Generally speaking, there are two basic types of competitive advantage:

- a lower price
- differentiation on product characteristics that consumers perceive to be important (Porter, 1985). These factors may include variety, quality, region, wine style, winemaking practices, environmental accreditation or a mix of these and others.

According to the literature, a vineyard or winery following a differentiation strategy will also aim to reduce costs, or increase process efficiency in areas of their business *provided that it does not adversely affect customer perceptions in regard to their unique image and products* (Porter 1985). The results of the study supported this finding.

> *'We're always interested in new technology, but sometimes it doesn't necessarily fit within our style of production. It's not always about efficiency.' [#3].*

> *'If I didn't have to sell it under XXX label I would machine [harvest], but the decision we made for hand harvesting isn't about a quality issue but it's what we put on our label. The people who are paying $50 a Pinot, they're paying for the hand harvesting. […] we're not making the decision, our customers are'.[#64]*

This winemaker realised that his customers valued wine consistency, and was not going to use novel yeasts in case they compromised this feature:

> *'You're not going to have consistency throughout your processing [with a new yeast] and the customer likes that brand and today the customers are pretty cluey. They like consistency all the time' [#41].*

Other examples of desire for competitive advantage driving the adoption of technologies were around energy efficiency and waste reduction. One large corporate business had an entire team devoted to developing sustainability initiatives:

> *'This is going to give us an edge over our competitors so we're going to go with that and be true to that [waste water treatment]. Then we can put the credentials out' [#10]; and*

> *'The Chinese really like the whole environmental, clean and green image' [#53].*

3.4.4 Perceptions of innovation and risk by business owner or decision-maker

Previous experience, attitude towards risk, values and cultural factors influence adoption behaviour

Personality, personal goals and values, previous experience, acceptance of risk and confidence play a major role in an individual's capacity, desire or willingness to adopt technologies.

Some people are cautious about trying new things for a range of reasons:

> *'I'd known about it [an organic crop spray] for a couple of years. I looked into it and looked into it and eventually I got my head around what I was trying to do … I tried it out this year' [#32].*

> *'If I've made a decision to buy something, a piece of equipment and it doesn't work, I would feel a real goose. I don't think I'd lose my job over it, but I would have to justify why it hasn't worked. They (the employer) can turn around and say: well, you didn't do your bloody research properly' [#57].*

3.4.5 'Perceived behavioural control' of the business owner or decision-maker

In many businesses, a decision-maker has some constraints over which technologies they are able to purchase. This may be a business partner or bank for smaller businesses or a board of management for a larger business. This leads to the concept of 'perceived behavioural control' - how difficult the person perceives performing the behaviour will be (Järvelin and Wilson, 2003). This was the case in the wine industry with some grapegrowers and winemakers having to make a strong case for purchasing new technology:

> *'We put forward a case for pretty much any new thing we do whether it be fertiliser, fungicide, development, anything' [#44]; and*

> *'Everything has to be signed off by the Board. Someone has to do a cost-benefit analysis. So someone will write a report on it and say this is what we currently do, this is what we intend to do, these are our savings, these are our paybacks' [#47].*

Summary:

- Contextual factors influence adoption of technology. These include: region, site, size, competitive strategy and characteristics of the business decision-makers.
- Differences between decision-makers can significantly influence whether a business is likely to adopt new technologies. The concept of a person's 'likelihood to innovate' was important and resulted in modification of the TAM2 model to accommodate this.
- A grapegrower or winemaker may have to obtain permission from others before they can purchase a new technology. This may be perceived to be easy or difficult depending on the circumstances and is termed "perceived behavioural control' in the modified model.

3.5 TAM2 drivers of adoption

The TAM2 model proposes that an individual would adopt a technology largely based on these two key beliefs: perceived usefulness and perceived ease of use. However, a range of other variables also impact on adoption, including experience, subjective norms, image, output quality, result demonstrability, voluntariness and job relevance (refer to Figure 1). In this study, voluntariness and job relevance[6] were not deemed relevant and were excluded. The other variables are discussed in detail below.

3.5.1 Subjective norms

Subjective norms are important in the wine industry. Grapegrowers and winemakers seek and value the opinions of their colleagues, peers and neighbours.

Subjective norms (i.e. valued opinions from other people) have been found to be important in influencing farmers' intentions to change (Ajzen, 2002; Quester *et al.*, 2007b). This was found to be true in the wine industry. Industry networks were highly valued and the most frequently used source of information. Information shared between grapegrowers and winemakers was usually practical, trusted, independent, and often experience-based, which made the information very influential.

3.5.2 Experience

A grapegrower or winemaker's experience with a technology will influence its 'perceived usefulness' and their intention to use it. If it was a positive experience, this will shorten the search for external information to support their decision-making.

People's previous experience, whether positive or negative, provides them with information about the likely usefulness of a technology and hence influences their intention to use it (Konig, 2012). The knowledge gained from experience forms part of someone's 'internal information'. The amount of internal information someone has on a topic then influences the amount of 'external information' (eg: online, articles, books, other sources) that person will use to source more information (Quester *et al.*, 2007a). This is also the case in the wine industry.

> *Facilitator: 'When you were getting this system, did you have to think about it for a long time or look for information?' Interviewee: 'No, because I'd done a similar process when I was at [XX winery] in 99 and also in Mildura in 2000, only on a much larger scale. So I knew it existed. It was just finding whether there was the equipment for small batch processing, and of course there is, so we went for it' [#30].*

3.5.3 Image

Image was not found to be a strong motivating factor in adoption of technology for grapegrowers and winemakers.

Previous research suggests that being seen by others to be using certain technologies can give that producer a positive 'image' or reputation. In many other agricultural crops, this can act as a motivator to others (neighbours, peers, etc) to adopt the same technology. In the wine industry, the opposite was found to be true as 'quality' of the grapes or wine being produced was the key contributor to image.

[6] Job relevance was taken as a "given" because it was one of the criteria for selecting the case study technologies

3.5.4 Output quality

Improving product quality was found to be important to most grapegrowers and winemakers

For winemakers, improving the quality of wine was consistently raised as an important driver for adopting a new technology. Technologies that significantly improved output quality were very attractive for wineries aiming for a high quality product (as opposed to high volume). As an example, cross-flow filtration is a technology that many winemakers sought to adopt because of the clear benefits for output quality. This often flowed through to the vineyard:

> *'We will be reducing our tonnage throughput and aiming more at the premium sector rather than the commercial end of the market where we have been the last few years. I think it'll be a more focused approach because everything we do in the vineyard will be blowing all the way through the winery. So all those technologies like the sorting table and so forth is where we're heading anyway' [#31].*

3.5.5 Result demonstrability

When a technology or product was useful and easy to evaluate, it was more likely to be adopted and retained in the business.

When the usefulness of a technology is easily demonstrated and evaluated it makes it easier and quicker for the grapegrower or winemaker to assess the potential benefits, increasing the likelihood, and reducing the risk of adoption.

For example winemakers evaluating or using flotation reported:

> *'You can see how clear it is, just by looking at the juice. So we could see the clarity, we could taste that it was still good quality.' [#39]; and*

> *'We've actually seen quality increases because we are able to process quickly…we are getting more extraction' [#46].*

On the flip side, where the result is not demonstrated, technologies may be rejected:

> *'So at one stage we were using 50 million yeasts. Basically now we've gone back to a simple regime of using quite natural strains, three or four varieties and that's about it because we could not see a lot of difference in the results*'. [#53]

3.5.6 Additional dimensions of 'perceived usefulness'

In addition to the TAM2 variables related to perceived usefulness described above, a number of additional factors emerged through the interview data. As a result, the additional dimensions of perceived usefulness that were added to the quantitative survey were:

- increasing efficiency and productivity,
- creating or sustaining competitive advantage,
- improving workplace safety and
- generating knowledge.

3.5.6.1 Increasing efficiency and productivity

Saving money is a strong motivator for all businesses to adopt technology that creates process efficiencies or reduces input costs.

Some technologies provided clear gains in efficiency and productivity. Table 5 summarises several examples from our interviews.

TABLE 5. USEFULNESS OF TECHNOLOGIES REGARDING BUSINESS EFFICIENCIES AND PRODUCTIVITY

Technology	Usefulness: efficiency and productivity
Changing the pruning technique	'It used to take 690 hours to prune the vineyard. We're now down to 630-odd and we've improved quality from $1,600 a tonne in most cases to at least $2,500 to $8,000 a tonne' [#9].
Flotation	'We've seen improved juice recoveries of up to about 98 per cent, whereas we were recovering as low as 80 per cent …we can float the juice as soon as it comes out of the press and have it fermenting the same day' [#31]. 'It is cheap, cheap as chips for what it does (juice flotation). It makes a big difference to the economics and the labour and stuff, oh and the heating and cooling costs. The quality, the juice clarity seems to be very similar.' [#33]
Cross-flow filtration	'It works overnight, cleans itself and everything' [#31]. 'Yeah. I think it worked out it was about a two-year pay-off period, with all the savings in consumables and labour' [#39].
Grape press	'Those sort of investments [grape press] have made a big difference … that was one of the big benefits behind the press … it makes vintage a lot more efficient … it's quite manageable with just myself' [#17]. 'We've just invested in a new crusher last year to improve our efficiency and quality' [#2].
Precision viticulture	Advantage of enabling the grower to manage variability in the vineyard, and therefore obtain production efficiencies (e.g. #9).

Technologies that demonstrate clear benefits in a short timeframe are likely to be adopted more widely.

3.5.6.2 Useful in creating or sustaining competitive advantage and meeting market needs

As mentioned in section 3.4.3 (page 33), technologies that can help a company build or maintain a competitive advantage are likely to be adopted.

3.5.6.3 Improving workplace safety

Employee safety was a strong motivator for adopting new technology. These were driven by genuine concern to keep workers safe rather than merely complying with regulations.

During the interviews, employee safety was regularly mentioned as examples of recently purchased and incorporated technology and was apparent across small, medium and large wineries.

> *'Safety-wise, because we are a small business, it's just my husband and I, any investment is to improve safety so that we don't do our backs or hurt ourselves' [#2].*
>
> *'We've got a special plunging machine made to plunge our open fermenters because of the safety issues associated with people standing on tanks to plunge ferments' [#50]*
>
> *'We try not to use the Diatomaceous Earth filter for sensory and OH&S reasons. We do have a big extractor fan and stuff and the guys wear masks and things. You still - you don't feel that comfortable about doing it' [#5]*
>
> *'If something's safety then it's - we actually have a rating scale and if something gets graded very high for priority for safety, so we just do it.[#10]*

3.5.6.4 Generating knowledge

A technology may be adopted to generate knowledge to support managerial decision-making.

In some cases, a technology is adopted to provide information that supports decision-making and/or reduces risk. For example, installation of soil moisture monitoring informs when and how much to irrigate but the reliance on data may decrease as the grapegrower gets better at recognising trends, coupled with visual observation, weather forecasts, etc. When combined with other technologies such as aerial mapping (precision viticulture) to observe variation in a vineyard, local microclimate data (weather station) and other information, there may be a reduced reliance on any one technology over time. One grower saw soil moisture monitoring equipment as a useful learning tool and '*a good discipline to go out and read them'* but eventually you develop a *'pretty good feel for what to put on and when to put it on'*

3.5.7 Perceived ease of use

How easy a technology is to integrate into the business and use successfully has been identified as another driver of adoption (Davis, 1993). If a technology is difficult to use, requiring additional staff training or skill development, this reduces adoption. Further, if the technology is cumbersome to incorporate into business operations, adds additional cost to the business, either in money, time, effort or risk, this also reduces adoption. This was observed for grapegrowers and winemakers during the interviews.

'Ease of use' was found to include a number of variables, including:

- Impact on existing infrastructure and business systems
- Ease and cost of maintenance and support
- Level of new knowledge and skills required

These are discussed in detail below.

3.5.7.1 Impacts of technologies on existing infrastructure and business systems

Adoption of different technologies requires various levels of change to incorporate within existing business infrastructure and systems. Some technologies are easy to incorporate (eg: novel yeast, new agrochemicals) while others can be more difficult to incorporate (eg: cross-flow filtration) requiring major engineering or modification prior to installation:

> *'When installing cross flow filtration we had to select a location that was suitable, and consider the fixed lines, water, power and cleaning considerations' [#3].*

> *'It's more extensive [automatic temperature control]. It's a whole electrical system set up that needs a computer to manage it and then you need to get all the wiring and everything through it.' [#54].*

It was found that the anticipated costs of time, energy and money installing the technology and incorporating it into the business system were considered (and often formalised and communicated) prior to making the purchase decision:

> *'Someone has to do a cost: benefit analysis on it and write a report saying this is what we used to do, this is what we would like to do, these will be the savings, these will be the paybacks' [#47].*

3.5.7.2 Ease and cost of maintenance and support

Cost and ease of maintenance were found to influence purchase decisions. Availability of support and spare parts were also important

In the interviews, much of the discussion around 'ease of use' seemed to be focussed on on-going maintenance requirements, cleaning and access to follow-up support to use the technology. These aspects influenced the type and brand of technology being purchased.

For example when purchasing a wine press:

> *'Companies will sell you the machine and they'll say it's good and everything. But then you won't hear from them for years. That's the biggest problem … we've bought equipment and then suddenly you want a part and you can't get parts. The most important thing is that you need service, you need back up and you need parts' [#41].*

This winemaker spoke about selecting a device that measures compositional characteristics of wine and grapes:

> *'It's not so much the cost of owning the machine; it's the cost of maintaining it, calibrating it, and it would need a staff member to run it … having someone that's capable of tweaking it' [#30].*

On-going maintenance was also a consideration for grapegrowers. One grower highlighted the need to buy machines that fit with existing equipment so you have equipment with interchangeable parts where *'if one breaks down and you're not using the other one…just grab the part off it'*.

3.5.7.3 Level of new knowledge and skills required

New technologies are particularly attractive if people are not required to develop much new knowledge or skills

Technologies may be more likely to be adopted when an individual already has the experience, skills and knowledge from a previous workplace

Winemaking technologies (specific technical equipment) can be quite complex and several winemakers spoke about how they needed to 'understand the machine'. One winemaker said it had taken three years to fully understand a new bottling line and that they were *'still always learning about it'* [#14].

Another winemaker was deterred by the new knowledge and skills he would require to operate cross-flow filtration:

> *I hate the thought. I'm too old. [Have] you seen how many taps are on one of those units?' [#55]; and*
>
> *'It'll take me longer to get it here and work out how to use it than for me to filter it normally'. [#55].*

By contrast another winemaker identified one of the benefits of his new wine composition tester as the ability for any staff member to monitor the wine without having to have specific skills and knowledge:

> *'It is fantastic to have. The speed of the results, you save money obviously and you don't have to buy all the enzymatic kits and things which are quite expensive. It's consistent – you always get the same answer no matter what operator uses it' [#5].*

Summary

- 'Subjective' norms are important in influencing the adoption of technology in the wine industry
- 'Experience' influences information-seeking and perceptions of usefulness
- 'Image' was not found to be an important driver of adoption
- 'Output quality' and 'result demonstrability' were both found to contribute to perceived usefulness
- A number of additional dimensions of 'perceived usefulness' were identified such as increasing efficiency and productivity, sustaining competitive advantage, increasing workplace safety and generating knowledge
- 'Perceived ease of use' was also found to be an important consideration for growers and winemakers when considering the adoption of new technology
- There were a number of dimensions of 'perceived ease of use' such as the impact of the technology on existing infrastructure and business systems, the ease and cost of maintenance and support and the level of new knowledge and skills required

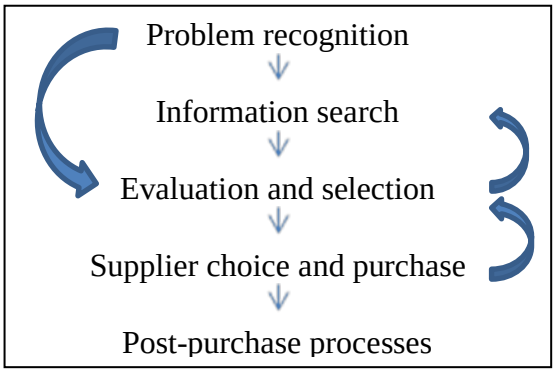
3.8 Information-seeking behaviour

The final major component of this qualitative research involved investigating the information-seeking behaviour of winemakers and grapegrowers. What was the process of selecting a new technology and what information did they seek, and why?

The marketing literature suggests there are a number of factors that influence the attitude and needs of the consumer (grapegrower or winemaker in this case). These include the consumer's culture, values, lifestyle, demographics, reference groups, personality, motives, perception and learning or memory (Quester *et al.*, 2007).

Information-seeking is crucial for making purchasing decisions and informs, or is informed by, a number of stages of the decision-making process (Quester *et al.*, 2007). The process of selecting a new technology or product is shown in Figure 2 (from Quester *et al.*, 2007, page 35).

FIGURE 2: CONSUMER PURCHASING PROCESS



During the interviews, grapegrowers and winemakers were asked about their decision-making processes, where they sought their information and what they looked for.

3.8.1 The process of selecting a new technology or product

The grapegrowers and winemakers became aware of new technologies through any number of sources of information including industry journals, seminars, their personal networks, suppliers and other sources. Once interested, they began an 'active' search for information which involved a number of stages, including:

Stage 1: Determining the options available

Stage 2: Identifying the key factors to be considered and features of the technology

Stage 3: Identifying the option they thought would best meet their needs.

The nature of the technology, availability of information, characteristics of the person and their previous experience influenced how long and complex this search was, and how many sources of information would be used. Below are examples of some purchasing decisions.

Example 1: A Yarra Valley winemaker who was seeking to buy a new wine press

'The first thing is to work out the general design of the press. You know, whether it is an open tank press or a closed tank press, and working out what is the majority of styles of wine that you're going to be putting through that press and what is going to suit. I got in contact with all the press suppliers that I know, and the brands that I know and got their information, but then used, you know word of mouth and spoke to a lot of people that have them, or have that press…, and got their impression on it, because you know people that sell presses have generally no idea how to run the bloody things or how to clean them' [#17].

In this case, the winemaker was undertaking Stage 1 by working out the design of the presses available, and Stage 2 by finding out which presses would suit which style of wine and which are easiest to run and maintain. The winemaker consulted a range of sources to obtain the different information he required.

Example 2: A McLaren Vale winemaker was looking for a good, fast, consistent way to measure alcohol during fermentation

He saw an OenoFoss unit demonstrated at a seminar in McLaren Vale and he describes his next steps below:

'I just really left it alone for quite a while. It was just one of those things that was stored away in the memory bank but I didn't do anything more about it. Then we were reasonably close to buying an alcolyzer which is about $25,000. All that does is measure alcohol but it's a pretty much industry standard piece of equipment.

Then I think I might have gone to a technical conference, and they also have that equipment display at the same time. I got speaking to the guys at the OenoFoss stand at that which re-sparked my interest. Then I started looking at it again a bit more seriously. It was a case of if we're going to spend $25,000 on something that measures alcohol, why don't we spend a bit more and get something that can do a lot more?

Interviewer: Did you talk to other wineries that had had them?

Yeah, I did basically the same as when we made our basket press purchase. I just got a list of names of locals, or people that had bought them and had been using them for a while in Australia. I just rang them up and spoke to whoever it was that used the piece of equipment and got their feedback and just took it from there. We bought one and I'm so happy that we did'**.**

In this example the winemaker was looking for something that could solve his problem: a need for a better way of measuring alcohol. To begin with, the winemaker had found two possible options, the Oenofoss and alcolyzer(stage 1). Over time he collected information on the features of both products from suppliers, spoke with other winemakers (stage 2) before making his decision (stage 3). This process occurred over two years.

Example 3: A grapegrower from Mornington Peninsula wanted to purchase a new spray unit

'Well, for me I started off with a single-row spray unit and quickly realised that it just wasn't going to do the job in the time that I needed for the area I had. So I spent a couple of years doing research on the Internet, grape-growing magazines and stuff like that. But finally I ended up buying the [Brand A] because a neighbour had bought one and I actually got to physically see it working, see the results and all the statistics on it. We use a lot less fuel with the [Brand A] than what we do with the [alternative brand] and all those kinds of thing were taken into consideration before buying one. But as I said, ultimately it was seeing my neighbour had bought one and it seemed like the right rig to use' [#38].

This example shows the outline and timeline of the grower's information search (stage 1 and 2), and how the decision on which unit to purchase (stage 3) was strongly influenced by the recommendation of his neighbour, and seeing the sprayer in action.

Example 4: A grapegrower/winemaker from Yarra Valley wanted to purchase a bottling line

'We've got a supplier who I trust and we've sort of got a relationship that goes both ways. So I knew, if I was going to buy the bottling line off him, I'd get good service and he would look after me on price and all that sort of stuff. So I didn't go out and talk to five different companies. I knew what we wanted, got a couple of quotes and just said, alright, go and do it [#14].

In this case, the staged process was cut short with the purchase being made from a trusted supplier.

Considering the examples above, the information search process played a part in each stage of the decision process, from problem recognition through to selection of product/supplier.

3.8.2. Where do grapegrowers and winemakers get information to inform their purchase decisions?

When interviewing people about their information-seeking process in regard to complex decisions, it became evident that information-seeking is a messy business. It is an iterative and often an opportunistic and/or intuitive process. Everyone has their own preferred information sources, ways of defining the issue and approach to gather the information they think they need to make a decision. Sometimes people have previous experience, while other times they know someone with experience. Often people will use the same source multiple times with slightly varying questions, all influenced by context and circumstances. Occasionally, fortuitous timing is important when an idea is heard or seen at the right time.

Despite this, the research identified some common themes; in general grapegrowers and winemakers will:

- Seek independent verification of information
- Seek region-specific information, particular in regard to viticulture decisions
- Use of a range of information sources
- Have a consistent set of source criteria

Each of these themes is discussed below.

3.8.2.1 Independent verification of information

One of the most commonly used sources of information was industry networks. These are a critical and widely used source of practical, trusted, independent information. Many grapegrowers and winemakers used their colleagues to provide them with opinions and information about technologies and suppliers they had experience with, and to discuss ideas with. This is another way of describing subjective norms as a key driver of adoption.

For example:

> *'It comes back down to independent endorsement. If I know of someone that's actually using a new piece of technology or a new bit of machinery or something like that, I will always give them a call or sound them out or go to them first. Or say hey, can I come and have a look at it in action, before I actually take the next step?' [#32]*

Independent information from other winemakers with experience of the technology can be a key piece of information in the decision-making process:

> *'We rang a few of the wineries that were using them and went out to talk to the winemakers and have a look at their (wine) presses. In the end we chose one, based on what we learnt in those visits' [#5]*

A winemaker in the Swan Valley was completing her first vintage at a winery and said:

> *'I have a friend of a friend who comes in two or three times a week, and we've been putting blends together. It's more a confidence thing for me to have a second person that I can bounce ideas off' [#56]*

3.8.2.2 Seeking out region-specific information

Knowing how a technology will perform in their region is very important, particularly to grapegrowers. As one grower said:

> *'Sometimes there is a disconnect between the research and what you actually can do in your own vineyard. The results you will get will depend on your site, soil type, varieties and there are so many variables in viticulture. How do you actually apply what someone else has done somewhere else to your own patch?' [#4]*

A winemaker said a similar thing about winery technologies:

> *'Sometimes application for technology can be quite specific, and it might be region by region. So I had a supplier sitting in front of me saying that I could get better colouring, a better colour extraction from my McLaren Vale Shiraz if I used the ultrasonic extraction, and I said to him, look my wines are black. I don't see how it can help…' [#3]*

In order to try to determine how a technology will perform in their region under their conditions the grapegrowers and winemakers talked to each other and, when possible, went to see the technology performing under similar conditions (for example soil types, trellis set up, wine style, wine varieties) to theirs.

> *'Ideally you'd talk to someone with similar cropping levels and canopy sizes, too, that have had experience in that particular machine. Because they'll tell you what their problems have been and what's good about it and what's bad' [#21].*

3.8.2.3 A range of types and sources of information are used

Previous research indicates that people actively seek information to reduce uncertainty and risk, or to 'make sense' of something (Case, 2007). When making a purchase decision, people often seek information to inform that decision. The more important or risky the purchase is to them the more information they seek, from more external sources (Hill and Kaine, 2011).

Beatty and Smith (1987) divided external information (information that is not memory based) into the following categories:

- printed media (newspapers, magazines),
- interpersonal (colleagues, friends, retailers),
- electronic media (Internet based),
- expert (paid or unpaid) and
- experiential (visits, demonstrations)

All of the grapegrowers and winemakers interviewed used external information at various times, depending on the information being sought. Experiential information through looking at the technology in action or trialling it if possible was considered vital to most people before purchase. As this winemaker in the Griffith region said *'we don't buy it unless we can trial it*' [#39].

When making a relatively simple decision (eg: purchase of a new yeast or new chemical spray), grapegrowers and winemakers used their experience and usually one or two external sources of information. When making a more complicated and potentially risky decision (eg: purchase of a cross-flow filtration system or planting an alternative variety), the information search was considerably longer, usually involving multiple types and sources of information.

Many grapegrowers and winemakers used the Internet, particularly when beginning a search for information.

> *'I will Google it first. I'd rather not ring somebody knowing absolutely nothing about what I'm asking about. I'd rather know a little bit about what I'm asking about first' [#58]*

> *'Yeah [I use the Internet], all the time. It's the fastest and easiest way to get an answer about something if you've googled it. Even if it's not the answer you need it'll usually give you an idea where to look' [#63].*

3.8.2.4 Application of source criteria to information sources

People use 'source criteria' combined with their previous experience when selecting sources of information (O'Keefe *et al.*, 2002). These are typically perceived characteristics of the source such as its availability and accessibly, credibility, how easy it is to understand and use and how unique it is (Barry and Schamber, 1998). This study identified some of these criteria for a range of information types, and found that (like most people) grapegrowers and winemakers value credible, trustworthy, independent, relevant information from knowledgeable, accessible sources.

3.8.3 Corporate information-seeking

Information-seeking and decision-making processes used within corporate wineries and vineyards varied from that of family or group-owned businesses, with much of their information being generated and exchanged within their group or corporate business, sometimes resulting in little if any reliance on Australian or regional research information.

Information was generally shared between vineyard teams, winemaking teams, technical specialists, viticulturists, regional viticulturists and often R&D managers, all with their own skills, knowledge, experience and personal information networks - forming a highly valuable body of collective knowledge.

> *'There's enough of us in our winemaking team that [between us] we've visited most of the countries that you can make wine at and we've all come back and shared stories' [#47].*

> *'Because we're so big and quite self-contained we almost have the community within our company as opposed to being a part of it [the wider community]' [#10]*

Several corporate winemakers spoke about the value of technical teams and committees:

> *'It is a committee and it's kind of time-intensive and everyone dreads it but it has been amazingly powerful…you don't get those people standing in the same vineyard at the same time. I think the positive out of it is the knowledge-sharing really rather than anything necessarily profound or ground-breaking' [#4]; and*

> *'There is a formal discussion group, which we hold once probably every six weeks or so. It's a teleconference and everything can be discussed from financials down to actual agronomic practices and that sort of thing' [#57].*

One large corporate business held a meeting of all their staff every few years to *'have a technical group meeting for a few days…bring samples from trials that we've done and talk about them'* [#7]. They also organise seminars for their staff with experts from within and without the organisations attending.

> *'We'll actually have a representative from the AWRI come in and talk to the group. Say, for example about Brettanomyces and what sort of strains are starting to rear their ugly heads. And our legal guys will then come in as well and talk about compliance internationally and all these sorts of things. Yeah, we're spoon-fed so to speak' [#60].*

One winemaker spoke about open information-sharing between all levels in his business:

> *'Open team management, everyone is responsible. Instead of pure hierarchical management from there down … everyone is empowered. The cellar hands come in and advise us what we should be doing as winemakers' [#8].*

Several of the corporate wineries interviewed had R&D managers and technical teams who had the specific job of identifying new technologies and distilling and interpreting information. For example, technologies in markets:

> *I'd like to have time to keep on top of everything that's coming out [new R&D ideas]. But that's not the reality. So we rely on the filter that the technical department provides in anything they see or either one: get involved or two: see if is worthwhile in having a conversation with us about getting involved' [#10].*

Corporate businesses can also play an important industry role as providers of information. One small winery (in adopting flotation) wanted to see the technology trialled by a bigger company in their local area before they tried it:

'Realistically for a place like us, we haven't got a lot of resources in research and development, we need to rely on some of the bigger companies taking up the technology. Because they'll try it and prove it so that we don't get caught' [#39].

Summary

- Growers and winemakers considering the adoption or purchase of technology use processes similar to other consumers - information-seeking is a crucial part of that process
- Growers and winemakers seek different types of information from a range of sources, particularly when a decision is 'complex', meaning important or risky.
- Independent verification of information is an important part of the information-seeking and decision-making processes, as is determining how a technology is likely to perform in a specific region. Most growers and winemakers have an extensive network of people they trust and use to obtain this information.
- Corporate vineyards or wineries often differ from family-owned ones in their information seeking as they usually have access to specialised R&D advice and considerable information from within their organisation, and consequently may rely less on Australian R&D information.

4.0 Discussion

The key findings from this study, their implications for the quantitative study and their potential implications for the provision of information, are discussed below.

4.1 The relationship between technology purchase and business phase.

This study found that expanding businesses had purchased more technology, and usually had access to more resources than those remaining the same size or contracting. Some of the businesses maintaining their size were interested in increasing productivity but did not have the resources to invest in expensive technology. Those winding down were in survival mode and were uncertain about the future.

The implications of this are that the phase of a business should provide a solid basis upon which to design market segments for the wine industry. Grower and winemaker profiles for each segment would further enhance understanding of their situations and needs.

Each segment should vary in regard to its capacity and motivation to adopt technologies. The 'expanding' winery and vineyard segment may have the need and resources to adopt more expensive, progressive technologies. The 'maintaining' segment may be interested in technologies that are inexpensive to adopt but that save money or increase production efficiency. The 'winding down' segment may require different services and support. Identifying and understanding these segments will assist in estimating the potential market size for a technology, and enable information offerings to be tailored to the market.

The implication of these findings for R&D and information providers is that a market segmentation based on business phase should enable market size to be predicted, and technological and information offerings to be targeted to where they will be most effective.

4.2 Key drivers of adoption of technology

The results of this study have shown that with modification and expansion the TAM2 model provides a relevant and useful framework to understand and potentially predict the adoption of technologies in the Australian wine industry. The TAM2 has been modified based on the findings from the study (see Figure 3 below). The model has been expanded to include the various dimensions of 'perceived usefulness', 'ease of use' and the concepts of the individual's 'innovativeness' and 'perceived behavioural control,' as these concepts were identified as being relevant. It does not contain the construct of 'image' as it was not supported by the data as being a driver of adoption of technology in the wine industry.

Figure 3 shows the modified TAM2 model, based on the results of this study. The constructs (a group of variables) are the ovals. The individual variables are represented by rectangles. The purple rectangles are from the original model, while the green rectangles represent the additions. The arrows show the relationship and direction of influence between the variables and constructs.

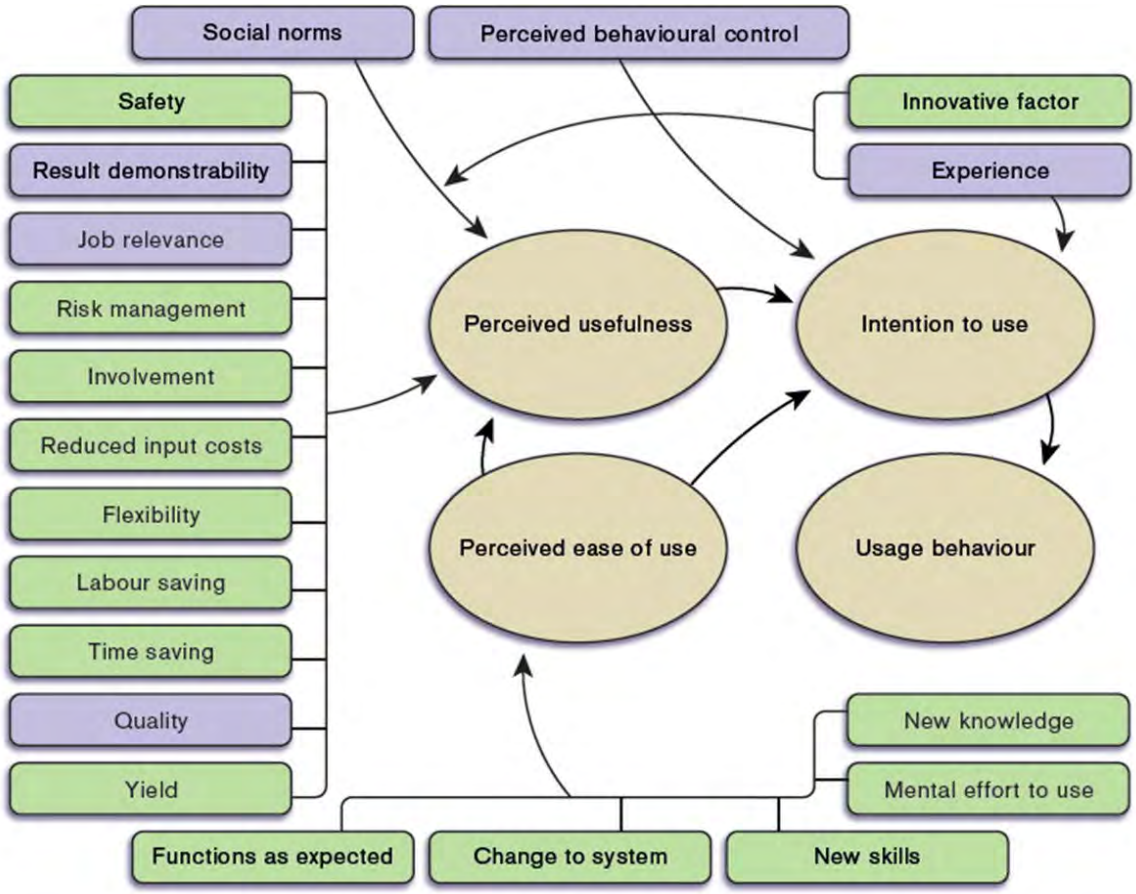


FIGURE 3: MODIFIED TAM2 MODEL INCORPORATING CONCEPTS IDENTIFIED IN THIS STUDY.

Perceived usefulness was considered to be very important by the grapegrowers and winemakers, who, in regard to important or potentially risky purchases, went to considerable effort in terms of information-seeking to ensure that the technology would in fact be useful to them and their individual business.

There does not seem to be any report of the TAM2 model being used in the wine industry before. This application of the model to a number of case study technologies has enabled the model to be refined into a robust, proven and useful tool for the future. The research has served to validate assumptions and provide detail in regard to the ways a technology can be perceived as useful in a modern, complex business environment.

This in turn enables the application of marketing literature to the adoption of technologies in the wine industry, as some of these dimensions of perceived usefulness and ease of use form the 'evaluation criteria'[7] grapegrowers and winemakers use when making a decision about a technology. There are well established methods for determining which evaluation criteria are most commonly used by people. These are then used to make information offerings most effective and relevant to the target audience.

[7] the product features or attributes associated by customers with either the benefits they desire or the costs they must incur – (Quester et al. 2010 p. 127),

The implications of these findings for R&D and information providers are that the TAM2 model should provide a useful basis for identifying and understanding why grapegrowers and winemakers will or will not adopt a technology, as well as helping to determine what information will be sought, valued and relevant to a particular target audience.

4.3 Information seeking

This study found that grapegrowers and winemakers generally seek a range of information (i.e. technical information, contextual information and opinions) from a range of sources (i.e. interpersonal, experiential) when evaluating technology and making decisions. Providers of information to industry need to understand where a particular source of information sits within people's "information horizon", (Savolainen, 2008). Grapegrowers and winemakers seek regionally relevant information, and when a decision is important they look for a range of types of information from a range of sources that meet a defined set of source criteria.

Two significant findings from this study with implications for the design of extension strategies were:

1. the strength of the wine industry network, and
2. the extent of use of the Internet as an information source.

The wine industry network is being used by most grapegrowers and winemakers to obtain, validate and process information relating to technologies. It is a key source of information, and related to the TAM2 variable of 'social norms' as a driver of adoption. This network also provides a unique source of experiential information to its members who frequently visit each other to view technology operating in a winery or vineyard. Experiential information is a key type of information in relation to risky decisions, such as those where aspects of the context strongly influences the potential benefits a technology will deliver.

Many grapegrowers and winemakers are using the Internet as an information source, and sometimes the starting point for their information search about technology. The implication of this is that availability online may be, or become, an increasingly important criterion for an information source in the wine industry. To become and remain a preferred provider of Internet-based information and services, there are then a number of information design guidelines and strategies to consider.

The study also found that grapegrowers and winemakers considering the purchase/adoption of technology followed a process similar to that of other consumers of seeking information in order to determine the options available and identify the key factors and features of the technology (ie. evaluation criteria); they then selected which technology would best meet their needs. The implication of this is that understanding this process may be useful when identifying and structuring information to best meet another important source criterion to grapegrowers and winemakers: 'relevance'.

The implication of these findings for R&D and information providers is that they should seek to identify and understand where they are positioned in the 'source horizon' and what are the 'source criteria' used by the grapegrowers and winemakers they seek to service. There are strategies available to increase the accessibility and value of an information source's usefulness to industry. It is also worth considering having industry technology "champions' – ie people that are influential in the industry to demonstrate new technologies and disseminate the relevant information.

5.0 Conclusion

In conclusion, on the basis of a large number of in-depth interviews conducted in a consistent manner, the following statements can be made:

- Using business phase as a basis of market segmentation should give an indication of who has been, and is going to be most likely to adopt technologies.
- Applying a modified TAM2 adoption model to the wine industry should provide robust information on the drivers of adoption for specific technologies.
- The wine industry relies on extensive internal networks, and grapegrowers and winemakers seek information from a range of sources to inform their decision-making.
- Understanding this process will be useful for providers of R&D and extension information in identifying and structuring information about new technologies to provide to industry.

These conclusions form the basis for the quantitative survey (conducted as part Bof this study), to validate and quantify the findings of part A. They also provide further information on 'The adoption of R&D outputs in the Australian wine industry: who what and why', and how to design extension strategies to better support adoption.

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Adoption of grape and wine R&D outputs: Who, what and why?

Part B: Quantitative survey



Australian Government
Australian Grape and Wine Authority

Department of Economic Development, Jobs, Transport & Resources
State Government Victoria

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Executive Summary

Part B of this report describes the quantitative research component - surveying grapegrowers and winemakers to collect information on demographics, business phase (whether their businesses were - and were likely to continue - expanding, staying steady or contracting), business scale and attitudes towards the case study technologies.

Using phone and online surveys, data was collected between August and December 2013, with 1066 valid responses collected from grapegrowers and winemakers. A range of statistical methods was used to analyse the data, including structural equation modelling, factor analysis and descriptive statistics to better understand:

- Who is adopting technology, and likely to adopt technology in future?
- What are the key drivers of adoption?
- What leads people to change from intending to adopt, to actually adopting?

Who is adopting technology?

Interview data (Hill *et al.* 2014) revealed that grapegrowers and winemakers with expanding vineyards or wineries were adopting technology and products to enable them to build or utilise opportunities. A range of technologies, including capital-intensive equipment such as cross-flow filtration and automated soil moisture monitoring were being purchased. In the survey, grapegrowers and winemakers were asked if their vineyard or winery operation had expanded, remained steady in scale, or contracted over the past five years (termed 'business outlook'), and what they thought would happen in the next five years. From the questionnaire data it was found that 16% of vineyard businesses and 31% of wineries had expanded in the last five years, with 13% of vineyards and 40% of wineries predicting that they would expand in the next five years.

The majority of people with 'expanding' businesses said that increasing productivity was very important and they would be able to expand their business further in future. A strong relationship between age, business outlook and attitudes to productivity was found, with a higher percentage of younger people (under 34 years old) likely to have expanding businesses and be confident of increasing productivity.

Grapegrowers and winemakers whose businesses had remained 'steady' in scale were also adopting technologies, however these technologies were less likely to be capital intensive, and had to be perceived as providing clear benefits in the short to medium term (Hill *et al.* 2014). This group represented the majority of the sample (71% of vineyards and 53% of wineries) and was consistent across most regions (excluding Tasmania), age groups and business scales. Views of respondents in the 'steady' group were evenly mixed between being 'confident' about increasing productivity, feeling 'frustrated' about their inability to achieve it or considering it 'unimportant'.

The 'contracting' group was identified as the smallest group from the survey. Respondents were mainly adopting low cost products or technologies, with short term benefits and avoiding any major expenses where possible (Hill *et al.* 2014). Located in all regions, higher numbers were found in WA and 'rest of NSW/ACT and Qld'. Many of these grapegrowers and winemakers were in the older age groups, working in smaller vineyards or wineries. More than 50% of the grapegrowers and 60% of the winemakers in this segment said that increasing productivity was 'unimportant' to them.

Drivers of adoption

The 'perceived usefulness' of a technology was the key driver of adoption by grapegrowers and winemakers for the case study technologies. The reasons why they were perceived as being useful varied for each technology. For example, the soil moisture monitoring systems were perceived as useful because adoption would reduce input costs, reduce risk and improve grape quality. For novel yeasts, use was able to maintain or improve wine quality, save time and, in some situations, it was considered risky not to use them.

Business scale was important for the adoption of soil moisture monitoring systems and cross-flow filtration with the larger businesses being more likely to adopt, primarily due to cost. This was not the case with new chemical sprays and novel yeasts.

Social norms – defined as the opinion of other people considered important or knowledgeable - were found to be a driver for all of the technologies considered. The contribution of other influences including decision control, ease of use, experience and innovative factor varied depending on the technology.

Intention to adopt

The key drivers that were found to move people from intending, to actual adoption, related to business scale, perceived usefulness, how easy people thought the technology would be to implement/use and social norms. A notable finding was that adopters of technology tended to have significantly more frequent contact with other grapegrowers or winemakers.

Suitability of the TAM2 model

The results of this study demonstrate that the technology acceptance model 2 is a useful tool for examining factors leading to intention to adopt a technology. The addition of business outlook, attitudes to productivity, business scale and grapegrower or winemaker 'connectedness' (to others) would strengthen the model's ability to predict actual adoption.

Research findings, methods and concepts described in this study can be effectively applied by research and/or extension providers to other existing and emerging grape and wine industry technologies and practices, to identify the scale and information needs of their target audience.

1. Introduction

1.1 Background

This report is part of the 'Adoption of R&D outputs in the wine industry who, what and why' project, funded by the Australian Grape and Wine Authority. This project investigated who was the target audience for research and development (R&D) outputs in the Australian wine industry, what outputs they were adopting and when. The project also explored the information seeking behaviour of grapegrowers and winemakers when making these decisions. This research has produced insights into what makes one R&D output more successful in the market than another, and how to target extension and communication efforts to be most effective.

The project had two main components:

- A qualitative research study to test the relevance of the Technology Acceptance Model (TAM2) adoption model for use in the wine industry and identify where grapegrowers and winemakers seek information when considering adoption of technologies (refer to Part A of the report).
- A quantitative phone-based questionnaire of over 1000 winemakers and grapegrowers to collect data and enable the project team to determine which concepts from the TAM2 model drove or influenced the adoption of four wine industry case study technologies.

This report presents the results of the quantitative research study component (part B).

1.2 Analysis framework

The objective of the survey was to identify and describe market segments that could be used to distinguish between adopters and non-adopters of technology in the wine industry and to test the usefulness of variables in the Technology Adoption Model (TAM2) in understanding adoption behaviour. The key variables examined were:

- **Business outlook and attitudes towards productivity.** This approach was used by Wilkinson *et al.* (2011) to divide Victorian farmers into market segments based on their business outlook (e.g. expanding, steady or contracting) and the farmers' aspirations for their farm's future productivity. Wilkinson *et al.* (2011) suggested that a business owner's outlook for their business and productivity aspirations describes the owners' motivation and available resources and hence, their likelihood to adopt new technologies.
- **Vineyard scale or winery production and region**. Kaine (2004) suggested that grapegrowers adopt a technology based on their *farm context* which is the combination of biophysical, financial and human resources available to the farm. Vineyard area or winery annual production and wine region were explored as some of the key physical elements of farm context.
- **TAM2 concepts.** The key elements of the TAM2 (Venkatesh and Davis, 2000) were used in this study (see Figure 1 below).

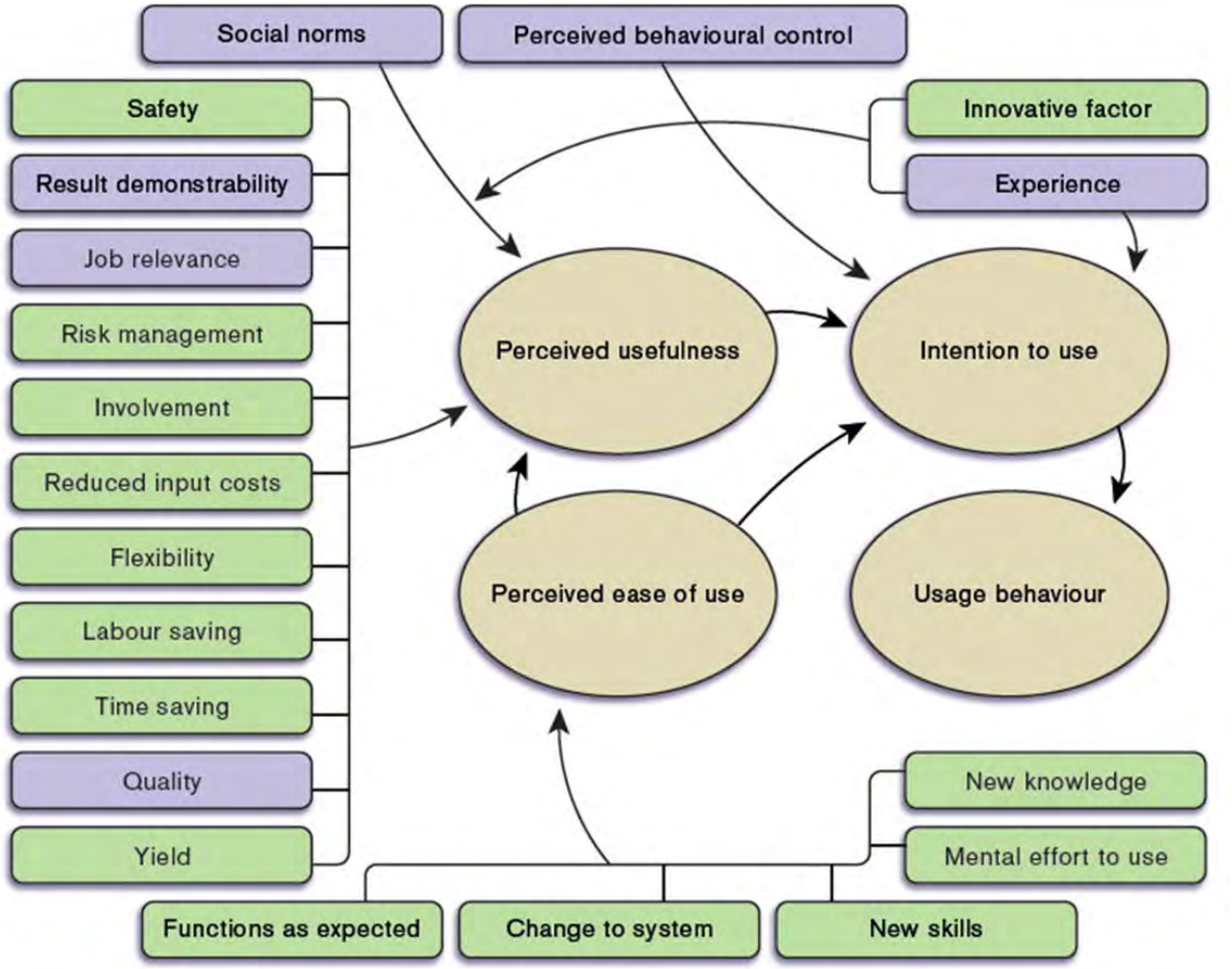


FIGURE 1: MODIFIED TAM2 MODEL USED IN THIS STUDY (FROM VENKATESH AND DAVIS 2000).

These key concepts are defined by Venkatesh and Davis (2000) as:

- **Perceived usefulness**
  The degree to which a grapegrower or winemaker believes that using the system or technology will help achieve gains in job performance.
- **Perceived ease of use**
  The degree of ease the grapegrower or winemaker associated with use of the system or technology.
- **Social norms**
  The degree to which a grapegrower or winemaker perceives that other important people, such as family, respected advisers or colleagues, believe that he/she should use the new system or technology.
- **Intention to use**
  The degree to which the grapegrower or winemaker has formulated conscious plans to use the system or technology
- **Adoption**
  Whether the technology has been purchased and is being used.

For a full description of how the model was tested and modified for use in the Australian wine industry refer to Part A (qualitative analysis) of this report (Hill *et al.*, 2014).

The relationship between the TAM2 drivers and the questionnaire questions is shown in Appendix 3.

Data on other factors such as age, gender and education level were also collected and tested, despite conflicting findings in previous research on the importance of these variables (Babutsidze, 2012, Beatty and Smith, 1987).

2. Method

2.1 Overview

Grapegrowers and winemakers were surveyed by phone or online and asked questions about their vineyard and/or winery business and their experience with one of the case study technologies. Data on grapegrower and winemaker information-seeking behaviour in regard to the case study technologies was also collected. This information is presented in part C of this report.

An independent contractor was engaged to conduct the surveys. Potential respondents were identified from a purchased contact database and contacted by phone to determine their suitability for the study. To qualify as a respondent, the person had to play a decision-making role in purchase or adoption of technology in the vineyard or winery. 5253 people were contacted initially, with 1066 ultimately participating in the survey.

Respondents were asked for the Geographical Indication (GI) that their winery or vineyard was located in. There are over 60 GI regions registered in Australia, so regions were combined into the following zones based on geographical location and climatic similarity:

- 'WARM INLAND' - Riverina, Swan Hill (NSW and Vic), Murray Darling (NSW and Vic), Riverland (SA)
- 'REST OF NSW/ACT/QLD'- all regions in NSW except those in the warm inland group, plus all of ACT and Queensland
- 'REST OF VICTORIA' - all regions in Victoria except those in the warm inland group-
- 'TASMANIA' - all regions in Tasmania
- 'REST OF SA' - all regions in SA except for the Riverland
- 'WESTERN AUSTRALIA' - all regions in WA

For a comprehensive list of GI regions in each state, visit:
www.wineaustralia.com/en/Production%20and%20Exporting/Register%20of%20Protected%20GIs%20and%20Other%20Terms/Geographical%20Indications.aspx

2.2 Questionnaire design

The questionnaire was drafted, tested and timed by the project team and then trialled and adjusted after testing with people involved in the wine industry. The questionnaire was modified so that it would not take more than 20 minutes to complete by phone or online.

The questionnaire consisted of demographic information and questions about:

- Attitudes to productivity
- The adoption of the case study technologies, based on the TAM2 model
- Information-seeking behaviour in regard to adoption of technologies
- General information-seeking behaviour.

The attitude to productivity variable is the sum of the following items:

- How important is it to you personally to increase the productivity of the vineyard/winery (scale from 1 'not at all important' to 5 'very important')?
- How likely is it that you will be able to increase the productivity of the vineyard/winery (scale from 1 'not at all likely' to 5 'highly likely')?

The list of questionnaire questions relevant to the TAM2 model can be found at Appendix 3

2.3 Selection of case study technologies

The case study technologies selected had to meet the following criteria:

- Be discrete from other technologies
- Be relevant to a sufficient proportion of vineyards and wineries to obtain a large enough sample scale of adopters
- Have been in the market for at least one year to allow sufficient time for adoption, but not more than five years, to ensure respondents could recall their decision process regarding adoption of the technology
- Represent one low and one high involvement technology each for vineyard and winery

Based on these criteria, the following technologies were chosen from a shortlist compiled by the project team in consultation with industry:

	Vineyard	**Winery**
High involvement	Soil moisture monitoring	Cross-flow filtration
Low involvement	New chemical sprays	Novel yeasts

See Appendix 2 for more details on each technology.

The term 'involvement' relates to how important a product or purchase decision is to a grapegrower or winemaker. Involvement can be described in terms of a level or intensity. Decisions or products perceived as potentially risky, for example the purchase of new, expensive equipment, usually entail higher levels of involvement than a routine, inexpensive purchase (Assael 1998).

When making decisions about products or technologies that are new, complex and important or risky to them, a grapegrower or winemaker is likely to use complex decision making, a cognitive process which entails expending energy on thought and information seeking. As risk is reduced with increased product experience and knowledge, the grapegrower or winemaker will seek and process a range of information before making a decision (Beatty and Smith 1987).

Low involvement products or technologies are routinely purchased and low risk to the grapegrower or winemaker. Such products are usually inexpensive everyday purchases, and the grapegrower or winemaker will minimise the time and effort devoted to the purchase decision, seeking little if any information when making their purchase decision (Assael 1998).

When considering the case study technologies, the adoption of soil moisture monitoring systems and cross-flow filtration would generally be considered high involvement due to their financial cost, opportunity cost and the need to integrate these technologies into the business system. New chemical sprays and novel yeasts are cheaper to purchase, less complex to adopt and can be more easily changed if found to be unsatisfactory, making the decision to adopt them a lower involvement decision.

2.4 Data analysis

The basic data analysis and segmentation was done by the research team using SPSS statistical software (IBM, 2013). Structural Equation Modelling (SEM) was used to predict the drivers of intention and adoption, using the variables in the TAM2 model. This work was done by an independent service provider, Insightrix Research Pty Ltd.

In this report, the majority of the results are reported using graphs because they present findings in the simplest and clearest way. Statistical significance of graphed variables has not generally been stated but it can be assumed that almost any pattern that can be discerned visually in a graph will be statistically significance because of the large sample scale.

Statistical significance is reported for the modelling of influences on intention and adoption. For the Structural Equation Modelling, the coefficient, t value and significance of the t value are reported. Coefficients represent the relative measure of the influence of the independent variable on the dependent variable (or just of one variable on another). Coefficients are standardised to vary between 0 and 1 where a number closer to 1 indicates a stronger relationship. A negative coefficient represents an inverse relationship. The t value approximates Student's t statistic. A value over 2 indicates a 95% confidence level. T value is calculated using a bootstrapping method which is a method of sampling and resampling to optimise the accuracy of results. The p value, or statistical significance, is calculated from the t statistic assuming infinite degrees of freedom. See Hair *et al.* (2010) for a full description of these tests and their interpretation.

3. Results

3.1 Response rate

A total of 1066 complete responses was obtained from winemakers and grapegrowers (262 online, 844 by phone). The number of completed questionnaires varied widely between states (see Table 1).

	WA	SA	Tas	Vic	ACT	NSW	Qld	Total
Total valid contacts	567	1630	124	1443	16	1277	196	5253
Completed questionnaires	126	376	38	296	6	188	36	1066
Total response rate (%)	22%	23%	31%	21%	38%	15%	19%	20%

TABLE 1: RESPONSE RATE FOR EACH AUSTRALIAN STATE SURVEYED.

The respondents were either owners and/or managers of one of the following business types:

- vineyards (44%),
- vineyard and winery (39%) or
- winery only (17%).

Eighty two percent (82%) of respondents were male and fifty-seven percent (57%) of the total respondents had tertiary qualifications.

3.2 Representativeness of sample

Businesses have been grouped into scale categories for easier reporting. The scale categories chosen were those used in other wine industry reports, which enabled comparisons to be made between the sample and population data to determine whether the sample obtained in this study was representative of the wider population of vineyards and wineries in terms of business scale and geographic location. Number and scale of survey respondent businesses were compared to ABS data (ABS 2012) to determine how representative the sample was of industry.

Figure 2 shows the distribution by state for vineyards and wineries in the sample and population data. It can be seen that South Australia and New South Wales were slightly under-represented in both vineyards and wineries, while Victoria was over-represented.

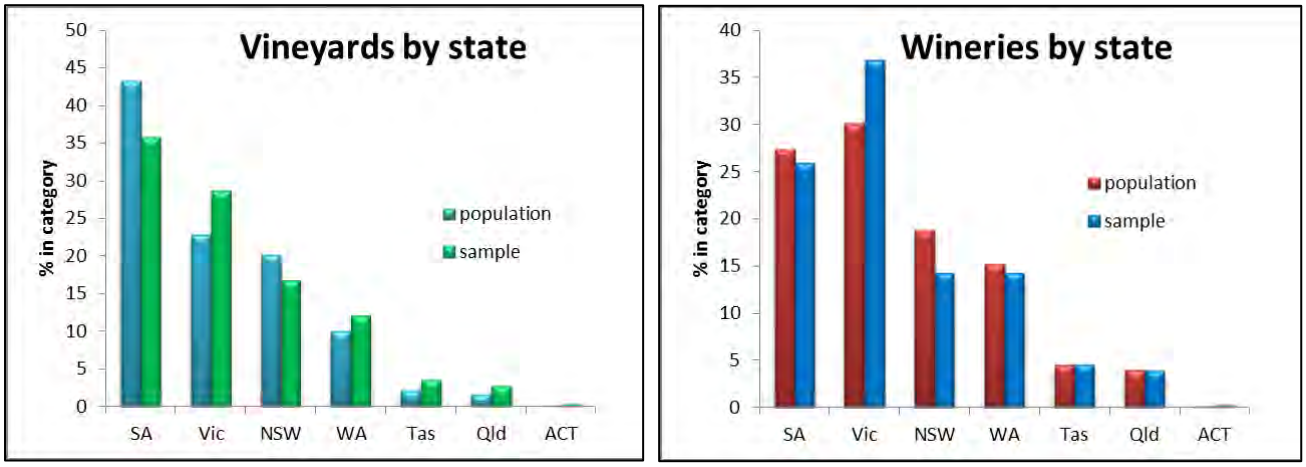


FIGURE 2: INDUSTRY AND SAMPLE DATA FOR VINEYARDS AND WINERIES BY STATE

Figure 3 shows the distribution by business scale for vineyards and wineries in the sample and population data. Vineyards and wineries in the smallest scale category were under-represented, while businesses in the largest scale category were over-represented.

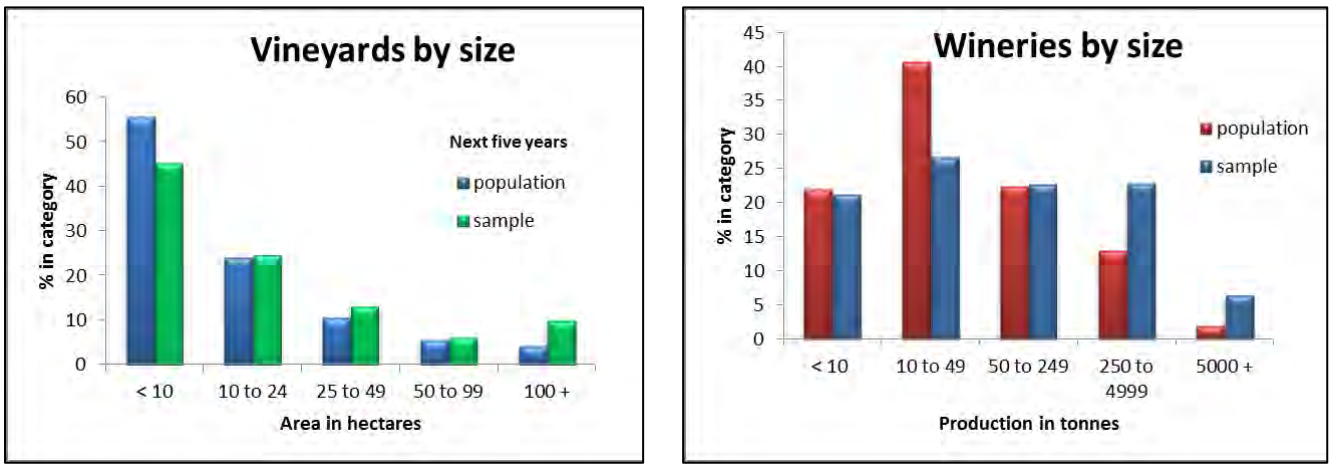


FIGURE 3: INDUSTRY AND SAMPLE DATA SHOWN BY VINEYARD AND WINERY SCALE

Overall these variations were not substantial, and the sample is considered to provide adequate representation of the population of grapegrowers and winemakers and a good spread of businesses from all States and business scales.

3.3 Drivers of adoption

3.3.1 Business outlook

The business outlook of respondents was defined as whether they reported that their businesses had expanded, contracted or remained the same scale over the past five years, and whether the owners planned to expand, contract or stay the same over the next five years (as per the classifications used by Wilkinson *et al.*, 2011).

A summary of the responses is shown in table 2 below.

	VINEYARDS			WINERIES		
Business outlook	Contracting	Steady	Expanding	Contracting	Steady	Expanding
Last five years	13%	71%	16%	16%	53%	31%
Next five years	9%	78%	13%	9%	51%	40%

TABLE 2: BUSINESS OUTLOOK FOR VINEYARD AND WINERY BUSINESSES

When considering both the previous and the next five years, a substantially higher proportion of winemakers had an expansion-oriented business outlook than grapegrowers.

There was a strong association between previous business changes and future intentions relating to the business. Past expansion was a strong indicator of future expansion, and past contraction a strong indicator of future contraction (see figures 4 and 5 below). This relationship was stronger for wineries than for vineyards.

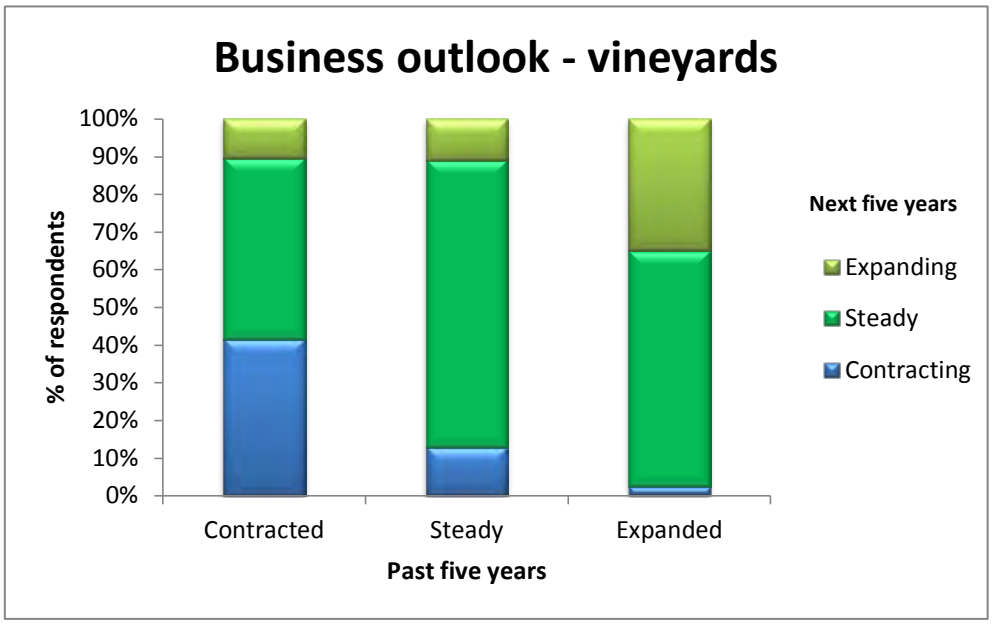


FIGURE 4: VINEYARD BUSINESS OUTLOOK FOR THE PREVIOUS FIVE AND NEXT FIVE YEARS.

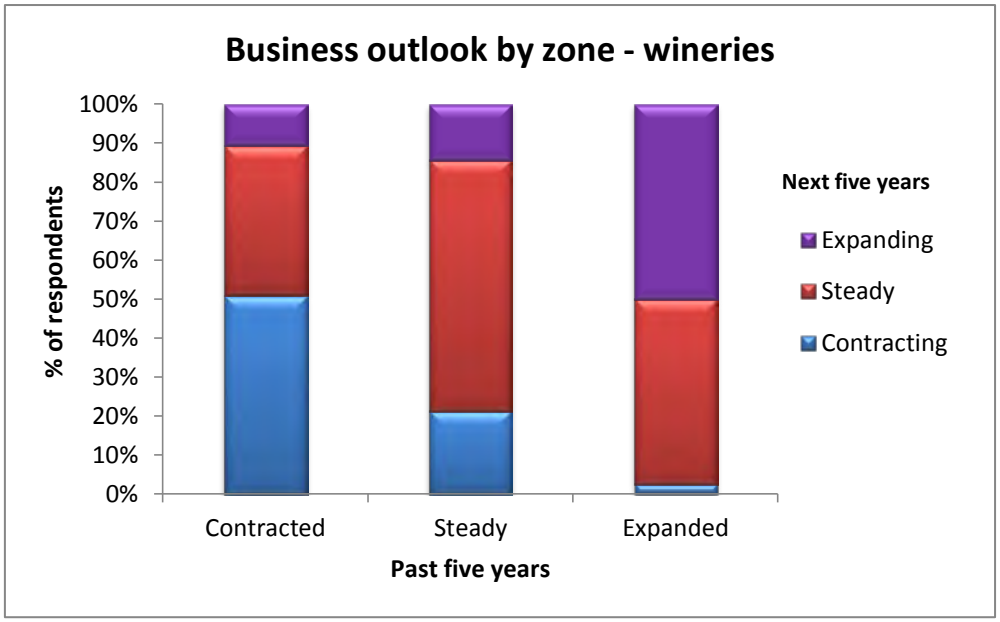


FIGURE 5: WINERY BUSINESS OUTLOOK FOR THE PREVIOUS FIVE AND NEXT FIVE YEARS.

3.3.1.1 Business outlook by geographical location

Business outlook was found to vary based on geographical location. Respondents from Tasmania had a relatively small number of vineyards, but a high proportion of them intended to expand in the next five years. Western Australia had the lowest proportion of vineyard owners planning to expand. This difference was more pronounced for wineries. A higher proportion of Tasmanian winemakers than average (though small in number) were expansion-oriented, while a large percentage of winemakers in Western Australia and the combined 'rest of NSW/ACT/Qld' were anticipating contraction in their winery business (figures 6 and 7).

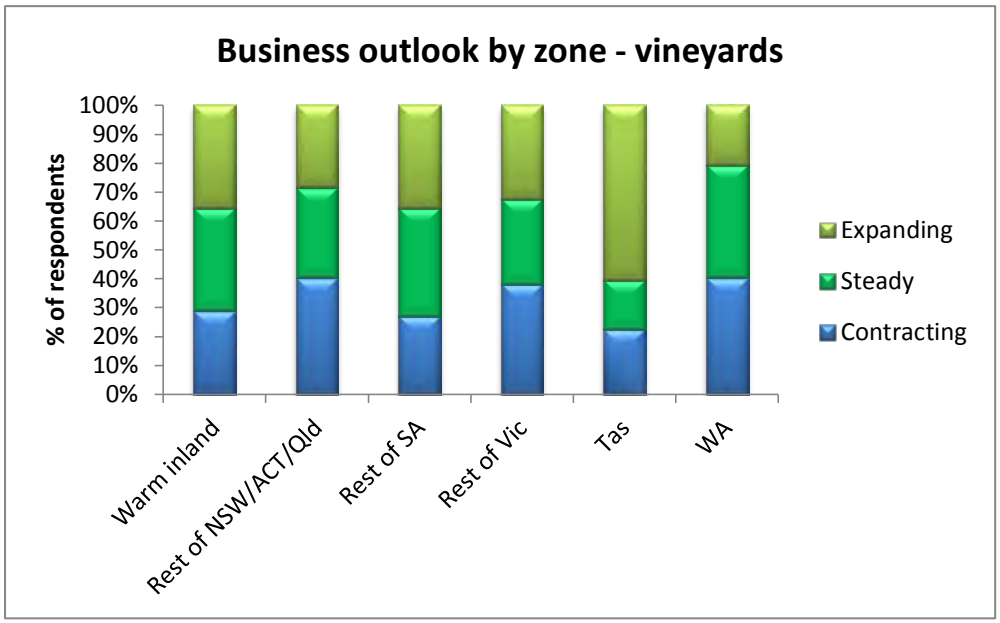


FIGURE 6: VINEYARD BUSINESS OUTLOOK FOR THE NEXT 5 YEARS, BY GEOGRAPHICAL LOCATION.

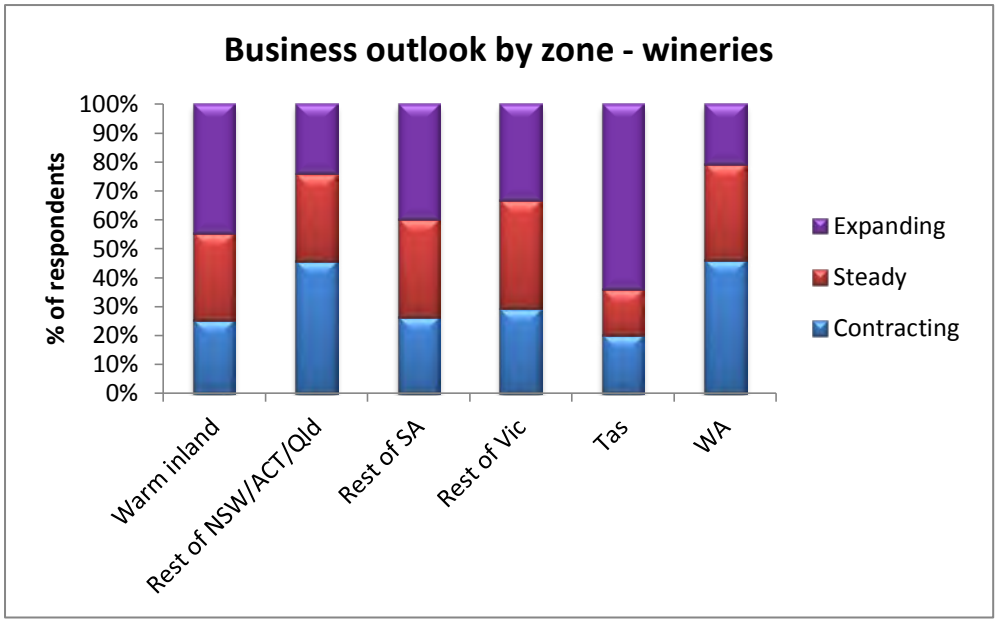


FIGURE 7: WINERY BUSINESS OUTLOOK FOR NEXT 5 YEARS BY GEOGRAPHICAL LOCATION

3.3.1.2 Business outlook by age group

The age of the business owner influenced their future intentions regarding expansion or contraction of the business. For both vineyard and winery businesses, the youngest age group had the largest proportion of respondents intending to expand in the next five years, while the oldest age group had the highest proportion intending to contract (figure 8 and 9). This relationship was much stronger for winemakers than for grapegrowers.

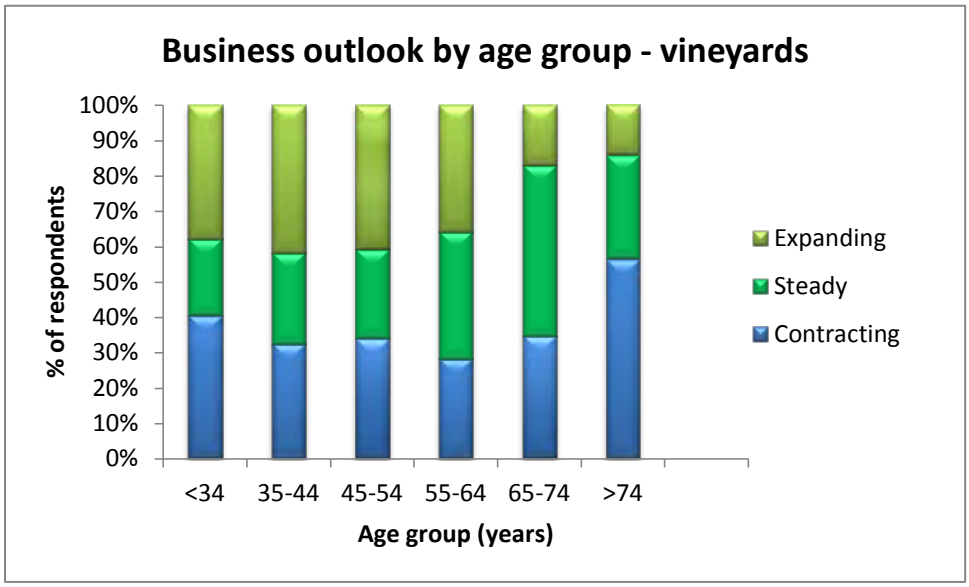


FIGURE 8: VINEYARD BUSINESS OUTLOOK FOR NEXT 5 YEARS BY AGE GROUP

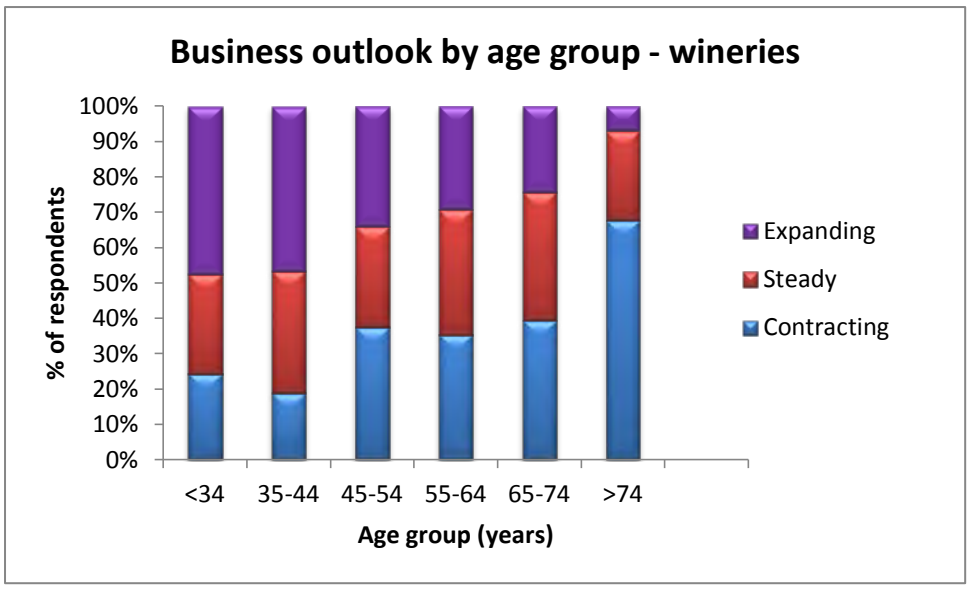


FIGURE 9 WINERY BUSINESS OUTLOOK FOR THE NEXT 5 YEARS BY AGE GROUP

3.3.1.3 Business outlook by business scale

The relationship between the scale of a vineyard and its five-year outlook was not linear. The group with the highest proportion of grapegrowers focussed on expansion was the 50 – 99 ha group, while owners of smaller vineyards and larger vineyards were fairly evenly split between expansion, contraction and remaining steady (Figure 10).

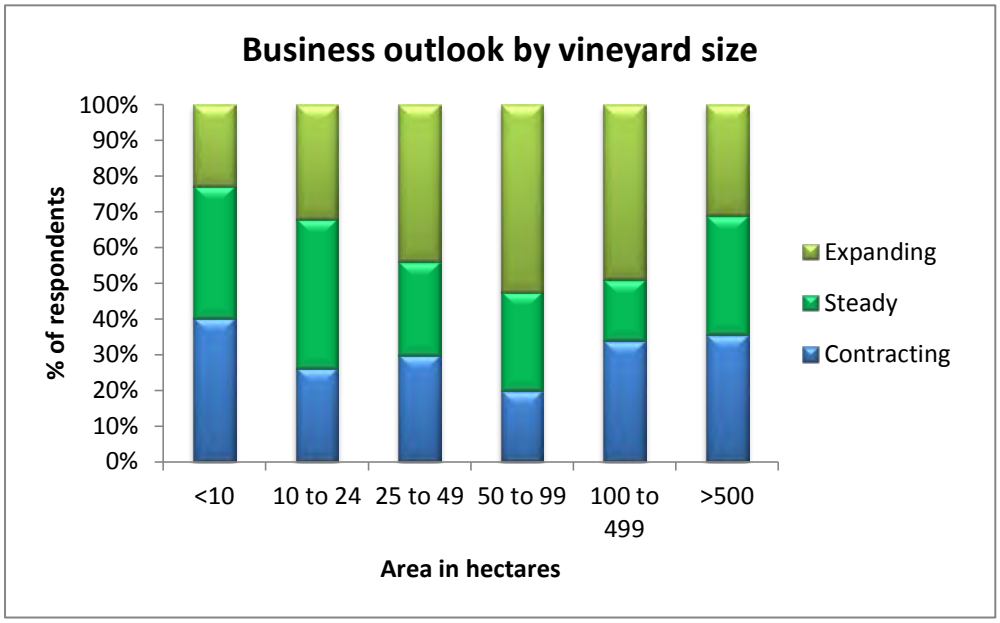


FIGURE 10: VINEYARD BUSINESS OUTLOOK FOR THE NEXT 5 YEARS BY VINEYARD SCALE.

The relationship between business outlook for wineries and scale of production was also not linear. In this case the largest scale group as well as the middle scale group had the highest proportion of expansion-oriented businesses (figure 11).

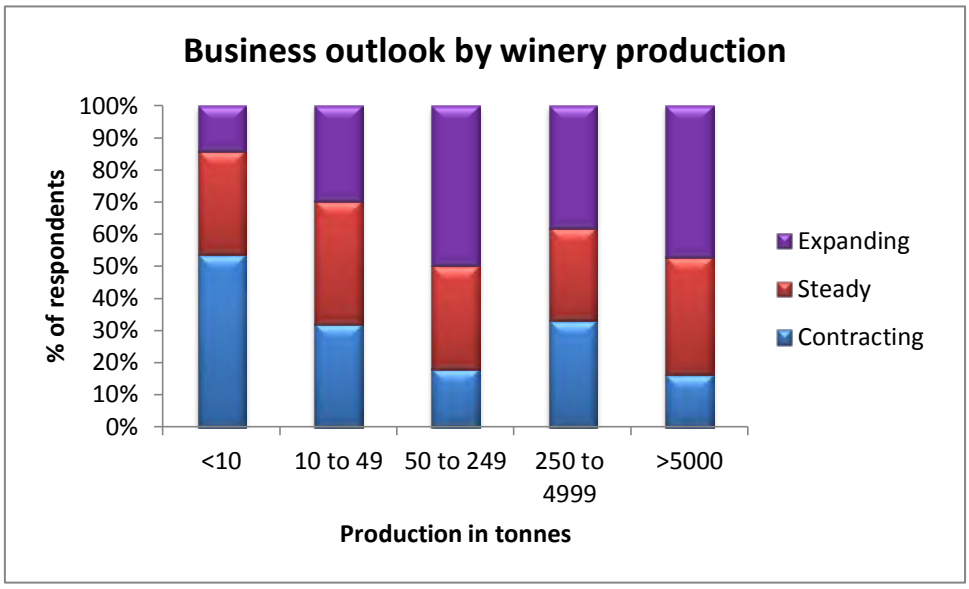


FIGURE 11:WINERY BUSINESS OUTLOOK FOR THE NEXT 5 YEARS BY WINERY SCALE (BASED ON TONNES CRUSHED).

3.3.2 Attitudes to productivity

Respondent attitudes to productivity were also considered in the questionnaire. They were measured as a combination of:

- How **important** it was to the respondent to increase productivity; and
- How **likely** they thought it was that they would achieve an increase in productivity.

In the questionnaire, productivity for vineyards was defined as 'increasing volume or quality of grapes produced per hectare and/or increasing efficiency, reducing inputs or changing varietal mix'. For wineries it was defined as 'increasing volume or quality of wine produced and/or increasing process efficiency or reducing inputs'.

Based on their responses, respondents were classified into three categories:

- **CONFIDENT**
  Grapegrowers and winemakers who thought increasing productivity was important AND expected to be able to achieve it.
- **FRUSTRATED**
  Grapegrowers and winemakers who, despite thinking increasing productivity was important, did not expect to achieve it.
- **UNIMPORTANT**
  Grapegrowers and winemakers for whom productivity growth was unimportant. In almost all cases, these grapegrowers and winemaker respondents also said they were extremely unlikely to achieve productivity increases – therefore these respondents have been grouped together, regardless of their response to the question about 'likelihood' of achieving an increase in productivity.

The proportion of respondents in each category is shown in table 3 below.

	VINEYARDS			WINERIES		
Attitude to productivity	Confident	Frustrated	Unimportant	Confident	Frustrated	Unimportant
% of respondents	32.8	33	34.2	40.3	24.9	34.8
Number of respondents*	320	322	335	176	109	152

TABLE 3: BUSINESS OUTLOOK FOR RESPONDENTS FROM VINEYARD AND WINERY BUSINESSES[1]

3.3.2.1 Attitude to productivity and business outlook

For grapegrowers, a 'confident' attitude towards productivity increases was strongly associated with an expansion-oriented business outlook, with more than half the grapegrowers in the 'expanding' market segment being confident of increasing productivity. More than half of the grapegrowers in the 'contracting' market segment were in the 'unimportant' group (figure 12).

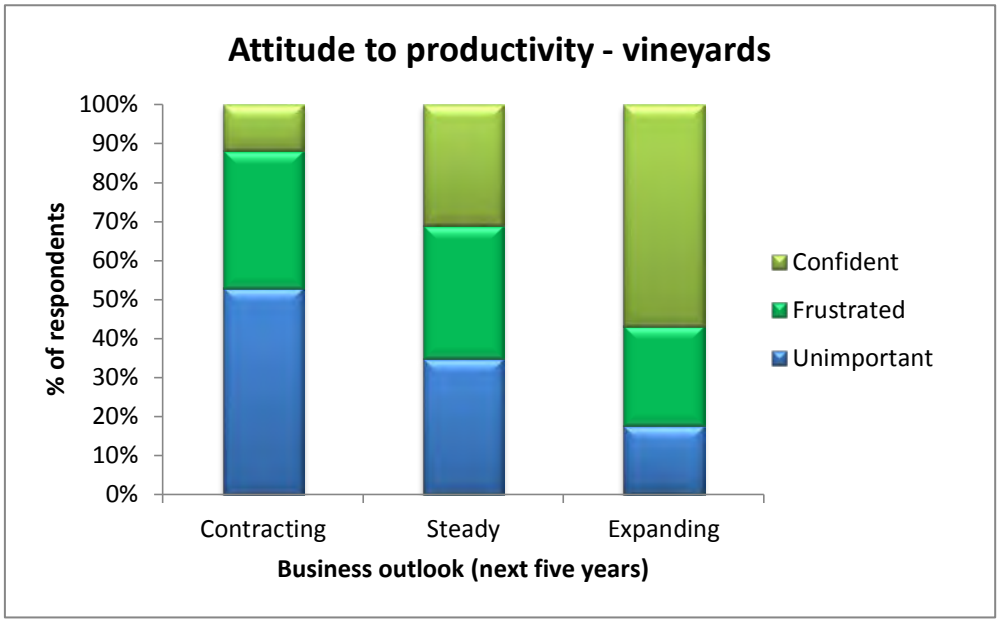


FIGURE 12: ATTITUDE TO PRODUCTIVITY, BY VINEYARD BUSINESS OUTLOOK FOR THE NEXT 5 YEARS.

[1] some respondents owned/managed vineyard and winery operations.

For winemakers, the relationship between attitude towards increasing productivity and their business outlook was stronger than for grapegrowers. More than 60% of the winemakers who anticipated that their winery would expand in the next five years were also confident of increasing productivity, while more than 60% of the winemakers in the 'contracting' market segment felt that productivity growth was unimportant, and usually unlikely to occur (figure 13).

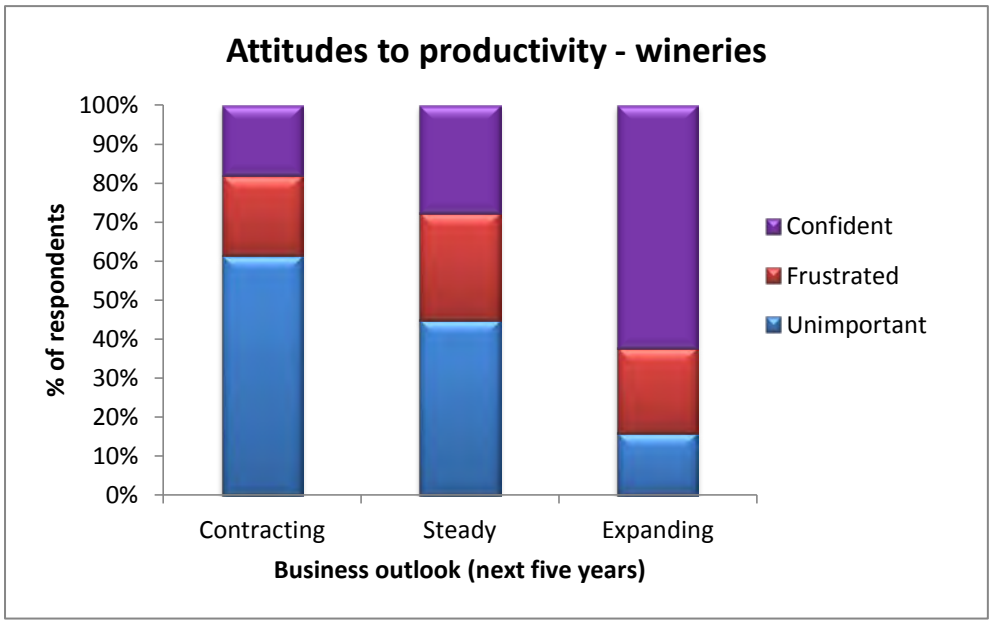


FIGURE 13: ATTITUDE TO PRODUCTIVITY BY BUSINESS OUTLOOK FOR THE NEXT FIVE YEARS - WINERIES.

3.3.2.2 Attitudes to productivity by zone

There were no significant differences between the productivity expectations of grapegrowers and winemakers from the different regional locations.

3.3.2.3 Attitudes to productivity by age group

For grapegrower and winemaker respondents there was a strong inverse association between age and attitude to productivity (figures 14 and 15). For grapegrowers, the majority (nearly 60%) of respondents in the youngest age group (< 34 years) were in the 'confident' group, compared with around 30% of the oldest age group (over 75 years). The results were very similar in the winemaker group. In other words, younger grapegrowers and winemakers were more confident about achieving productivity increases.

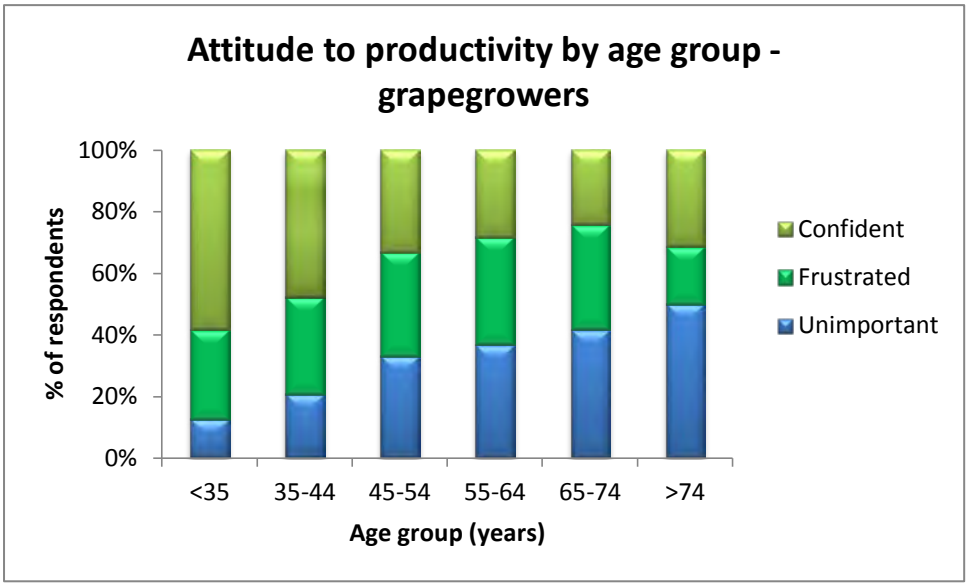


FIGURE 14: ATTITUDE TO PRODUCTIVITY BY AGE GROUP FOR GRAPEGROWERS

N=946 P=0.009

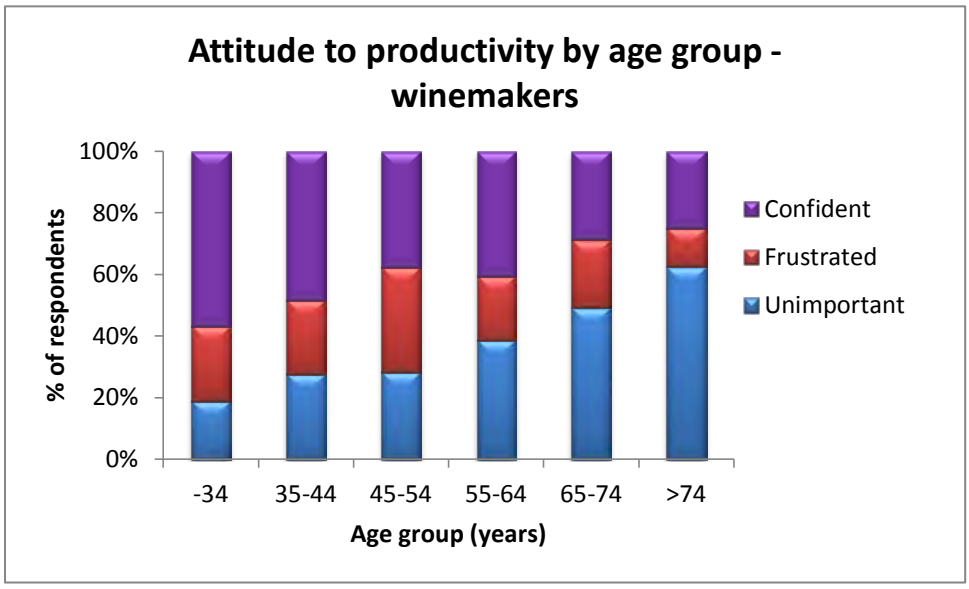


FIGURE 15: ATTITUDE TO PRODUCTIVITY BY AGE GROUP FOR WINEMAKERS

N=417, P=0.001.

3.3.2.4 Attitudes to productivity by business scale

There was a strong correlation between business scale and attitude towards productivity. The largest businesses had a much higher proportion (> 50%) of respondents with a 'confident' attitude compared with approximately 20% of the smallest businesses (figure 16 and 17).

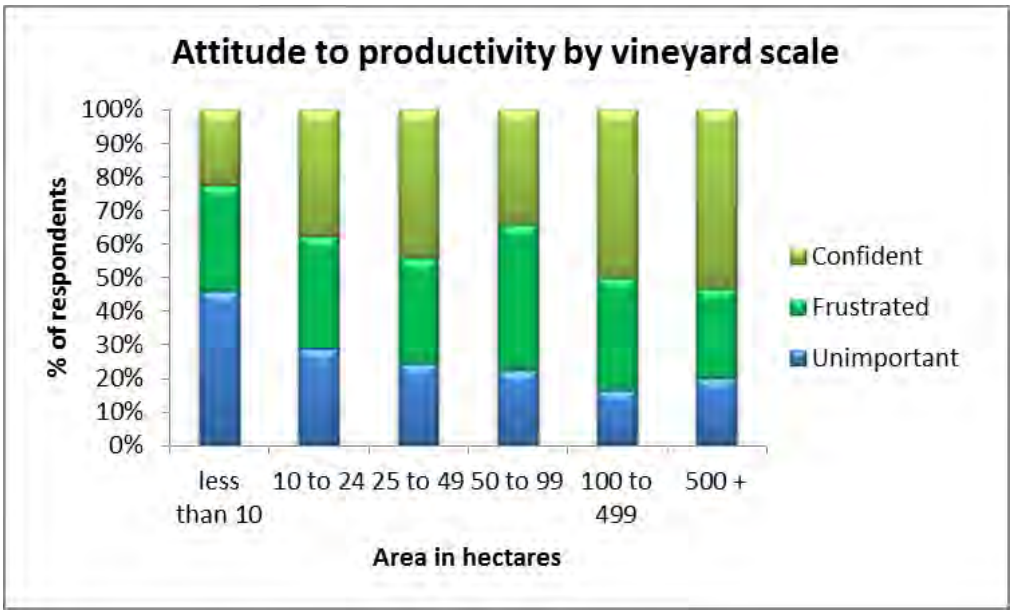


FIGURE 16: THE RELATIONSHIP BETWEEN BUSINESS SCALE AND ATTITUDES TOWARD PRODUCTIVITY

GRAPEGROWERS N=970, P<0.01

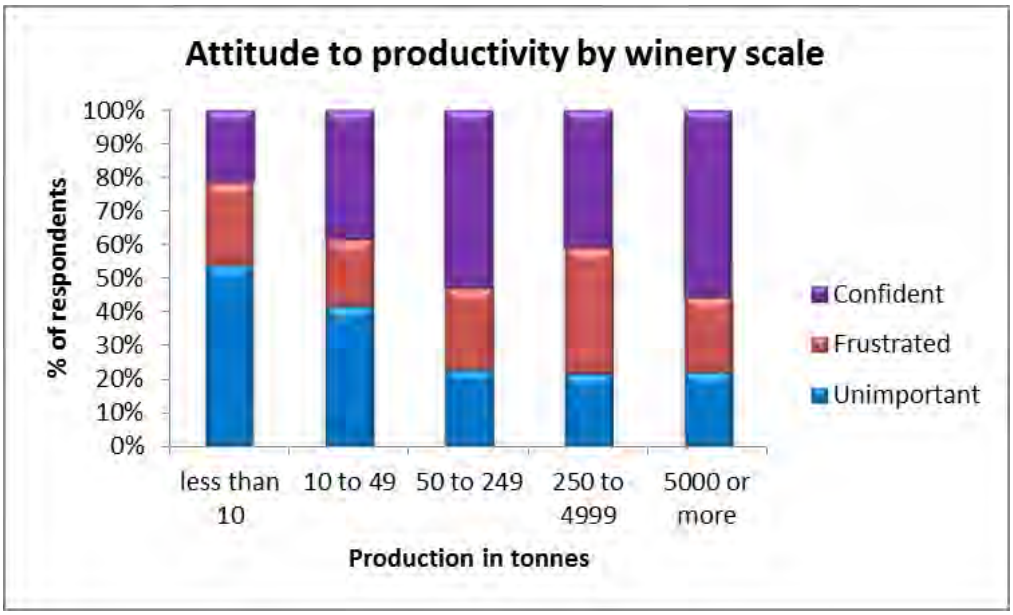


FIGURE 17: THE RELATIONSHIP BETWEEN BUSINESS SCALE AND ATTITUDES TOWARD PRODUCTIVITY

WINEMAKERS N=419, P < 0.01

3.3.3 TAM2 drivers

Structural Equation Modelling was used to identify which of the drivers described in the TAM2 model (refer to Figure 1) influenced grapegrower and winemaker intentions to adopt the various case study technologies.

An overview of the key results is shown in Table 4.

TABLE 4 SIGNIFICANT INFLUENCES ON INTENTION TO ADOPT TECHNOLOGIES (FROM STRUCTURAL EQUATION MODELLING)

	Soil moisture monitoring		**New chemical sprays**		**Cross-flow filtration**		Novel yeasts	
	coeff.[a]	t value[b]	coeff	t value[c]	coeff	t value	coeff	t value
Perceived usefulness	0.71	36 ***	0.65	34 ***	0.65	33.6 ***	0.73	40 ***
Social norms	0.084	1.68 *	0.36	7.6 ***	0.32	8.1 ***	-0.21	2.9 **
Decision control	0.095	2.6 **	0.24	7.1 ***	0.36	9.5 ***		
Perceived ease of use	0.050	2.7 **			0.10	5.5 ***		
Experience					0.36	9.3 ***	-0.12	3.0 ***
Innovative factor					-0.29	7.7 ***	0.17	4.6 ***

[a] Coefficient – standardised to vary between 0 and 1. The closer to 1, the stronger the relationship. A negative coefficient represents an inverse relationship.
[b] Significance of t value * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.
[c] t value approximates Student's t statistic. A value over 2 indicates a 95% confidence level. The p value, or statistical significance, is calculated from the t statistic assuming infinite degrees of freedom.

Table 4 shows the variables that were significantly significant in influencing intention to adopt for grapegrowers and winemakers. The strongest influence by far was the perceived usefulness of the technology. This was significant at $p<0.001$ for all four case study technologies.

Social norms were also significant influences on intention to adopt for all four technologies, although at a lower level of significance in some cases. For novel yeasts, the influence of social norms on intention to adopt was negative ie: winemakers were more likely to indicate an intention to adopt if they thought other people were *not* using them. Significant interactions were observed between social norms and other factors for all technologies except soil moisture monitoring, suggesting that social norms mediate the effects of other factors.

Decision control was influential on intention to adopt all technologies except novel yeasts. Perceived ease of use was influential on intention to adopt soil moisture monitoring and cross-flow filtration.

3.3.4 Intention to adopt and actual adoption

The percent of variation (or R^2) that the model explained for each case study technology was determined using confirmatory factor analysis (Hair *et al.*, 2010) and is shown in table 5. The percent of variation for *intention* to adopt accounted for by the model was generally much higher than for actual adoption itself. These figures are satisfactory for this type of behavioural research where typically a R^2 over 50% can be rare due to the difficulty in dealing with a complex and dynamic topic such as human behaviour. Even where the R^2 is low (particularly for novel yeasts), as long as the main coefficients are statistically significant, important conclusions about drivers of behaviour can still be reached, as the coefficients represent the mean change caused by one variable (eg the impact of social norms) on the behaviour (eg intention to adopt) while holding all the other variables constant (Hair *et al.*, 2010).

TABLE 5: PERCENTAGE OF VARIANCE IN INTENTION AND ADOPTION BEHAVIOUR ACCOUNTED FOR BY THE MODEL

	New chemical sprays	Soil Moisture monitoring	Novel yeasts	Cross-flow Filtration
Intention to Use	53%	60%	66%	64%
Adoption	21%	30%	9%	10%

Nonetheless, while the TAM2 model was very effective at explaining stated intention to use new technologies, it was less effective at explaining the variation in adoption. This is reflected in the literature where the TAM2 has been criticised for ignoring situational constraints on adoption and oversimplifying the social interactions that underlie the adoption process. This is discussed in detail by Bagozzi (2007). There are at least four potential explanations for the model's limited prediction of adoption:

- Intending adopters will become adopters given the passage of time. This slow transition cannot be detected with a single shot survey;
- Other intervening factors not included in the TAM may prevent or slow the transition from intention to adoption;
- The adoption grouping in the model may include those who have intentions to disadopt the technology in the future; and
- Intentions to use the technology in the future may be ill-formed or lacking in conviction, rather than being a reliable indicator of future adoption.

3.3.5 Key drivers at different stages of adoption

The questionnaire data allowed further examination of some of these potential explanations of the TAM2's explanatory weakness. Rather than modify and rerun TAM2, we decided to put aside assumptions about the variables influencing the adoption process and explore the data without a theoretical starting position. This was done using the following four steps:

- For each case study technology respondents were sorted into one of four groups based on the following definitions:
  - Non-adopters – had not adopted the technology and had no intention of doing so;
  - Intending adopters – had not yet adopted the technology but intended to;
  - Adopters – adopted the technology and intended to continue using it; and
  - Disadopters – adopted the technology but did not plan to use it in the future.
- The explanatory variables were merged into a smaller number of aggregate variables based upon a combination of similarity of meaning and observed inter-correlation;
- T-tests were used to find statistically significant differences between the four stages of adoption groups; and
- Discriminant analysis was used to calculate the predictive power of the aggregate variables in explaining adoption group membership.

Figure 18 shows the distribution of adoption behaviours of respondents for each of the four case study technologies. Note that for this component of the survey, approximately equal numbers of adopters and dis-adopters were sampled so these figures do not represent overall industry trends for these technologies. Disadopters were identified by asking adopters if they intended to continue using the technology in future. The questionnaire responses of these disadopters indicated that they did not perceive any value in the continued use of the technology. All respondents who adopted a given technology, including disadopters, were included in the adoption sample used in the TAM2 structural equation modelling, which may partly explain the relatively low correlation found between intention to adopt and actual adoption.

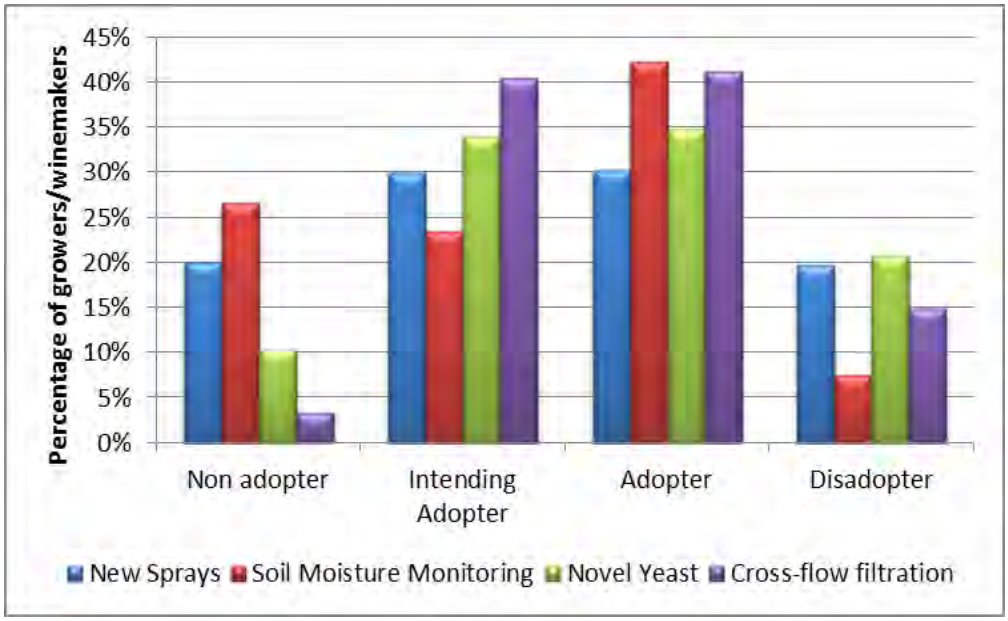


FIGURE 18: ADOPTION BEHAVIOUR OF SELECTED RESPONDENTS IN RELATION TO THE CASE STUDY TECHNOLOGIES.

The questionnaire contained 37 variables that could be related to adoption behaviour. Data exploration using all of these variables would inevitably be a cumbersome process. An exploratory factor analysis demonstrated that there was significant intercorrelation between a substantial number of these variables. Factor analysis was then used as a guide to create a number of aggregate variables that reflected the observed inter-correlations, but also kept separate potentially different explanations of the adoption process. The majority of these variables are the same as those used in the rest of this report and analysis (ie. perceived usefulness, social norms, decision control, age and business scale). The other variables are as follows:

- Perceived ease of use was split into two variables: 'ease of implementation' (ie. 'I had to learn new skills to use this technology') and 'ease of use' (ie. 'I find it easy to get the technology to do what I want')
- 'Productivity aspirations'- includes the variables related to 'business outlook' and 'attitudes to productivity'
- 'Local grapegrower or winemaker contact' describes how frequently the respondent said they had contact with other grapegrowers or winemakers (ie. daily, weekly, monthly, less than monthly)

Other variables considered but not found to be significant were: how innovative the respondents were, if they had trialled the technology, if they conducted external searches for information (ie. written, interpersonal information), and if they were members of formal networks such as grapegrower or winemaker groups and committees.

Stages of adoption- Soil moisture monitoring systems (SMMS)

Figure 19 shows the exploratory analysis for the adoption of SMMS. There are relatively few disadopters in this sample. Non adopters are much more numerous than disadopters. At the base of the figure is a list of variables which statistically differentiate between each group, who are at different stages of the adoption process. These variables are ranked in order of statistical significance. The percentage of explained variance is also shown.

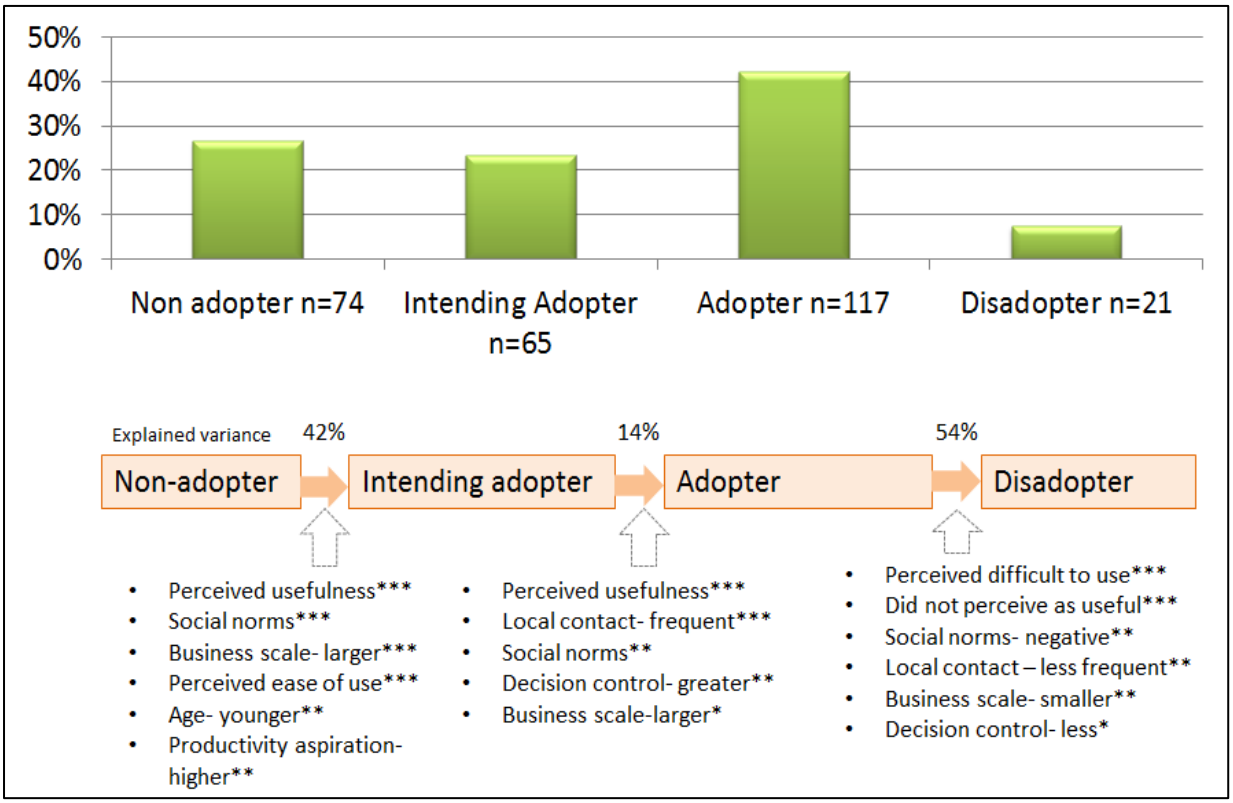


FIGURE 19 EXPLORATORY ANALYSIS OF ADOPTION OF SOIL MOISTURE MONITORING SYSTEMS.

SIGNIFICANCE ***P<0.001, **P<0.01, *P<0.01.

The difference between **non-adopters** and those **intending to adopt**, was that a higher proportion of the intending adopters believed that SMMS would be useful and easy to use. Their peers were using it, and recommended that they use it (social norms) and they were younger, with larger vineyards and higher productivity aspirations (all correlated), than non-adopters.

The difference between the group that **intended to adopt** and those that **had adopted**, is that those that had adopted had an even stronger belief about the usefulness of SMMS, stronger social norms and larger vineyards than those intending to adopt. Interestingly those that adopted had more frequent contact with other grapegrowers, and more decision control (ie. 'it is entirely my choice whether we use SMMS') than those that intended to adopt. There were no significant differences between these two groups' opinions about the ease of adopting and implementing SMMS.

Those that **disadopted** (stopped using) SMMS were much more likely to believe that SMMS was not easy to use, nor useful, than those that had adopted and intended to continue using the technology. Their colleagues were less likely to use, and recommend they use SMMS, and the dis-adopters had less frequent contact with other local grapegrowers and were on smaller vineyards. These relationships suggest that for a relatively complex technology such as SMMS, peer networks are important in successfully learning how to use a new technology effectively. Also in some cases the disadoption decision may not have been theirs to make (ie. less decision control).

Stages of adoption- New chemical sprays (NCS)

Like SMMS, the difference between grapegrowers that were non-adopters and those intending to adopt, was that intending adopters believed that NCS would be useful and easy to implement and use, and their peers were using it, and recommended that they use it (social norms). Again, like SMMS they were also younger, with larger vineyards than non-adopters. Interestingly those intending to adopt NCS were more likely to use external sources of information than non-adopters. Decision control did not emerge as a factor influencing adoption of NCS.

Again, consistent with the structural equation modelling, perceived usefulness emerged as a key driver, with the group that had adopted NSC having more positive attitudes about their usefulness than the intending adopters. This was reflected in the social norms (their peers' positive opinions), which tended to be strongly correlated with perceived usefulness. Adopters were also younger, with larger businesses and higher productivity aspirations, and were more likely to believe that NCS were easier to implement than the intending adopters. Again adopters had more frequent contact with other grapegrowers than those intending to adopt.

The group that disadopted NCS did not find them useful or easy to use or implement and did not believe that their peers thought favourably of the technology. Disadopters were likely to be older and less likely to search for external information.

The decision to adopt NCS will generally be a relatively simple process. The financial and system constraints will be low compared with many other innovations. Thus the influences on the decision to adopt (and disadopt) are mostly related to beliefs about the advantages of the spray compared to alternatives. For such an innovation, the provision of credible information as to the advantages of the product will be the main strategy to enhance rates of adoption.

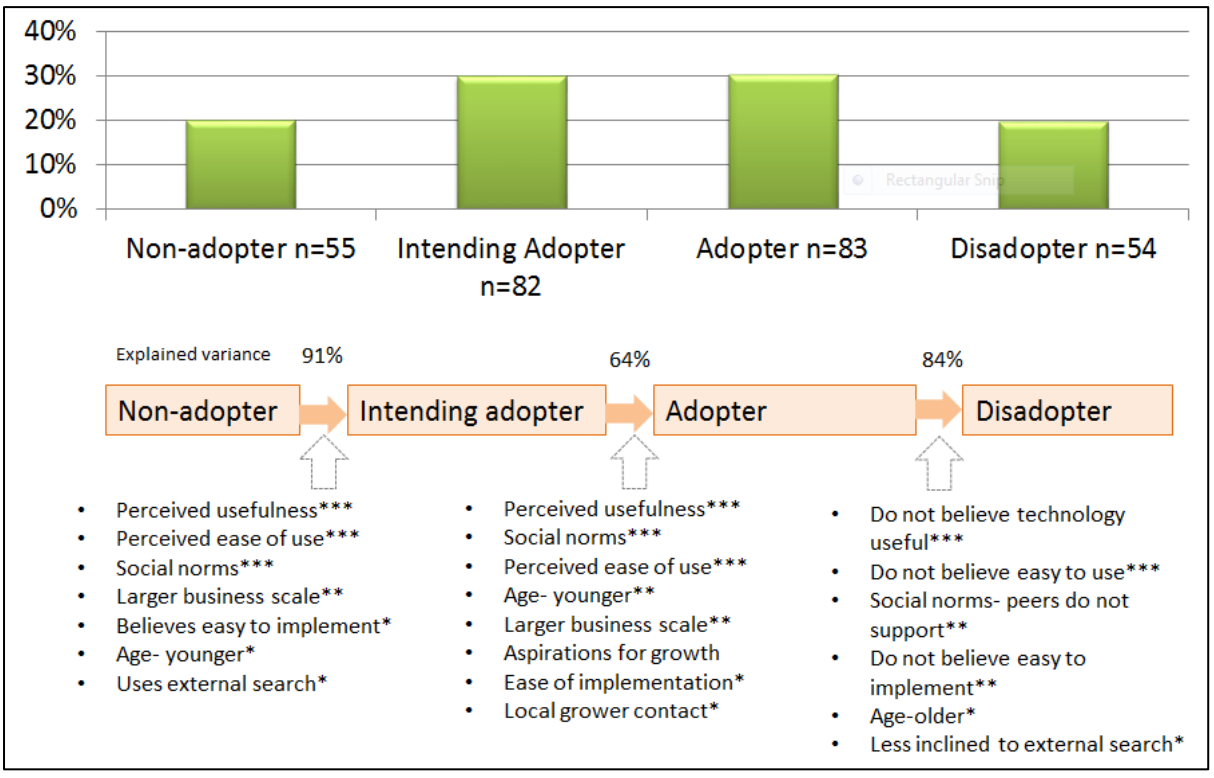


FIGURE 20 EXPLORATORY ANALYSIS OF ADOPTION OF NEW CHEMICAL SPRAYS.

SIGNIFICANCE ***P<0.001, **P<0.01, *P<0.01.

Stages of adoption- Cross-flow Filtration (CFF)

Figure 21 shows a summary of the exploratory analysis for the adoption of cross-flow filtration technology in wineries. As there are few non-adopters, there is little value in testing the differences between the non-adopter and intending adopter groups. Beliefs about the usefulness and ease of implementation show marginal significance.

The difference between intending adopters and adopters is moderately well explained by the aggregate variables. The statistically strongest difference was due to winery scale. Large wineries were much more likely to have made the transition from intention to adoption. Beliefs about the advantages and usefulness of the technology were also much stronger amongst adopters. There is also a strong association between frequency of contact with other winemakers and beliefs that those winemakers also support the technology.

The transition from adoption to disadoption is well explained by the aggregate variables, with 73% of the variance accounted for. Disadopters are much more likely to believe the technology is not useful or easy to use, to have smaller wineries and to believe their peers do not believe in the technology. The combination of relationships suggests that smaller wineries have found it harder to implement the technology without owning the equipment.

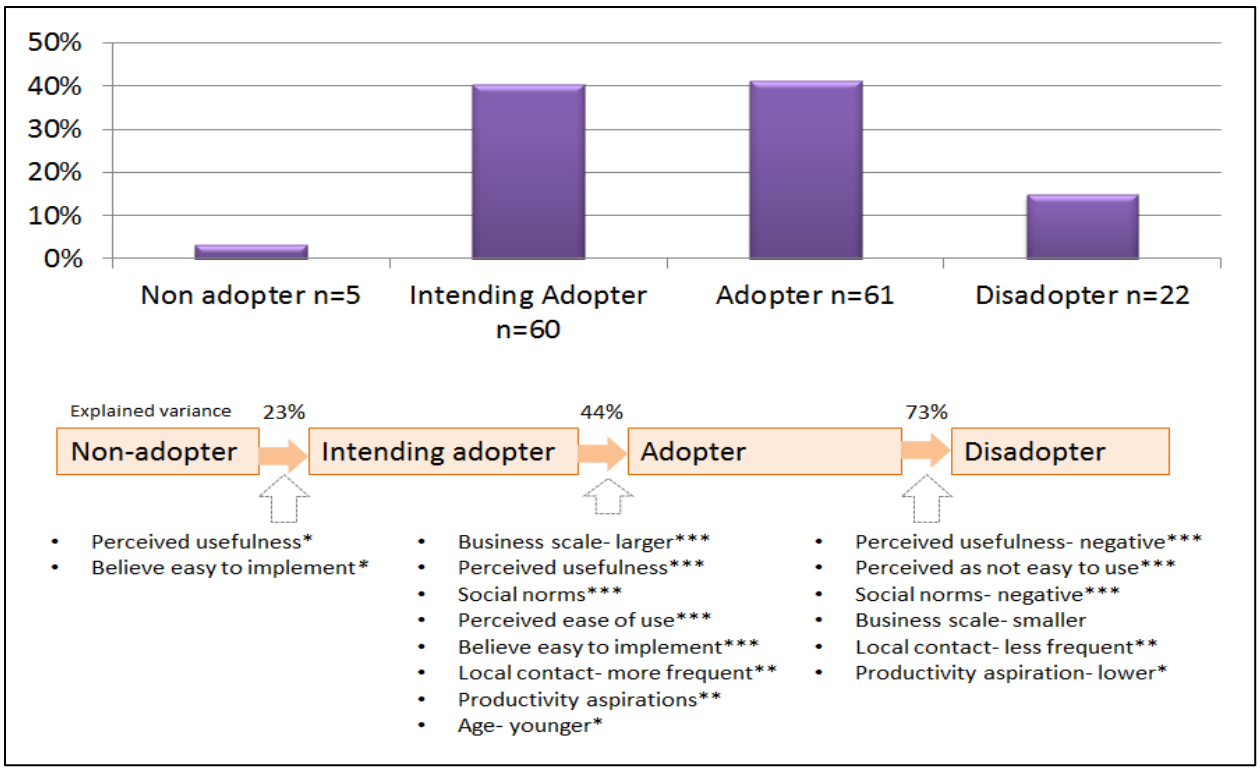


FIGURE 21 EXPLORATORY ANALYSIS OF ADOPTION OF CROSS-FLOW FILTRATION

SIGNIFICANCE: ***P<0.001, **P<0.01, *P<0.01.

Stages of adoption- Novel Yeasts (NY)

The exploratory analysis for this technology is shown in Figure 22.

Novel yeasts are relatively simple to adopt. The difference between the non-adopters and intending adopters was most strongly associated with beliefs about the advantages of novel yeasts. Other factors that differentiated these groups were:

- greater contact with other winemakers
- beliefs about ease of use and implementation and
- growth aspirations (i.e business outlook).

The most significant difference between the intenders and the adopters was a belief in peer support for novel yeasts. This indicates that social norms are an important driver for this technology.

The difference between the adopters and the disadopters was primarily in the respondents' beliefs that the technology was not useful and the lack of approval or support from peers. A lack of control over the decision-making process was also a contributing factor.

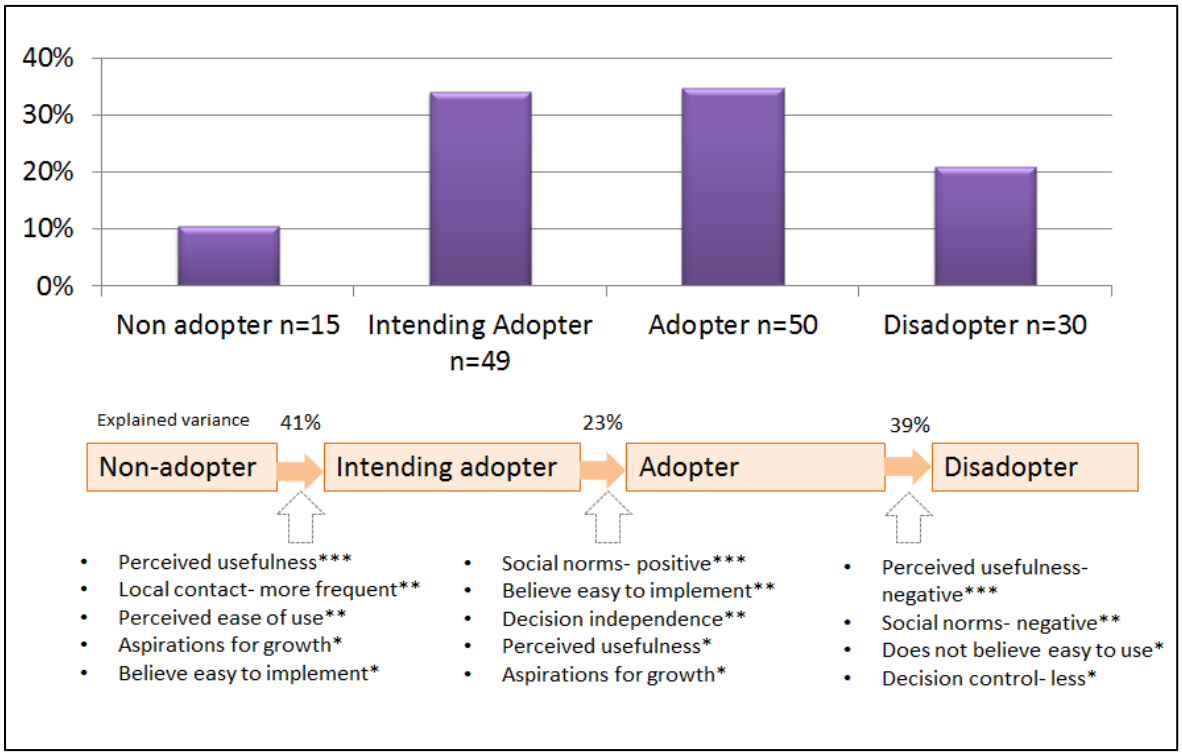


FIGURE 22 EXPLORATORY ANALYSIS OF ADOPTION OF NOVEL YEASTS.

SIGNIFICANCE: ***P<0.001, **P<0.01, *P<0.01.

3.4 Overall drivers of adoption of case study technologies

In this section the factors influencing adoption of the individual case study technologies are reported. The factors considered for each case study technology (see page 57) were:

- business outlook and attitudes to productivity *(productivity)*,
- business scale and location *(farm context)*
- TAM2 concepts – in particular perceived usefulness and ease of use; also other aspects of TAM2 identified by the structural equation modelling (see section 3.4.1) - including decision control, experience and innovative factor

Significance of the variables business outlook, attitude towards productivity and farm context variables was determined using chi square tests. The strength of relationship between the dimensions of perceived usefulness or perceived ease of use and grapegrower or winemaker intention to adopt the technology was determined using structural equation modelling. The coefficient value is standardised to vary between 0 and 1. The closer to 1, the stronger the relationship. A negative coefficient represents an inverse relationship. The t value approximates Student's t statistic. A value over 2 indicates a 95% confidence level.

3.4.1 Soil moisture monitoring systems (SMMS)

Overall, 33% of vineyard respondents had adopted SMMS. A summary of the influence of drivers of adoption on SMSS is shown in table 6, table 7 and figure 18.

TABLE 6: SUMMARY OF INFLUENCE OF KEY DRIVERS ON ADOPTION OF SOIL MOISTURE MONITORING SYSTEMS.

Key driver	Result
Business outlook	Although proportionally more grapegrowers on expanding vineyards adopted SMMS, than those on 'steady' or 'contracting' vineyards, the relationship was not statistically significant.
Attitude towards productivity	A strong relationship was found due to productivity improvement drivers. 60% of the 'confident' group had adopted SMMS, 53% of the 'frustrated' and 32% of the 'unimportant' group ($p<0.001$)
Farm context	There was a strong relationship between vineyard scale and adoption of SMMS ($p<0.001$ – refer to figure 23). For a break-down of overall adoption for each scale category please see Appendix 1. Proportionally more vineyards in the 'warm inland' and 'rest of SA' zones had adopted SMMS compared with other zones and fewer in Tasmania. This is possibly due to the distribution of vineyards by scale in the various zones or due to irrigation requirements in warm versus cooler climates.

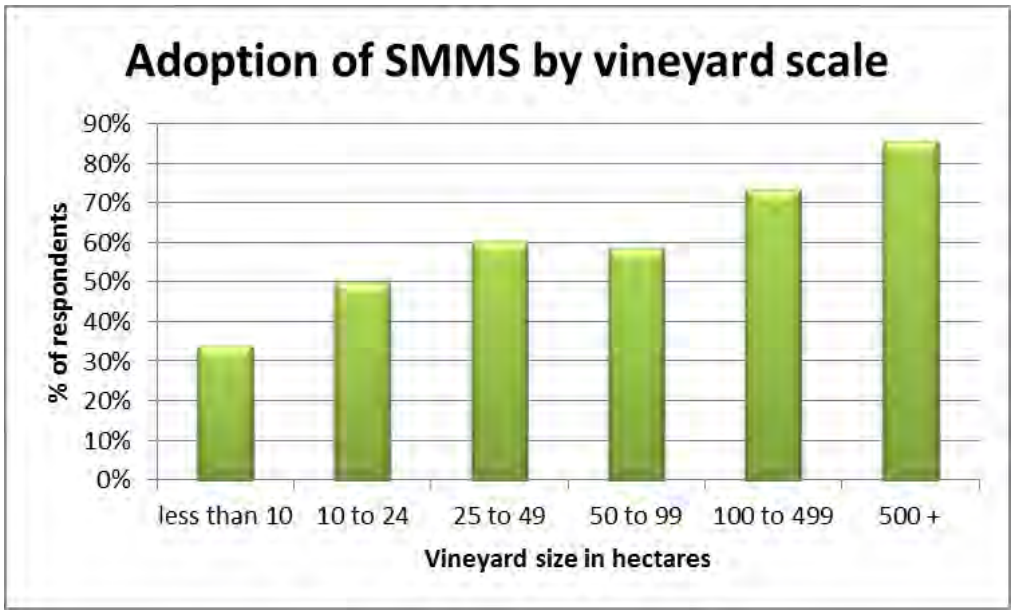


FIGURE 23: ADOPTION OF SMMS BY SCALE CATEGORY N=138

Variable	Element	Result	
		coefficient	*t-value*
Perceived usefulness	On my vineyard SMMS is important	0.397	15.915
	It helps me produce the grapes I want to	0.221	6.135
	To reduce input costs	0.206	9.537
	To reduce risk	0.176	8.621
	To help improve grape quality	0.155	4.803
	To generate useful information to run the vineyard [2]	0.122	7.319
	Gives me more flexibility in the vineyard	0.077	3.158
Ease of use	It is easy to get it to do what I want	0.945	72.680
	Using system initially required a lot of mental effort	0.211	4.620
	Using the system initially involved learning new skills	0.209	4.606
	I had to look for a lot of extra information to be able to use it	-0.210	4.042

TABLE 7: SIGNIFICANT DIMENSIONS OF PERCEIVED USEFULNESS AND EASE OF USE IN RELATION TO SMMS

(p=<.001)

[2] 11% of the grapegrowers surveyed said their vineyards were non-irrigated, and hence they could not use the information to monitor and schedule irrigation

Vineyard scale was the key influence in regard to the adoption of SMMS with the majority of grapegrowers on large vineyards (over 100 ha) adopting them. These grapegrowers saw SMMS as important to their businesses mainly to help them maintain or improve grape quality, reduce (water) costs and reduce the risk of running out of water or not watering at the correct time. Although the grapegrowers reported the need to learn new skills and use some mental effort initially, they did not need much extra information to use the systems and found them easy to operate. They found it easy to see the difference that using SMMS made (coefficient 0.066, t-value 4.019).

Social norms played a role in influencing grapegrowers' perceptions of the usefulness of SMMS and their intention to adopt, but this was not as strong as it was for some of the other technologies. Decision control was important (refer to table 4 on page 20), while neither previous experience with the technology, nor a general liking for experimentation with new technologies and practices were found to be relevant.

3.4.2 New chemical sprays (NCS)

The overall adoption rate of NCS was high, with 66% of the respondents having adopted or trialled this technology. A summary of the influence of drivers of adoption on NCS is shown in table 8, table 9 and figure 24.

Key driver	Result
Business outlook	Although proportionally more grapegrowers on 'expanding' vineyards adopted NCS than on 'steady' or 'contracting' vineyards, the relationship was not statistically significant.
Attitude towards productivity	A strong relationship was found: 63% of the CONFIDENT group, 52% of the FRUSTRATED and 39% of the UNIMPORTANT group had adopted NCS ($p<0.007$)
Farm context	There was no significant relationship between vineyard scale and adoption of NCS although more grapegrowers in the 100-499ha category had adopted the technology than in the other scale groups. For a break-down of overall adoption for each scale category please see Appendix 1. In terms of geographical location, Tasmania had the highest rate of NCS adoption and the 'warm inland' area the lowest.
Demographics	There was a strong correlation between age and adoption of NCS, with younger grapegrowers being more likely to adopt ($p<0.006$). Refer to figure 24 for details.

TABLE 8: SUMMARY OF INFLUENCE OF KEY DRIVERS ON ADOPTION OF NEW CHEMICAL SPRAYS

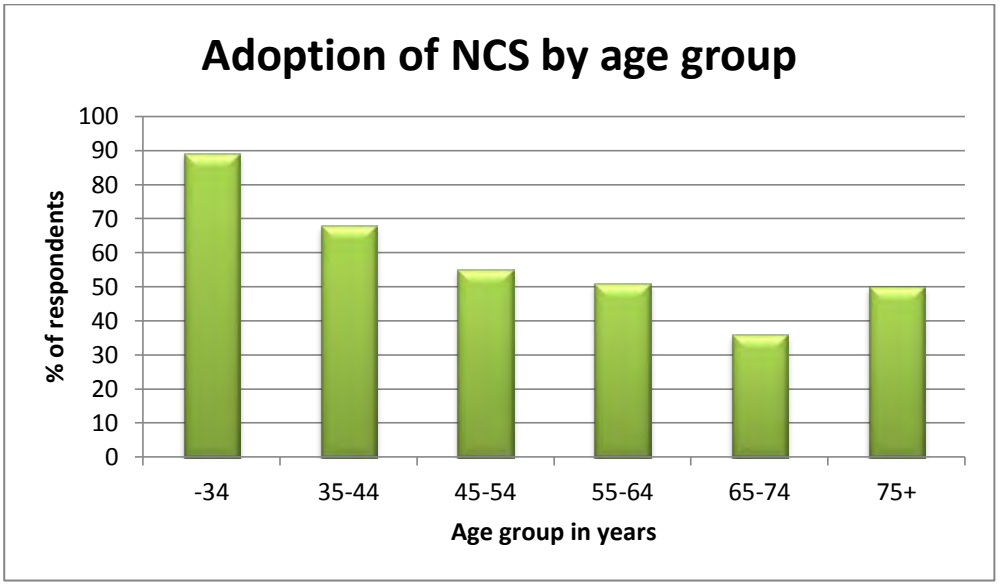


FIGURE 24: ADOPTION OF NCS BY AGE GROUP

Variable	Element	Result	
		coefficient	*t-value*
Perceived usefulness	Using NCS helps us produce the grapes we want to	0.292	8.040
	It helps me improve grape quality	0.244	8.176
	On my vineyard NCS is important	0.211	7.600
	Using NCS makes my vineyard management easier	0.154	4.459
	NCS give me more flexibility in the vineyard	0.147	5.236
	Getting the right NCS is important	0.120	4.129
	NCS reduce my risk of disease resistance	0.082	3.468
	NCS are safer than the alternatives	0.075	3.659
	Using NCS saves me time	-0.071	3.157
	Using NCS helps me manage my grape yield	-0.087	3.941
Ease of use	Perceived ease of use did not have a direct effect on the grapegrowers' intention to adopt but only on how useful NCS were perceived to be (coefficient 0.388 and t-value 15.421). NCS were perceived to be easy to use, with little need to change any existing practice in the vineyard, learn new skills or seek new information.		

TABLE 9: STATISTICALLY SIGNIFICANT DIMENSIONS OF PERCEIVED USEFULNESS AND EASE OF USE IN RELATION TO NCS

(p=<.001).

Younger grapegrowers on all scaled vineyards were more likely to adopt NCS. The strongest motivation was to increase or maintain grape quality, followed by increasing ease and flexibility of vineyard management.

New chemical sprays were *not* perceived to reduce input costs or save time.

Other drivers

Social norms played a strong role in influencing grapegrowers' perceptions of the usefulness of NCS and their intention to adopt these. As for SMMS, decision control was a strong influence (refer to table 4 on page 20), while neither previous experience with the technology, nor a general liking for experimentation with new technologies and practices were found to be relevant.

3.4.3 Cross-flow filtration (CFF)

Overall 41% of the winery respondents had purchased , leased or trialled CFF, or had their wine filtered using it. A summary of the influence of drivers of adoption on NCS is shown in table 10, table 11 and figure 25.

Key driver	Result
Business outlook	Significantly more of the expanding wineries had adopted CFF (67%) compared with steady (56%) or contracting wineries (30%) $p<0.01$.
Attitude towards productivity	Attitude to productivity did not emerge as a significant driver of adoption of CFF.
Farm context	Winery scale was strongly associated with adoption ($p<0.001$) of this technology, with 87% of the wineries in the largest scale group adopting CFF, compared with around 5% in the smallest scale group (refer to Figure 25). For a break-down of overall adoption for each scale category please see Appendix 1. The highest rate of CFF adoption was in the 'warm inland' region category, and the lowest in the 'Rest of NSW/ACT/QLD' area. This probably reflects the variations in winery scale distribution between these areas.
Demographics	There was a definite trend towards younger winemakers having a higher adoption of CFF, but this was not statistically significant.

TABLE 10: SUMMARY OF INFLUENCE OF KEY DRIVERS ON ADOPTION OF CROSS-FLOW FILTRATION

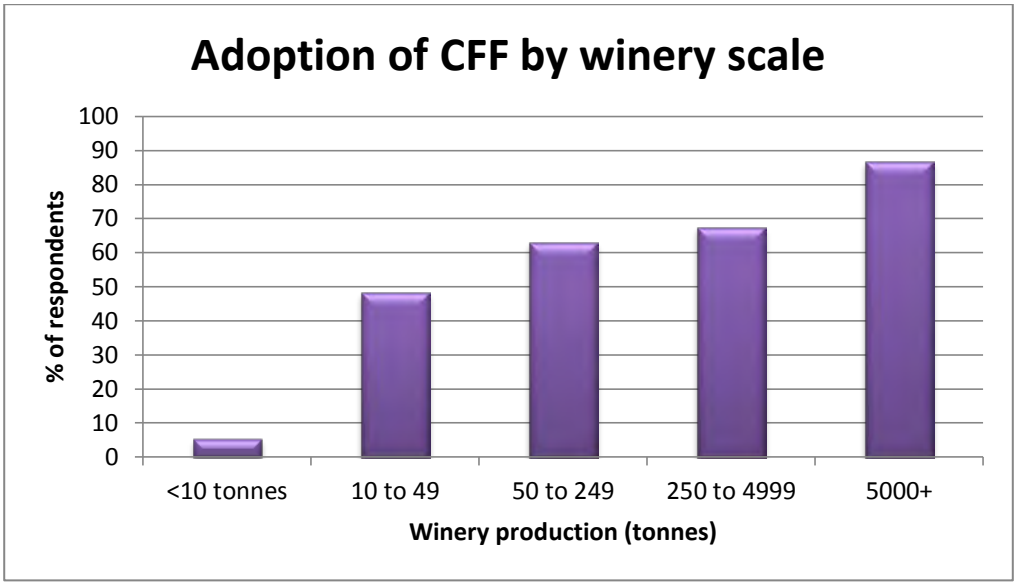


FIGURE 25: ADOPTION OF CFF BY BUSINESS SCALE

Variable	Element	Result	
		coefficient	*t-value*
	In my winery CFF is important	0.294	10.128
Perceived usefulness	Using CFF reduces my input costs	0.287	10.942
	CFF is safer to use than diatomaceous earth filters	0.141	5.154
	CFF helps us produce the wine we want to	0.139	5.699
	CFF helps us improve or maintain wine quality	0.132	5.699
	CFF makes winery management easier	0.115	4.848
	CFF gives us more flexibility in the winery	0.081	3.315
	CFF helps us reduce wine losses	0065*	2.504
Ease of use	It was easy to get CFF to do what we wanted	0.908	70.372
	Using CFF initially involved learning new skills	0.284	8.914
	We needed to look for a lot of extra information to use CFF properly	0.124	3.592
	Using CFF initially required a fair bit of mental effort	-0.280	8.794

TABLE 11: STATISTICALLY SIGNIFICANT DIMENSIONS OF PERCEIVED USEFULNESS AND EASE OF USE IN RELATION TO CFF

(p=<.001), * p=<.05.

Winemakers from large and expanding wineries were more likely to adopt CFF. The principal motivations were: to reduce input costs, increase workplace safety and improve quality. While it was reported that some new skills, information and knowledge were required initially to adopt CFF, the winemakers then found CFF easy to operate.

Other drivers

Winemakers reported having no trouble seeing the difference using CFF made (coefficient 0.069, t-value 3.192). Social norms played a role in influencing winemaker perceptions of the usefulness of CFF and their intention to adopt. Decision control and previous experience were also strong influences. For winemakers who did not like to experiment with new technologies and practices, there was a higher rate of adoption of CFF, possibly indicating that CFF was perceived as an established and proven technology.

3.4.4 Novel yeasts (NY)

Overall 60% of the winery respondents had used novel yeasts (at least twice). A summary of the influence of drivers of adoption on NCS is shown in table 12 and table 13. There was very little difference in rates of adoption between segments based on business outlook, attitude to productivity, business scale or demographics.

Key driver	Result
Business outlook	No significant relationship.
Attitude towards productivity	No significant relationship.
Farm context	There was little association between adoption and winery scale. The highest rate of NY adoption was in the 'warm inland' and the lowest in the 'Rest of Vic' areas.
Demographics	No significant relationship with age group.

TABLE 12: SUMMARY OF INFLUENCE OF KEY DRIVERS ON ADOPTION OF NOVEL YEASTS

Variable	Element	Result	
		coefficient	*t-value*
Perceived usefulness	Using NY helps me maintain or improve wine quality	0.460	17.896
	In my winery NY is important	0.284	12.398
	Using NY saves me time	0.211	7.816
	NY help us produce the wine we want	0.073	2.864
	It is risky not to use NY	0.063	3.441
Ease of use	I find it easy to use NY	0.916	50.082
	Using NY initially involved a lot of mental effort	0.267	5.095
	Using NY reduces my input costs	-0.116	5.028
	We had to change a number of other things so we could use NY	-0.111	2.290

TABLE 13: STATISTICALLY SIGNIFICANT DIMENSIONS OF PERCEIVED USEFULNESS AND EASE OF USE IN RELATION TO NY

(p=<.001).

Winemakers used NY to maintain or improve wine quality and to save them time. Some winemakers said it was risky not to use them. NY were seen as easy to use, although some mental effort was required when first using them.

Novel yeasts were not perceived as making winery management easier, reducing wine losses or providing more flexibility in the winery, and using them *increased* rather than reducing winery costs (coefficient -0.116 and t-value 5.028) Winemakers found it easy to see the difference using novel yeasts made to their wine (coefficient 0.166 and t-test 8.224).

Other drivers

Social norms had an inverse relationship with intention to adopt. Ie winemakers were *less* likely to adopt if others were known to use the technology. Previous experience and liking to experiment with new products were also inversely correlated with use of NY. Decision control was not a significant influence.

4. Discussion

4.1 Summary of results

Most of the vineyards and wineries surveyed have stayed steady in scale over the last five years, and anticipated staying 'steady' over the next five years. Of the grapegrowers (16%) on vineyards that have expanded during the last five years, 40% said they thought it likely they would continue to expand over the next five years. Very few of these thought it likely their vineyard would contract. Of the grapegrowers on vineyards (13%) that had contracted, 40% thought it likely they would continue to contract over the next five years. This pattern was echoed in the wineries surveyed.

Attitudes towards productivity were associated with business outlook. Over 50% of the grapegrowers and winemakers surveyed from expanding businesses were 'confident' of productivity growth in their businesses, compared with less than 20% in the 'contracting' business outlook group. Younger grapegrowers and winemakers were more likely to be 'confident' of increasing productivity and there were no distinct regional trends.

Scale of business was a strong influence on whether high involvement technologies such as soil moisture monitoring (SMMS) and cross-flow filtration (CFF) were adopted, but not low involvement technologies such as adoption of new chemical sprays (NCS) or novel yeasts (NY).

Of the 'TAM2' concepts, 'perceived usefulness' was by far the strongest driver of intention to adopt the case study technologies. The importance of the individual items that made up the concept of perceived usefulness (ie. saves time, increases quality etc) varied for each case study technology. This is to be expected as each technology provided different benefits. However themes emerged around cutting costs, increasing efficiency and improving grape and wine quality.

'Perceived ease of use' influenced grapegrower and winemaker perception of the overall usefulness of SMMS and CFF. 'Social norms' significantly influenced grapegrower and winemakers intentions to adopt all four technologies, while 'decision control' influenced intention to adopt all except NY.

Experience influenced adoption of CFF and negatively influenced adoption of NY. That means winemakers were less likely to adopt NY if they had experience with using them. If the winemakers liked trying new products and technologies (innovative factor) they were *less* likely to adopt CFF, but *more* likely to use NY. Experience and innovative factor were not significant influences in the adoption of SMMS or NCS.

When considering the factors that move people from intending to adopt to actual adoption, the key drivers that emerged related again to business scale, perceived usefulness, how easy people thought the technology would be to implement and use, and social norms. Adopters tended to have significantly more, and disadopters less, frequent contact with other grapegrowers or winemakers.

4.2 Analysis and interpretation of results

This section integrates the results of the quantitative study with the results of the initial qualitative research based on interview data (detailed in Hill *et al.* 2014a&b). Supporting graphs are presented in Appendix 4.

4.2.1 Business outlook and attitudes to productivity as predictors of adoption behaviour

The 'expanding' market segment

One of the main findings of the qualitative component of this project (part A) was that grapegrowers and winemakers owning, managing or working in expanding businesses were more likely to adopt new technologies than those from steady or contracting businesses.

The quantitative study did not support or contradict this finding, due to the small number of case study technologies selected. This was necessary in order to keep the survey length manageable. During the interviews however, most of the grapegrowers and winemakers with expanding businesses said they had invested in a range of new technologies and practices to support their expansion and to increase process efficiency and product quality. In vineyards, these purchases included: new plantings (sometimes with alternative grape varieties), machinery, technology related to precision viticulture, weather stations, soil moisture monitoring systems, manures and composts. In wineries, purchases included: tanks, barrel sheds, crushers, pumps, flotation and filtration systems, barrels, waste systems and energy saving or generating technologies such as solar panels and automated cooling systems. Some interviewees has also made other investments such as internet-based sales systems or expanded cellar door, function centre or other tourist-related developments.

These businesses were expanding for a range of reasons as the following excerpts illustrate:

> *'Under our previous owners we were just being maintained and if anything scaling back in terms of premium production. More the focus [was] on commercial scale types of volume through this facility in the last few years, so to that end there wasn't a lot of investment in terms of winery or vineyard infrastructure. Any of the projects that we were undertaking were more driven towards saving costs, I guess. But now we've turned 180 degrees under a new ownership regime that's very keen on developing the site, so we are putting programs in place to invest in technology and infrastructure in the winery going forward'. [# 31, medium vineyard and winery, Central Victoria.]*

> *Facilitator: 'What part of the business are you seeking to expand'?*
>
> *Interviewee: 'All of it. Export markets are expanding. Our contract processing is expanding, as is our full contract winemaking, but I don't want the full contract winemaking to take over the business. The processing is good because it's in and out and it's not a lot of fuss and it helps provide return on a fairly substantial investment. Our own wine sales domestically are increasing relatively significantly' [# 58, medium-large winery and vineyard, Tasmania.]*

> *'We are expanding. The winery is growing quite rapidly. We've got a new cellar door we're building next door. Yeah, it's going good, I'm quite happy with it. We don't retail, we only do direct marketing. So in doing so we get better money for our product. We have been doing that for 10 or 12 years now and it is slowly building up.' [# 55. Small vineyard and winery, Swan Valley.]*

> *'We're looking at purchasing a property at the moment; if that doesn't happen it'll be some redevelopment work. We want to expand. A because of succession planning and B to get the sort of scale we're after and optimise all the machinery. [# 21, Medium sized vineyard, Riverland.]*

Who is in the market for innovation?

The majority of respondents (55% grapegrowers, 65% winemakers) with expanding businesses said that increasing productivity was important and achievable for them and thought their business would continue to expand in the next five years. The results of this research indicate that this market segment is mostly likely to have the resources, confidence and motivation to adopt more capital intensive, risky and innovative technologies or practices in future. This information can be used to identify the scale of the potential market for emerging technologies or products that fit this description.

Where can the expanding business market segment be found?

The largest number of vineyards in the expanding category were found to be in the small to medium scale categories (<50 Ha), perhaps because there were more respondents in these scale categories, in South Australia (Rest of SA) and Victoria (Rest of Vic). The highest proportion was in the 50 to 99 Ha category, and in Tasmania. For wineries, they were mainly located in South Australia (rest of SA) and Victoria (Rest of Vic) with the largest group (32%) in the 50-249 tonne category.

What information were they seeking?

Interviewees in the expanding business category were found to be very actively seeking information on research, technologies and practices from a range of sources including the internet, colleagues, seminars and suppliers to inform their decision making.

The 'steady' market segment

The majority of the interviewees (71% vineyards and 53% wineries) said their businesses had stayed 'steady' in scale and/or production over the last five years. A similar proportion said they were likely to remain steady over the next five years. This group was fairly evenly divided into the three groups based on attitudes towards productivity improvement: a) confident of achieving productivity improvements, b) frustrated (ie they wanted to increase productivity but did not think they could achieve it), or c) productivity improvement was considered unimportant.

During the interviews, grapegrowers and winemakers in this segment said they were adopting some new technologies and practices, but did not have access to much capital and hence were not making high cost investments. Instead, their main driver was to increase productivity through being more efficient with labour and inputs, by increasing grape or wine quality or value, or by replacing worn or outdated equipment. Where capital was being invested, it was generally if the person could see that the technology would achieve a quantifiable cost saving in the short to medium term. Technologies adopted by this group included: vine replanting, compost, fertigation, soil moisture monitoring, new chemical sprays or 'biological' practices (ie. low input, low chemical use). In the winery, examples of technologies adopted were flotation, energy saving measures and inputs such as novel yeasts.

The following are examples of motivations for businesses in the 'steady' market segment:

> *'I will probably maintain (the vineyard) as it is at present because of the uncertainty that's around, I guess, more than anything. I was full time on the block for a number of years but then when the drought came on, I think we spent around $60,000 on water in a three or four year period, just to keep the vines alive. Prices were down, everything was down'* [#26, small-medium vineyard, Riverland].
>
> *I'd always worked part time at XX and my wife worked full time. The block just wasn't enough so I had to get a full time job and one became available so I just took it. It makes things easier. It's not a matter of what's the finances? Can I go and buy some spray this month? You know you're going to be right'* [#35, medium-sized vineyard, Mornington Peninsula].

'I just think I'm probably young enough to keep it going. It's all set up. There's not a real lot of manual work. I've done some young vines just in the last few years which, of course, that's what takes your time, but it's mechanically pruned and mechanically picked. We've got all the gear, the tractor, the two row spray, all that sort of thing. We're just hanging onto it because I don't want to chop it up and sell ours and have someone live next to me. I like being in the middle of the block, and I don't want to live in a dust bowl either'. [#26, medium-sized vineyard, Riverland].

Last year we got a new fruit sorter. The goal is to move away from handpicking because labour costs are so high, but keep the quality. Certainly on our shiraz this year we were able to machine pick it and put it through the fruit sorting gear and we were pretty happy with the result'. [#50,medium-large winery, Margaret River].

Who is in the market for innovation?

While this segment of the market was unlikely to make extensive capital investments, often they were still actively making changes and adopting technologies and new information aimed at achieving their business goals. This segment represents a significant target market segment for technologies that provide short to medium term benefits such as reducing input costs, increasing workplace safety or increasing quality or process efficiency.

Where can this market segment be found?

The largest group of grapegrowers in this segment were in South Australia ('Rest of SA') on smaller vineyards (<10ha). The wineries were mostly in Victoria (rest of Vic), in all winery scale categories.

What information were they seeking?

Many people in this segment were actively seeking information, usually to identify new technologies, products or practices that could enable input costs to be cut, or product value (i.e. quality) to be increased, without major capital investment, or changes to their existing businesses.

The 'contracting' market segment

The group of 'contracting' businesses represented 13% of vineyard businesses and 16% of wineries. It had the highest percentage of people regarding productivity increases as 'unimportant'. Around 40% to 50% of these grapegrowers and winemakers envisaged that their businesses would continue to contract over the next five years. Approximately 10% anticipated that their business would expand and the remainder said they thought their business would remain steady over the next five years.

Technologies or products adopted by people in this group tended to be relatively low cost and low risk, such as compost or new chemical sprays in the vineyard, and novel yeasts in the wineries. Machinery and equipment was usually only replaced when strictly necessary. Some of the interviewees in this group stated that they had not adopted any new products or technologies in the last few years.

The following are examples of motivations for businesses in the 'contracting market segment:

I've had it. My body's had it. There's just no money in it to do things you'd like to do. You're just existing at the moment. I just haven't got the - I've had it, it's been a hard road and yes, to me a lot of prices we get now, are what we were getting in 1998, 2000'. [#27, medium-sized vineyard, Loxton].

'They won't let me buy a new tractor. There is no money. So we are just hanging on, tinkering with it and pampering it, trying to get it through' [Interview #12, large vineyard, Yarra Valley].

'Up until five years ago were adopting a lot of new technology or methodology in being efficient…we had more capital available…now it is about consolidation' [#32,medium-large winery, Central Vic].

Who is in the market for innovation?

This segment of the market is very unlikely to make capital investments or much change. This segment will still purchase some low cost, low risk inputs if they perceive a benefit, or through necessity. There may be opportunities to provide support services to some people in this segment.

Where can this market segment be found?

The largest number of contracting businesses was in Victoria (rest of Vic) and were on smaller vineyards (<10 ha) and wineries (<10 tonnes).

What information were they seeking?

Interviewees in contracting businesses exhibited different behaviour depending on the reason for scaling down. People selling out or retiring said they were not interested in new information on technologies or practices. Those who planned to remain in the wine sector, albeit in a reduced capacity, tended to remain aware of new technology and practices, but were only likely to adopt cheaper technologies or products, with short term benefits.

4.2.2 Other drivers of adoption

Benefit based market segmentation

Aside from business outlook, a number of other factors were found to determine whether grapegrowers and winemakers perceived a technology or practice as useful. These were largely based on contextual factors such as the physical features of their vineyard or winery, access to resources and their existing knowledge, skills or competitive strategies. Kaine (2004) termed this 'farm context'. Kaine suggested that these contextual factors are identifiable and define the key benefits a grapegrower or winemaker will seek from a new technology or practice. These factors can be used to underpin a benefit-based market segmentation approach. For example, a number of dimensions of perceived usefulness were identified in this study as significant drivers of intention to adopt Soil Moisture Monitoring Systems. Appendix 5 shows how these dimensions can be used as the basis for benefit-based market segmentation.

This research has shown that it would be useful for researchers and extension practitioners to create benefit segments for the technologies or practices being promoted. Market segmentation, in conjunction with insights from the TAM2 model, can help to:

- identify the scale of a target market,
- better understand the needs of the target market and the information they will seek,
- develop new technologies or practices, or modify existing ones, to meet a segment's needs, and
- formulate a communication strategy for selected segments (Assael, 1998).

In this study, perceived ease of use was related to:

- the amount of effort a grapegrower or winemaker would need to expend in learning to use the technology, and
- the amount of effort required to incorporate it into the vineyard or winery physical and management systems.

This relates to Rogers (2010) innovation characteristics of complexity and its compatibility with the existing system. Effort, time and risk of frustration are considered by grapegrowers and winemakers as very real costs. Hence accurate information, possibly in case study format, would be expected to prove useful to grapegrowers or winemakers seeking to evaluate the real cost of adoption.

Social norms and contact with peers

Social norms emerged as a key driver of adoption. A strong correlation was found between a person's own beliefs about a technology and the reported beliefs of their peers. This raises questions about the causal links between the two belief sets. Do people only pay attention to peers who confirm their own existing opinions? None-the-less a technology with quantifiable advantages might be expected to generate shared common attitudes within a grapegrower/winemaking community.

Ease of use and contact with peers were two variables found to play a role in predicting the transition from intention to actual adoption. It was also found to have an involvement in predicting the transition from adoption to disadoption (working in the opposite direction). A reasonable explanation for this observation is that, for more complex technologies, the path to successful adoption is not a single decision point, but a journey of learning to use a new technology and to integrate it into the business.

This learning journey appears to be assisted by the sharing of experiences with fellow adopters. Those grapegrowers and winemakers with closer links with their peers are more likely to make the step from intention to adoption, and less likely to make the further (reverse) step to disadoption. It is reasonable to conclude that these closer links with other adopters are aiding the adoption process.

The excerpt below is from a winemaker who changed from using commercial to natural yeasts, and illustrates the importance of peer support:

> *'Yeah, so (XX wine maker colleague) and I, we have some really good talks about ferments. XX has done a lot of trial and error. My stress levels are very high when I walk to a red ferment that's just sitting there and it stinks. XX has also found that. He has suddenly had problems with Hydrogen Sulphide and spikes and raging temperatures and everything' [# 2, small winery, McLaren Vale.]*

Grapegrowers and winemakers often selected suppliers whom they said they trusted to provide good after-sales support. For example:

> *'The most important part is that you need service, you need back up and you need parts. If a company cannot give you that, well, then you've got a machine that sits there and every time you've got problems you haven't got back up, then it's worth nothing to you after' [#41, medium winery, Griffith.]*

Strong networks were found to play a vital role in providing the information and support necessary for grapegrowers and winemakers to adopt new technologies and implement changes to practices. Extension programs that build new networks or utilise existing networks around new technologies (either personal or internet based), will aid the adoption process.

Business scale

Business scale and grapegrower or winemaker age were found to be moderately intercorrelated with scale appearing to be the more important of the two variables, as it was significantly related to adoption behaviour for two of the four case study technologies. This relationship appeared stronger as the cost of the technology increased. Larger businesses would have greater capacity to fund more capital intensive technologies (eg cross-flow filtration). Larger businesses can also support greater experimentation and assumption of risk associated with unknown technology.

This association implies that not all technologies are equally suited to all businesses. Some technologies may only be suited to a narrow target audience and full adoption across the industry is not a realistic objective.

The observations from this study can assist in identifying the potential target market for a new technology, based on business scale. This approach will enable a more realistic evaluation of the success of an adoption strategy or the value of a new technology. Where a technology is most relevant to large businesses, the success of an adoption strategy may be high when measured in terms of the percentage of total crush or hectares planted, although low in terms of numbers of businesses that have adopted the technology.

Use of TAM2

One of the aims of this study was to identify the key factors that led to grapegrowers or winemakers adopting specific technologies. The TAM2 model (with some modifications) proved to be a simple yet robust enough conceptual model to achieve this aim.

Consistent with findings from other studies using TAM2, the major influences on grapegrowers' and winemakers' intention to adopt and actual adoption were found in this study to be the perceived usefulness and ease of use of the technology, and social norms. This study represents the first application of the TAM2 framework to measure the relative influence of a number of drivers of adoption of technologies in the Australian grape and wine sector.

However, the TAM2 model has limitations and could be refined for future use in the wine industry. A gap was found between the intention to adopt and actual adoption that this model could not explain. Additional analysis demonstrated that the explanatory power of the model was increased by the addition of the following variables:

- business scale
- frequency of contact with other grapegrowers or winemakers
- attitudes to productivity

and by removing the population of 'intending disadopters' from the adoption group.

5. Conclusion

This study found that the major influences on grapegrowers' and winemakers' intention to adopt and actual adoption were perceived usefulness and ease of use of the technology, and social norms. This is consistent with other studies using TAM2. When considering the factors that move people from intending to adopt to actual adoption, the key drivers that emerged related to business scale, perceived usefulness and how easy people thought the technology would be to implement and use, and social norms. Adopters tended to have significantly more, and disadopters less, frequent contact with other grapegrowers or winemakers.

This study represents the first application of this framework, particularly in conjunction with structural equation modelling, to the adoption of technologies in the Australian grape and wine sector. The methods used here of conducting interviews to identify relevant business scale, attitudes to productivity and dimensions of perceived usefulness and ease of use to inform survey design and data collection, provide a robust and objective means to identify market segments and extension and communication content.

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Appendix 1 Demographics of use of case study technologies

Winery production (tonnes per annum)	% of surveyed winemakers who had used a NY more than twice (n=268)	% of surveyed winemakers who had purchased leased, trialled or had their wine filtered using CFF (n=173)
Less than 10	42.7	5.6
10-49	61.6	23.2
50-249	61.1	54.7
250-4999	82.3	69.8
5000 or more	88.9	88.9
% of total winery respondents(n=419)	63.8	41.5

TABLE 14: PERCENTAGE OF WINEMAKERS BY SCALE CATEGORY WHO HAD USED NY AND CFF

Vineyard scale	% of surveyed grapegrowers who had adopted NCS (n=640)	% of surveyed grapegrowers who had adopted SMMS (n=315)
Less than 10 ha	61.3	17.5
10-24 ha	59.6	35.4
25-49 ha	74.6	42.3
50-99 ha	75.8	50.0
100-499 ha	84.5	66.7
500 ha or more	86.7	73.3
% of total vineyard respondents (n=970)	66.0	32.5

TABLE 15: PERCENTAGE OF GRAPEGROWERS BY SCALE CATEGORY WHO HAD ADOPTED NCS AND SMMS

Wine Region grouping	% of surveyed winemakers who had used a NY more than twice (n=264)	% of surveyed winemakers who had used CFF n= (173)	% of surveyed grapegrowers who had adopted SMMS (n=312)	% of surveyed grapegrowers who had adopted NCS (n=640)
Warm Inland	79.5	66.7	46.8	56.7
Rest of NSW/ACT/Qld	70.8	23.1	22	70.5
Rest of SA	64.1	53.4	45.9	65.9
Rest of Vic	56.9	33.3	22.7	68.5
Tasmania	57.9	52.6	14.7	79.4
Western Australia	67.8	49.2	18.4	69.3
% of total respondents	63.8 (n=414)	41.8 (n=414)	33 (n=946)	66.4 (n=946)

TABLE 16: PERCENT OF RESPONDENTS BY ZONE WHO HAD ADOPTED THE CASE STUDY TECHNOLOGIES.

Appendix 2: Case study technologies

1. Soil moisture monitoring systems (SMMS) - Vineyard

There are a range of soil moisture monitoring systems available to the wine industry, and these vary from using capacitance probes, to installing gypsum blocks, or more complex systems such as the 'g-bug','red light/ green light' system or 'environscan' which enables ongoing collection and storage of soil moisture data.

Grapegrowers monitor soil moisture in order to determine moisture levels at soil depth, where the vine root system is located. This information can then be used to guide management practices, such as the scheduling of irrigation, or to evaluate existing practices.

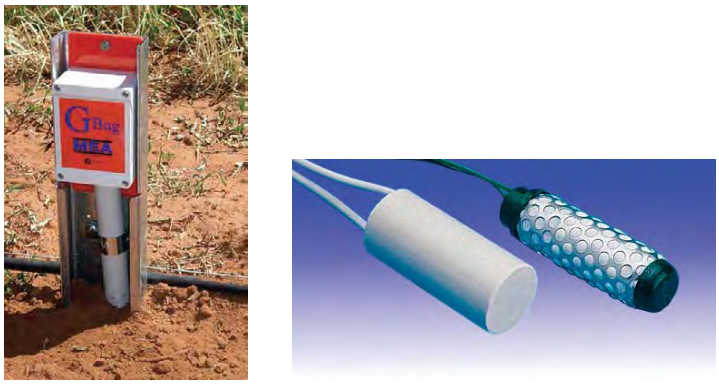


FIGURE 26: A 'G-BUG' SOIL MOISTURE LOGGER, AND GYPSUM BLOCKS.

2. New chemical sprays for disease control- Vineyard

The new chemical sprays we have selected for this case study have the product names of : 'Legend', 'Prodigy', 'Revus', 'Samurai', 'Vivando', 'Talendo' and 'Custodia'. Made by a range of companies, these chemicals have been available in Australia for up to five years. These new sprays are supposed to provide more effective control of powdery and downy mildew, last longer and be more rain fast than other products (check). The grapegrowers interviewed and surveyed were asked about 'new vineyard chemical sprays' rather than specific product names.



FIGURE 27: EXAMPLES OF TWO COMMERCIALLY AVAILABLE FUNGICIDE SPRAY LABELS.

3. Cross-flow filtration systems (CFF) - Winery

Cross-flow filtration is a form of filtration where, instead of the wine or juice being fed though a membrane or bed with the solids being trapped in a filter, it passes across the surface of the filter, so it does not block the filter up, and hence a cross-flow filtration system can operate continuously, even with wine or juice with high loads of solids. Cross-flow filtration systems are large, are able to process large quantities of liquid rapidly and can be fully automated. They have been available to the Australian wine industry for approximately nine years, with increased uptake in the last five years. There are currently a number of smaller and mobile cross-flow units available to industry now. The price tags of the smaller units still start at $200,000, with approximately four distributers in Australia.



FIGURE 28: EXAMPLES OF A SMALLER PORTABLE, AND A LARGER CROSS-FLOW FILTRATION SYSTEM.

4. Novel yeasts (NY) - Winery

Yeasts are an essential part of the winemaking process as they convert sugars in the grape into alcohol. Yeasts occur naturally in the air, and some winemakers rely on these yeasts to inoculate their wine juice. This is known as a 'natural ferment'. Alternatively, commercial yeast can be purchased and added to the juice, arguably giving the winemaker a more predictable result in regards to ferment reliability and resulting wine flavour and style.

There are many commercial yeasts available to winemakers. The novel yeasts selected this case study are the commercial yeasts with product names of 'Bayanus', 'Alchemy', 'Elegance', 'Maurivin Advantage',' Distinction' or 'Platinum'. The product features of these yeasts are that they provide benefits such as: increasing fruit intensity or strong or distinct fruit aromas in the wine (ie. Alchemy I, Alchemy II, Elegance) or low production of sulphides and volatile aromas during ferment (ie. Bayanus, Maurivin Platinum) during fermentation.



FIGURE 29 TWO COMMERCIAL YEAST VARIETIES.

Appendix 3 Quantitative survey items

Respondents who **had** adopted the vineyard technologies (new chemical sprays, soil moisture monitoring) answered the questions below. People who **had not** adopted were asked similar questions; however the wording was modified where necessary so that the question made sense, for example:

- On my vineyard [new chemical sprays/a soil moisture monitoring system] **would** be important.
- I **would** have no trouble seeing the difference using [new chemical sprays/a soil moisture monitoring system] makes.

Grapegrower ***questions***

Grapegrowers were asked about new chemical sprays or soil moisture monitoring, represented here as 'X'

Grapegrower questions	**Variable or concept represented**	**Source of item**
I know some pretty cluey grapegrowers who use X	Social norms	Venkatesh and Davis, 2000
People who are important to me recommended that I use X	Social norms	Venkatesh and Davis, 2000
On my vineyard X is important	Involvement	Venkatesh and Davis, 2000
I have no trouble seeing the difference using X makes	Result demonstrability	Venkatesh and Davis, 2000
Getting the right X is important to my business	Product involvement	Venkatesh and Davis, 2000
I like to experiment a bit with new technologies and practices	Innovative factor	Venkatesh and Davis, 2000
It is risky not to use X	Perceived usefulness	Developed from interview data
Using X helps us produce the grapes we want to	Perceived usefulness	Developed from interview data
[this question for chemical sprays only] New chemical sprays reduce my risk of disease resistance	Perceived usefulness	Developed from interview data
Using X gives me more flexibility in the vineyard	Perceived usefulness	Developed from interview data
Using X reduces my input costs	Perceived usefulness	Developed from interview data
Using X makes my vineyard management easier	Perceived usefulness	Developed from interview data
Using X saves me time	Perceived usefulness	Developed from interview data
[this question for soil moisture monitoring only]A soil moisture monitoring system] helps me generate useful information for running the vineyard	Perceived usefulness	Developed from interview data
Using X helps me improve my grape quality	Perceived usefulness	Developed from interview data
Using X helps me manage my grape yield	Perceived usefulness	Developed from interview data
[this question for chemical sprays only) New chemical sprays are safer to use than alternatives	Perceived usefulness	Developed from interview data
I find it easy to get [new chemical sprays/a soil moisture monitoring system] to do what I want	Perceived ease of use	Venkatesh and Davis, 2000

Grapegrower questions	Variable or concept represented	Source of item
We had to chAnge a number of other things so we could use X	Perceived ease of use	Venkatesh and Davis, 2000
I had to learn new skills to use X	Perceived ease of use	Venkatesh and Davis, 2000
I had to look for a lot of extra information to be able to use X	Perceived ease of use	Venkatesh and Davis, 2000
Using X initially requires a lot of mental effort	Perceived ease of use	Venkatesh and Davis, 2000
It is entirely my choice whether or not I use X	Decision control	Venkatesh and Davis, 2000
I intend to continue using X	Intention to use	Venkatesh and Davis, 2000

TABLE 17: SURVEY QUESTIONS, CONCEPTS REPRESENTED AND SOURCE OF QUESTION FOR GRAPEGROWERS.

Winemaker questions

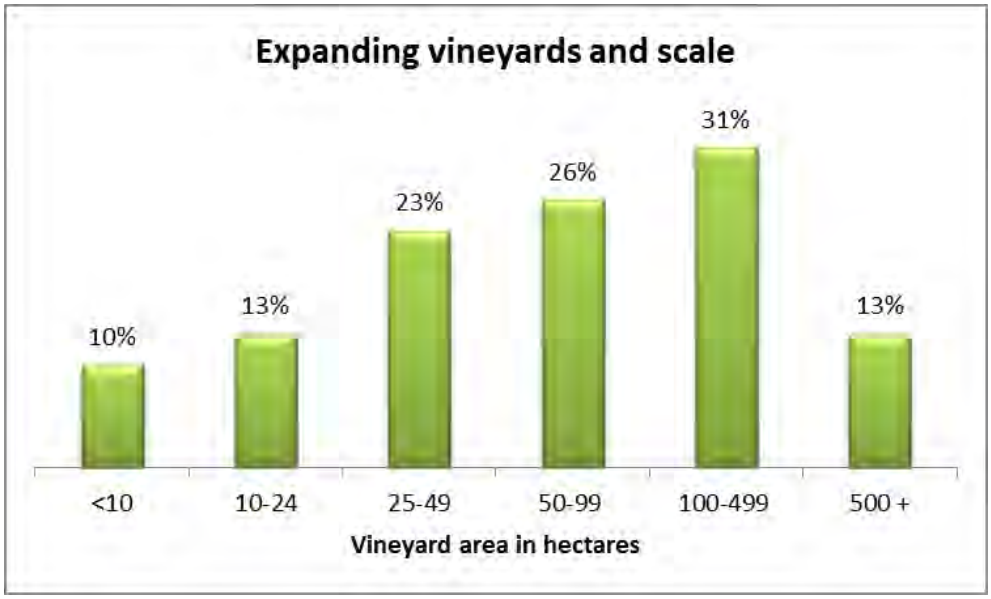
A similar process was followed for the winery technologies or cross-flow filtration and novel yeasts (X)

Winemaker questions	Variable or concept represented	Source of item
I know some pretty cluey winemakers who use X	Social norms	Venkatesh and Davis, 2000
People who are important to me recommend that I use X	Social norms	Venkatesh and Davis, 2000
In my winery X could be important in future	Involvement / job relevance	Venkatesh and Davis, 2000
I would have no trouble seeing the difference using [novel yeasts, cross-flow filtration] would make	Result demonstrability	Venkatesh and Davis, 2000
Getting the right X would be important to my business	Product involvement / job relevance	Venkatesh and Davis, 2000
I like to experiment a bit with new technologies and practices	Innovative factor	Venkatesh and Davis, 2000
It is risky not to use X	Perceived usefulness	Developed from interview data
Using X would be helpful for producing the wine we want to	Perceived usefulness	Developed from interview data
Using X would give me more flexibility in the winery	Perceived usefulness	Developed from interview data
Using X would reduce my input costs	Perceived usefulness	Developed from interview data
Using X would make my winery management easier	Perceived usefulness	Developed from interview data
Using X would save me time	Perceived usefulness	Developed from interview data
Using X would help me improve or maintain my wine quality	Perceived usefulness	Developed from interview data
Using X would reduce my wine losses	Perceived usefulness	Developed from interview data
[this question for cross-flow only) Cross-flow filtration is safer to use than alternatives	Perceived usefulness	Developed from interview data
I would find it easy to get X to do what I want	Perceived usefulness	Developed from interview data
We would have to change a number of other things so we could use X	Perceived usefulness	Developed from interview data
I would have to learn new skills to use X	Perceived ease of use	Venkatesh and Davis, 2000
I would have to look for a lot of extra information to be able to use X	Perceived ease of use	Venkatesh and Davis, 2000
Using X would require a fair bit of mental effort	Perceived ease of use	Venkatesh and Davis, 2000
It would be entirely my choice whether or not I used X	Decision control	Venkatesh and Davis, 2000
I intend to use X in future	Intention to use	Venkatesh and Davis, 2000

TABLE 18: SURVEY QUESTIONS, CONCEPTS REPRESENTED AND SOURCE OF QUESTION FOR WINEMAKERS.

Appendix 4: Location and scale of businesses by business outlook[3]

Expanding market segment



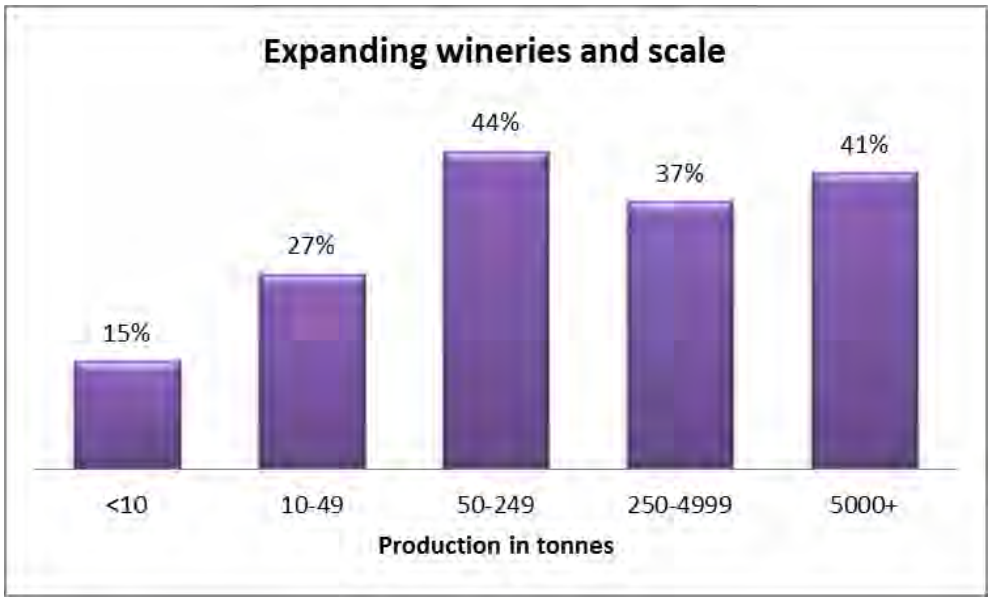


FIGURE 30 PROPORTION OF BUSINESSES IN THE EXPANDING CATEGORY BY BUSINESS SCALE.

[3] Percentage totals do not equal 100% exactly as respondents who answered 'other' have been excluded.



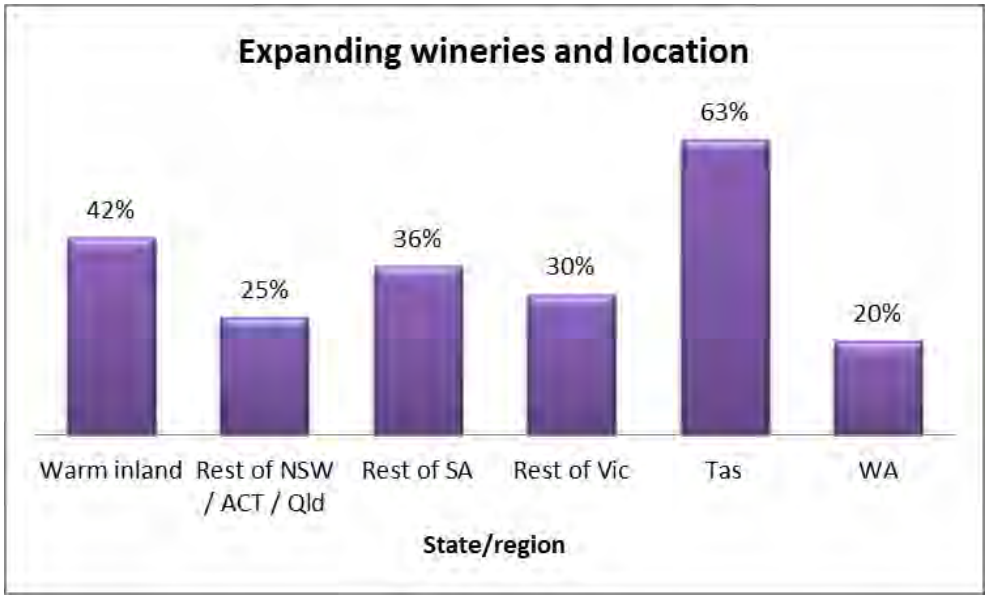


FIGURE 31 PROPORTION OF BUSINESSES IN THE EXPANDING CATEGORY BY GEOGRAPHICAL LOCATION.

Steady market segment

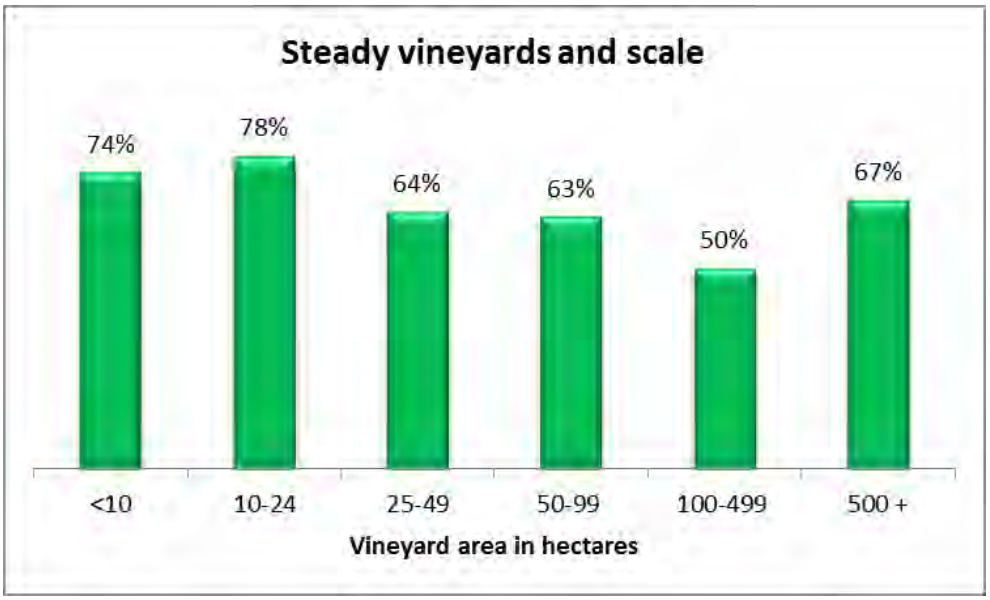




FIGURE 32 PROPORTION OF BUSINESSES IN THE STEADY CATEGORY BY BUSINESS SCALE.

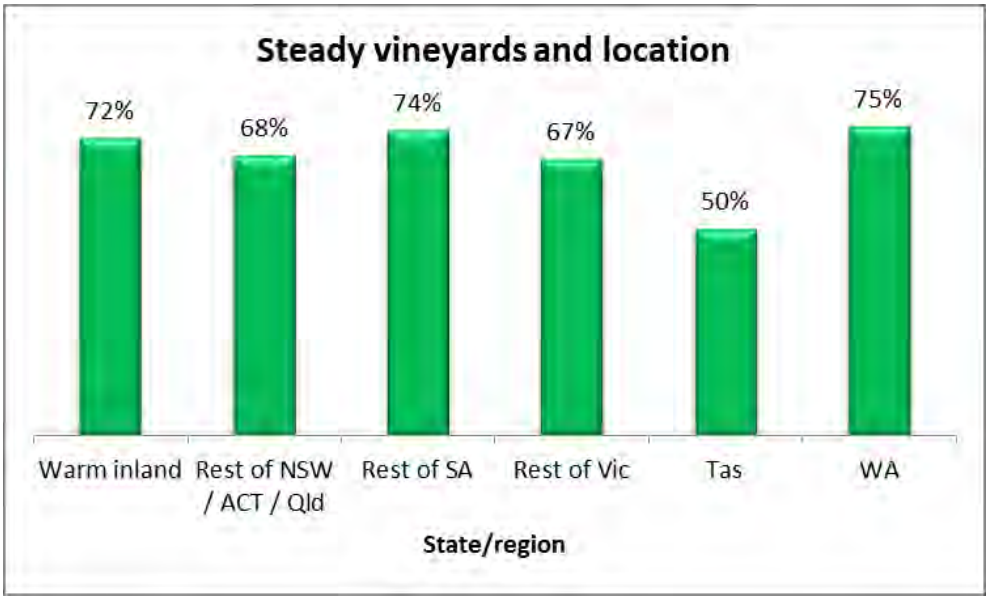
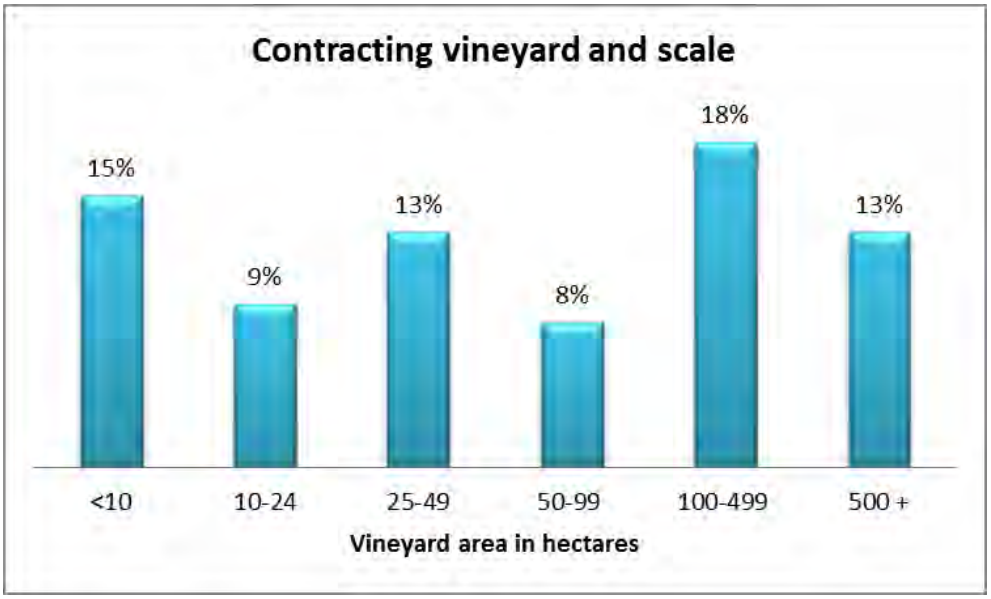




FIGURE 33 PROPORTION OF BUSINESSES IN THE STEADY CATEGORY BY GEOGRAPHICAL LOCATION.

Contracting market segment



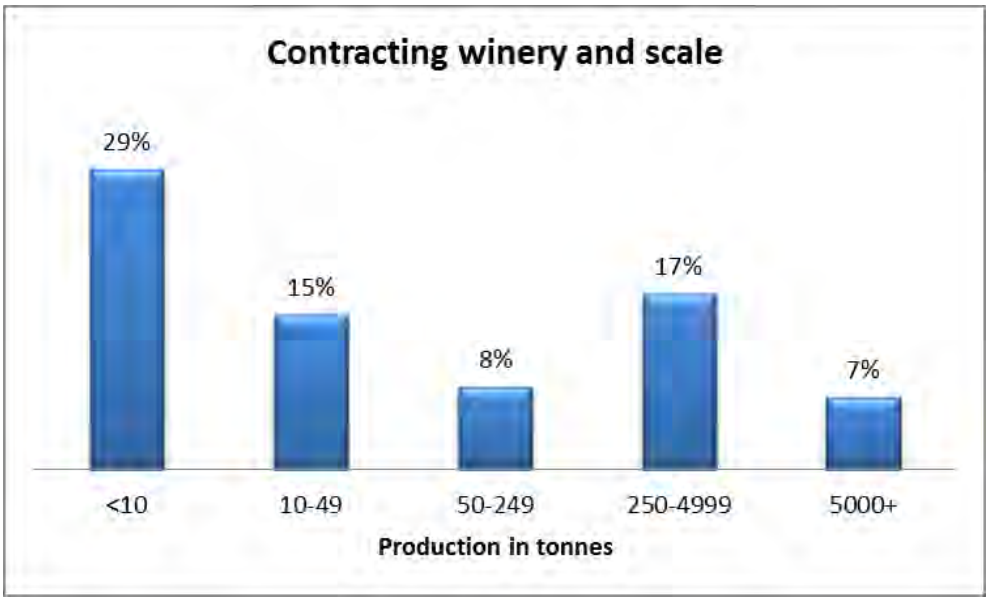


FIGURE 34 PROPORTION OF BUSINESSES IN THE CONTRACTING CATEGORY BY BUSINESS SCALE

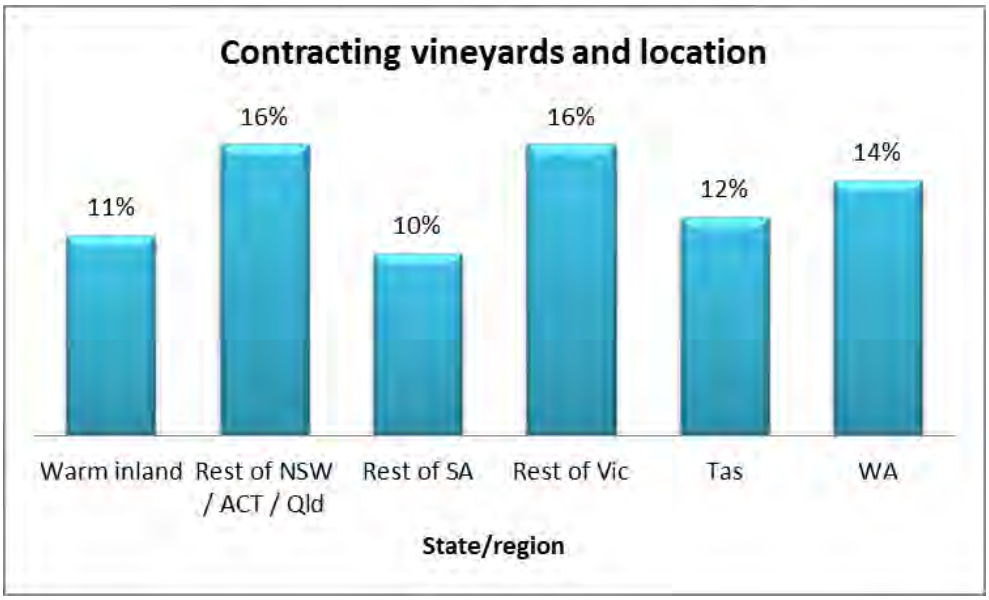




FIGURE 35 DISTRIBUTION OF CONTRACTING VINEYARDS AND WINERIES.

Appendix 5: Benefit segments for soil moisture monitoring systems

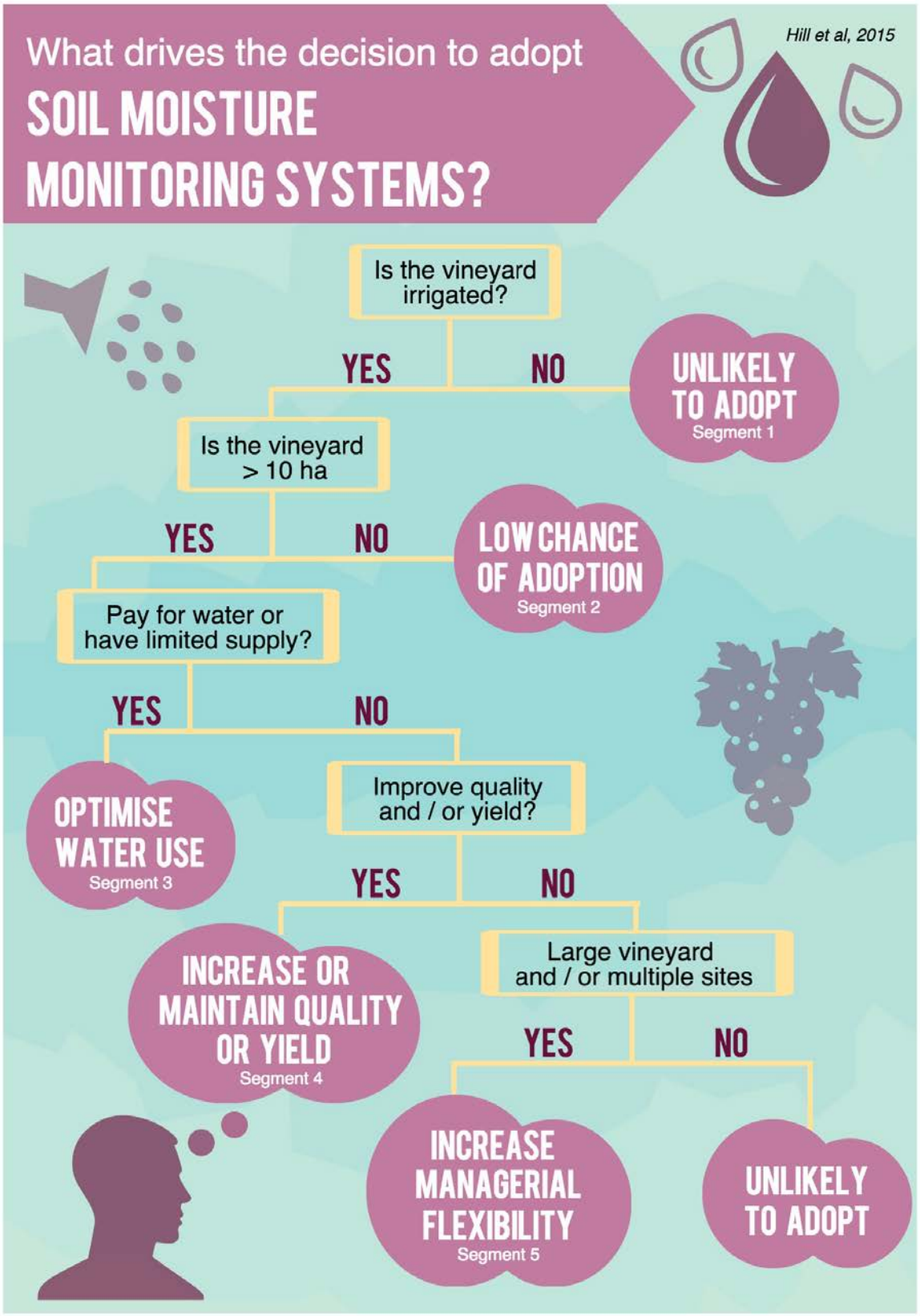


FIGURE 36 MARKET SEGMENTS DESCRIBING BENEFITS SOUGHT THROUGH ADOPTION OF SOIL MOISTURE MONITORING SYSTEMS.

Examples of interview data for people in the various market segments:

Segment 1:

(Facilitator) 'Do you have any use for soil moisture monitoring?'

*(*Grapegrower*) 'Not particularly because I'm not irrigating and there's nothing I can do about it if the soil's dry' (Small vineyard, Tasmania)*

Segment 2:

'I don't need a system to tell me what the soil moisture is doing, my vineyard is so small I can walk around and look at every vine' (Small vineyard, Yarra Valley)

Segment 3:

'I have grapegrowers in the are paying over $3000 a megalitre on a private pipeline which they've funded themselves. So they're well out of pocket and they're very tentative to turn the taps on, but they know that they have to turn them on at critical stages because they can't dry grow vineyards very easily in the Clare. (Viticultural consultant, McLaren Vale)

Segment 4:

'Depending on the variety, if it's at that crucial time at ripening, if you miss a water then that can affect - stresses them out when they don't need to be stressed'. (Large vineyard, Griffith)

Segment 5:

'We have got large pumps and long run times for our irrigation, and we manage a number of sites, so we need to have pretty good soil moisture information to get everything to work out' (Large vineyard, Griffith) .

Adoption of grape and wine R&D outputs:
Who, what and why?

Part C: Design and evaluation of an extension strategy



Australian Government
Australian Grape and Wine Authority

Department of Economic Development, Jobs, Transport & Resources
State Government Victoria

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Executive summary

This research investigated information seeking behavior and adoption of several 'case-study' technologies within the Australian wine industry. The 'market, message, means of communication' framework was then applied to the design of an extension strategy.

It was found that grapegrowers and winemakers used a number of sources when seeking information when considering the adoption of new technologies.

When seeking information, grapegrowers and winemakers look to understand how useful and how easy the technology is to use in their situation (i.e. 'what's in it for me?). Grapegrowers and winemakers then predict the net benefit that should be achieved if the technology were adopted and hence the 'relative advantage' of the innovation over existing technologies, practices or processes.

The most useful information sources were industry networks followed by internet search engines/websites. However a considerable amount of variation exists between individuals and their perceived usefulness of different information sources.

In general, more information is sought and more sources used as the complexity, cost or riskiness of the technology increases.

People often have 'patterns' of source use – for example they may use do an internet search, then talk to a supplier. However, each individual search will be unique, depending on the topic under consideration.

There are some key features of messages that should be included in the design of extension material to make it as usable and attractive to the target audience as possible.

Introduction

In this component of the project: '*Adoption of R&D outputs in the wine industry: who what and why?',* an approach is described for designing or evaluating an extension strategy. The "market, message, media" framework (Huffer, 2012) is used as a starting point in conjunction with project results to develop a series of key questions for consideration when developing an extension program or strategy. Project findings in relation to the adoption of soil moisture monitoring systems are presented as an example to illustrate the principles (page 17, part C). The project results come from face-to-face interview and telephone survey data, collected during the project. Further information on data collection methods and findings are detailed in Results/Discussion Parts A and B of this report.

Applying the framework to extension strategy design or evaluation



FIGURE 1: MARKET, MESSAGE, MEDIA FRAMEWORK (HUFFER 2012) – MODIFIED FOR THE PROJECT.

Market

Understanding who is in the market to adopt a given technology, product or practice change[1] is the first step in designing an effective extension and communication strategy. The 'market' is the population of actual or potential users (Assael, 1998).

Market segmentation is the process of dividing a population into distinct subsets, based on their characteristics. Markets segments can be based on factors including geography, demographics, psychological, psychographic, user-related or situation-specific characteristics, benefits the consumers seek, or a combination of these characteristics (Schiffman *et al.*, 2014). The characteristics of the segments must be easily identified and not likely to change (eg location, owner age, business size) and there must be sufficient people in the segment to warrant targeting it (Schiffman *et al.* 2014). Examples of market segmentation approaches used in agriculture can be found in Kaine (2004), Kaine *et al.* (2005), Wilkinson *et al.* (2011).

[1] Please note that in order to effectively design or evaluate an extension strategy the objective/s and desired outcomes of the extension must be clearly defined.

Market segmentation can be a powerful descriptive tool for investigating how groups of people behave and can be refined or developed as additional information is collected (Quester *et al.* 2010). Data can be collected through face-to-face interviews, telephone or written surveys of grapegrowers or winemakers, service providers and industry experts.

Generally a technology or innovation is not relevant to everyone. By segmenting the market and identifying who is in the market, and their needs, a relevant message can be designed that will be specific and targeted. This is much more likely to attract the attention of the target audience (Assael, 1998, Quester *et al.* 2010, Schiffman *et al.* 2014). Identifying potential market size can inform investment decisions in R&D projects and enable a more accurate evaluation of success than measuring adoption as a percentage of the total population of grapegrowers and winemakers.

The potential market for adoption of technologies in the wine sector can usefully be segmented based on the benefits sought from the technology. For example, our research (see Figure 6) found that grapegrowers with unirrigated vineyards (11% respondents) were highly unlikely to adopt soil moisture monitoring (segment 1). Those who adopted soil moisture monitoring were categorised into the following segments:

- Grapegrowers with small vineyards (under 10 ha) – 35% of respondents (segment 2)
- Grapegrowers who pay for irrigation water and use soil moisture monitoring to reduce input costs (segment 3),
- Grapegrowers who have limited water supply with vineyards that may dry out in critical times, risking production (segment 4)
- Grapegrowers with large vineyards or vineyards on multiple sites who use the technology to support their management decisions and increase managerial flexibility (segment 5).

This approach can assist not only with estimating the size of the market, but also in identifying useful key messages and technology features, to influence the different segments of the market.

Size of business was found to be a strong influence on whether high involvement technologies such as soil moisture monitoring (SMMS) and cross-flow filtration (CFF) were adopted, but not low involvement technologies such as adoption of new chemical sprays in viticulture (NCS) or novel yeasts in winemaking (NY).

Message



The topic of 'message' has been divided into message content and message features.

Message content

Grapegrowers and winemakers seek and use information if they are aware of a problem or opportunity and feel it warrants action. Like consumers who purchase goods or services in response to a perceived need, grapegrowers and winemakers use their internal information (memory and existing knowledge) or if that is not sufficient, external information (ie. written, interpersonal) to:

1. define the opportunity or problem
2. identify the available options and determine their evaluative criteria (i.e. the features of the options most important to them)
3. select the option they perceive will be best for them (Assael, 1998, Schiffman, 2014).

As demonstrated and discussed in earlier sections of this report, this process and the time and effort expended will depend on how *involving* the decision is – that is: how risky, complex and important.

The project findings were that within steps 2 and 3 above, grapegrowers and winemakers seek to identify the potential or 'perceived usefulness' of a new technology, product or practice for them, given their 'context' or unique mix of business location, business scale, physical and technical resources, goals (business and personal) and skills (Kaine 2004).

The interview data revealed that the region a person operated within (or where the technology was to be used) was a particularly important element of the 'context' – especially for grapegrowers.

The **'**perceived ease of use' of a technology or practice has two key aspects:

a) how easy the user thinks the technologies will be to adopt (purchase, install and use); and

b) how easy the user finds continued use of the technology. The time and effort involved in seeking information on the technology and developing skills to use the technology are highly important. These will greatly influence how useful a technology is perceived to be.

The dimensions of perceived usefulness and ease of use have been identified, described and ranked for the case study technologies in Part B of this report.

Message features

Features or characteristics of the message are known as 'source criteria' and can influence why people choose to use a particular source of information.

The majority of survey respondents (86% of grapegrowers and 94% winemakers) used the Internet to seek information about new products and technologies. Of these, 25% of the grapegrower and 31% of winemaker respondents said they had a favourite website. Respondents were asked to identify the preferred attributes of their favourite wine industry website. The responses about preferred attributes ('source criteria') are presented in Table 1, with rank 1 being the most frequently given reason. Source criteria with low response numbers have been omitted.

Rank	Criteria	Definition	Responses
1	Currency	Information is up to date or timely	16%
2	Range/ variety	Provides a variety of information	11%
	Regional information	Contains information specific to regions	9%
3	Relevance	Information is seen to be about the issue at hand in general	8%
4	Range of types of information	When making important decisions people seek a range of information types ie. written, visual, experiential	7%
5	Reliability and accuracy	How reliable is this information? Is it accurate, correct and valid? Can you trust and believe it?	7%
6	Authority/ credibility	Source is reputable, expert, professional or experienced and trustworthy. Users can have confidence in the information	6%
7	Scope/ depth/ ordered	Information is 'layered' or ordered, establishing a relationship among 'levels' of information from simple to more complex, detailed or technical	5%
8	Tangibility/ how practical	The extent to which information relates to real, tangible issues, definite, proven information is provided, hard data or actual numbers are provided	5%
9	Level of information/ target audience	Is it advanced, technical, basic or general information?	5%
10	Usability/ ease of navigation	Source is easy to use; requires little effort to operate or learn to operate, there are no technical problems	5%
11	Accessibility	Source is both available and easy to use: generally convenient. Little effort or cost required for access/operation	5%
12	Statement about organisation	Vision and mission statement- give user insights into organisations aims and objectives, build trust and empathy	4%
13	Originality	Unique or novel information provided	3%
14	Presentation quality	User prefers source because of the way it presents information, it is clear, readable, attractive and easy to follow and understand	2%
	Other		2%

TABLE 1 SOURCE CRITERIA USED BY RESPONDENTS IN ASSESSING WEBSITES

RANK1= MOST FREQUENT RESPONSE, N=307.

DEFINITIONS OF TERMS FROM : BARRY AND SCHAMBER 1998, SAVOLAINEN, 2008.

These criteria were found to be similar to those identified by Savolainen (2008) who studied the information-seeking behaviour of Finnish people in regard to a range of topics. Barry and Schamber (1998) found that specificity (scope/depth), topicality (relevance to issue) and familiarity were the source criteria used by students using print documents, and occupational users of multimedia weather data. Lack of specificity,

accessibility, not being able to understand the information and insufficient clarity and usability were the source criteria used when rejecting websites.

Barry and Schamber (1998) p. 219 concluded that there are 'a finite range of criteria, which are applied consistently across types of information users, problems and source types'.



Means of communication (media[2])

The means of communication selected to communicate the message to the market is also important. Different people prefer different means, or in this case extension tools.

In this project, information sources were divided into:

- Talking to other grapegrowers or winemakers face-to-face or telephone (interpersonal)
- Talking to the retailer or supplier (suppliers)
- Talking to an independent expert such as a consultant or scientist (independent expert)
- Reading articles or reports (reading)
- Seeing it at another vineyard or winery (seeing it)
- Trialling it at their own vineyard or winery (trial)

These categories were based on approaches used in consumer studies (Beatty and Smith, 1987, Kilpatrick *et al.*, 1999 and Blodgett and Hill, 1991). The internet is not included as a source of information, as it is an information 'channel' through which a range of types of information (i.e written, interpersonal) information can be communicated.

General use of communication sources

This study found that grapegrowers and winemakers use a range of information sources, and some are relied upon more heavily than others. In a small pilot study as part of this project, 15 grapegrowers and winemakers were asked to identify information sources and their frequency of use from a list supplied. (Descriptors for each of these sources can be found in Appendix 1.)

Figure 2 shows the preferences of one respondent, a grapegrower/ winemaker from the Hunter Valley (data collected May 2014). This respondent was typical of all the respondents as he listed 'talking to or visiting other grapegrowers or winemakers' among his most frequently used sources of information. All except one respondent said they also frequently used internet searches. The next most frequently used sources were: industry organisation websites, peer reviewed journal articles, regional association meetings and seminars.

The majority of the respondents rarely or never used DVD's, social media, State Department of Agriculture websites, smart phone apps or webinars. Each respondent was unique in their ordering of 'sometimes' and 'rarely' used sources.

[2] The term "means of communication" has been used in this project as it is a broader term than the term "media" used in the original Huffer (2012) framework.

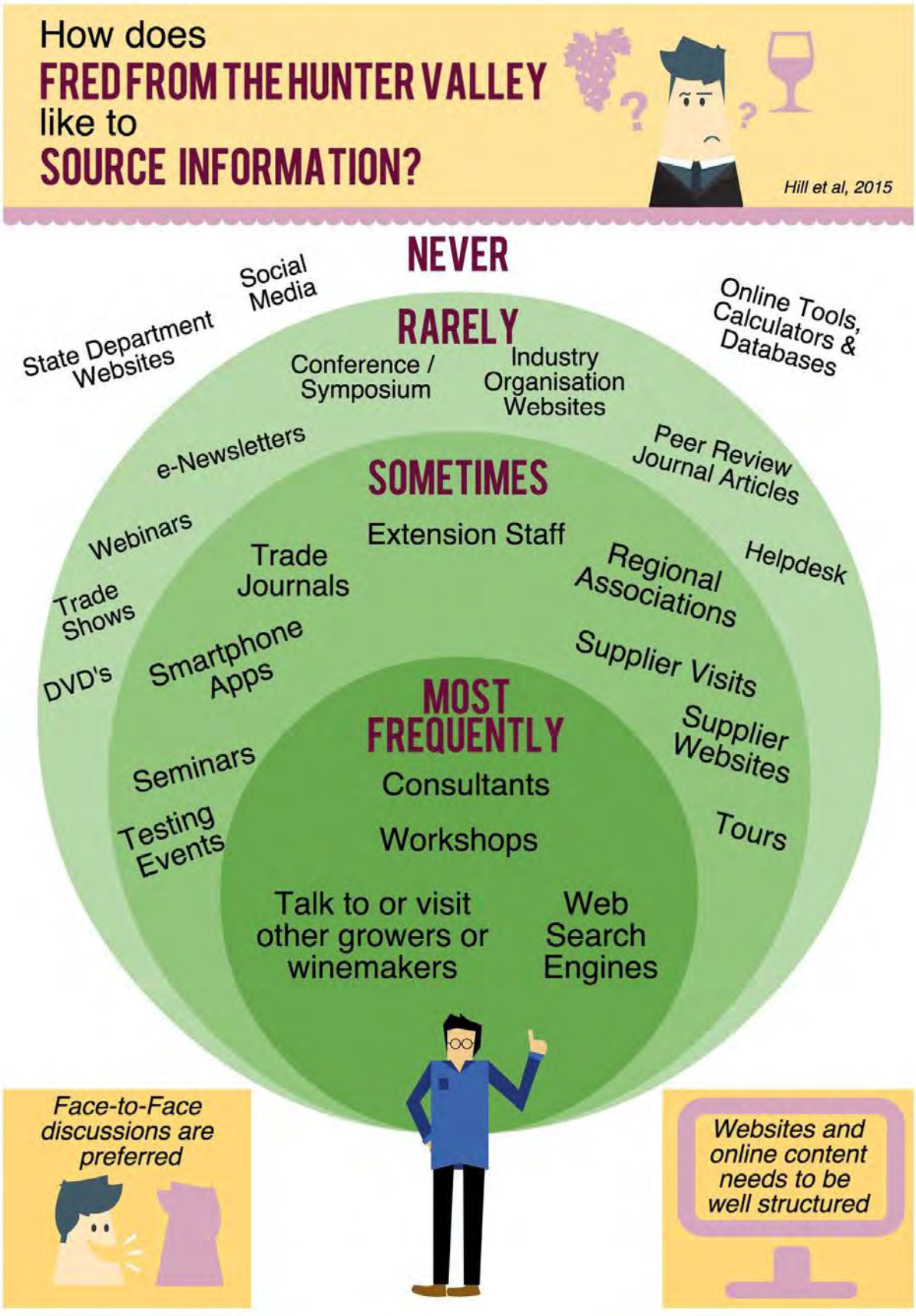


FIGURE 2: PRIORITISED USE OF GENERAL INFORMATION SOURCES OF A GRAPEGROWER/WINEMAKER FROM THE HUNTER VALLEY.

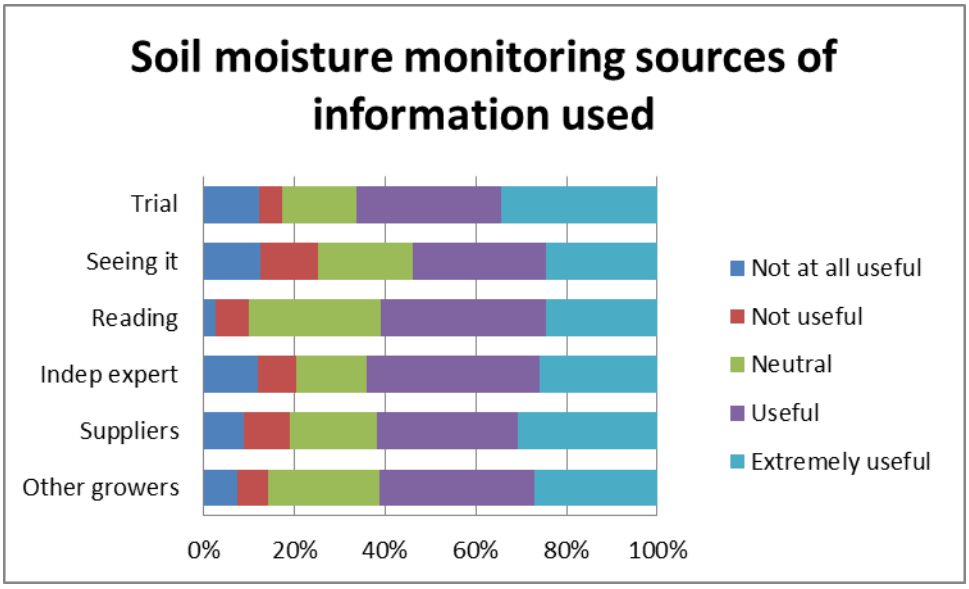
Based on data in Figure 2, If this Hunter Valley winemaker wished to find out some information, he would consciously or unconsciously think about the potential sources of information sources that were easy to access, and select according to experience, preferences and perceived likelihood of obtaining the information. Savolainen (2008) termed this the 'information horizon' - a term which describes 'how sources are mapped in a preference order in an imaginary field'.

Which sources are the most useful?

In the quantitative survey, grapegrowers and winemakers were asked which sources of information they used when considering one of the case study technologies. For grapegrowers, these were soil moisture monitoring and new chemical sprays. For winemakers, these were cross-flow filtration and novel yeasts. Quantitative survey results indicated respondents used most information sources, regardless of the technologies under consideration (high or low involvement). This is contrary to interview (qualitative) data and literature which indicates that the type and number of information sources varies depending on the decision-maker's level of involvement in the technology and purchase decision.

The survey data also showed that there was variation in how useful the respondents found the different sources of information to be. For example, when seeking information about soil moisture monitoring, while over 50% of grapegrowers in the survey found each source of information useful or extremely useful, there was still at least one third of respondents who found each of the sources not useful or neutral at best (refer to Figure 3. This was the case with all the case study technologies and sources of information investigated.

FIGURE 3: SOURCES OF INFORMATION ON SOIL MOISTURE MONITORING SYSTEMS USED BY GRAPEGROWERS



(ADOPTERS AND NON-ADOPTERS) N=155.

Some differences were observed in the use (and usefulness) of information sources between adopters of the different case study technologies. For example, 36% of the grapegrowers that had adopted soil moisture monitoring (SMMS) found supplier information to be extremely useful, with fewer grapegrowers finding that the other sources were extremely useful (table 2). By contrast, independent experts and other grapegrowers were found to be the most useful information sources with regard to novel chemical sprays (NCS), with fewer respondents finding suppliers to be extremely useful.

In the case of both cross-flow filtration (CFF) and novel yeasts (NY), winemakers found trialling the technology to be the most useful, while interpersonal sources also rated highly.

	Trial	Seeing it	Reading	Independent experts	Suppliers	Interpersonal i.e. other grapegrowers/ winemakers
SMMS	26	21	26	30	36	29
NCS	32	13	26	43	30	38
CFF	64	44	31	20	38	59
NY	41	16	38	28	29	37

TABLE 2: PERCENTAGE OF ADOPTERS THAT FOUND THESE SOURCES EXTREMELY USEFUL.

Interpersonal communication and social norms

As described in Part A and B of this report, decision-making by grapegrowers and winemakers was significantly influenced by speaking with their peers. Fellow grapegrowers and winemakers were seen as a valued source used to seek independent verification of information and through the roles of 'social norms' (eg: an experienced colleague or people important to me thought I should use this technology). It was also found that industry networks are often a vital source of support and information leading a grapegrower or winemaker to move from intending to adopt, to actually adopting a technology (see report Part B).

Of the grapegrower and winemaker survey respondents, more than half talked to their peers at least weekly (Table 3).

How often do you see colleagues in the industry?	Daily	Weekly	Monthly	Less than monthly
Grapegrowers	15.2%	47.5%	25.6%	11.8%
Winemakers	17.4%	48.2%	23.9%	10.5%

TABLE 3: FREQUENCY OF GRAPEGROWER AND WINEMAKER CONTACT.

There was found to be a relationship between business size and frequency of contact with other growers or winemakers. Growers and winemakers on small vineyards and wineries are unlikely to see each other daily, but rather weekly, monthly or even less frequently than monthly. Growers and winemakers in large businesses are likely to see each other daily or weekly. This is logical as often there will be a number of growers or winemakers working together in a large business, while at the other extreme many small winemakers and grape growers who are geographically isolated or only work part-time in the business. While it was found that many grapegrowers and winemakers were involved in local or regional groups or associations (70% grapegrowers, 73% winemakers), people from small businesses were less likely to be involved than those from larger vineyards or wineries (data not shown).

Corporate information seeking

The information-seeking behaviour of people working in corporate vineyards and wineries was different from that of people in smaller, family-owned businesses. This is likely to be because they have the benefit of sharing information between various teams and individuals including viticulturists, grapegrower liaison officers, vineyard employees, winemaking teams, cellar and laboratory staff , technical specialists, and often R&D managers. Each of these groups has its own skills, knowledge, experience and personal information networks which forms a highly valuable and diverse body of collective knowledge:

> *'There's enough of us in our winemaking team that [between us] we've visited most of the countries that you can make wine at and we've all come back and shared stories' (#47).*

> *'Because we're so big and quite self-contained we almost have the community within our company as opposed to being a part of it [the wider community]' (#10).*

For additional information please see Part A of this report.

Source criteria for different means of communication

When selecting sources of information, people use 'source criteria' combined with their previous experience (O'Keefe, 2002). An analysis of grapegrower and winemaker interviews provided information on how the various information sources were valued and used.

A summary is presented in Table 4, with further detail in Appendix 2.

TABLE 4: SUMMARISED REASONS WHY VARIOUS INFORMATION SOURCES ARE VALUED AND USED.

Information source	Why is it valued?	Source criteria
Trial	Provides information on how a technology would work in a specific vineyard or winery system	• Unique • Experience based
Magazines and journals	Handy for current news, updates and reference material Some people prefer reading printed, rather than electronic media	• Convenient • Range of topics • Accessible • Understandable
Expert (phone based)	Easy, efficient way to get advice and problem-solve from credible source of expertise. Used to solve a specific technical problem.	• Interactive • Depth of specific and unique knowledge
Consultants	Knowledgeable, skilled source of information and ideas. To help build confidence to implement new ideas or technology, as a 'fresh pair of eyes'	• Range of knowledge • Provide support • Independent
Other winemakers and grapegrowers	A credible, trusted, independent source of (commercially) unbiased information. Information is communicated in a low pressure, understandable, interactive format. A valuable source of, often experience based, regional and context specific information	• Experienced/ knowledgeable/ credible • Understandable • Interactive • Independent • Unique site/region-specific information
Groups	On-going regular forum for sharing information, experience, ideas and support around a common, reasonably complex, area of interest (e.g. alternative varieties, growing pinot noir)	• Provide support • Interactive • Experienced/ knowledgeable • Independent
Suppliers	Provides features of new products, technical information and support	• Unique knowledge • Depth of specific knowledge
Seminar/ workshop/ conferences/ tasting events	Provide awareness of latest industry, technical and market developments. Acts as an interactive forum where often complex, sensory or experiential information is communicated by experts. Enables networking and relationship building opportunities with experts and colleagues	• Interactive • Unique information and knowledge • Opportunity to network
Electronic media - Internet	Provides an accessible (convenient), immediate and extensive range of information. Excellent way to start search for information.	• Range of information • Convenience

This suggests that different means of communication have strengths and weaknesses and are suited to communicating different types, and levels of complexity of information.

How much information is sought?

From the literature it is clear that people actively seek information to reduce uncertainty and risk, or to 'make sense' of something (Case, 2007). Prior to making a purchase, people often seek information to help decide and support their decision. The more important or risky the purchase, the more information they seek from more external sources (Hill and Kaine, 2011).

The marketing literature is clear that consumers expend less effort and time seeking information when making a simple, less important decision, than an important or risky decision. An information search has been found to be less extensive if the seeker has previous experience, and hence knowledge, of the topic (Assael, 1998). Farmers making a high involvement decisions were found to use more and varied sources of information than when making a low involvement decision (Hill and Kaine, 2011).

The same was found in this study. Data from the qualitative study demonstrated that when considering the more low risk technologies, less time and effort was spent on information seeking and the decision-making process. With more expensive or complex technologies the reverse was true.

During this study, interviewees were asked about the behaviours when making a relatively simple decision – in this case, use of a new chemical spray or new yeast. Grapegrowers and winemakers used their experience and usually one or two external sources of information to assist. One grower describes the process of selecting a new chemical spray:

> *'I've used 'Legend®'. I think I first knew about it from a postcard I got in the mail. I read Grapegrower and Winemaker magazine and speak to the local chemical reps. There's lots of other growers around, we bump into each other and chat". (#20).*

This winemaker decided to use a different commercial yeast on a variety new to him:

> *"We tried a new yeast that we got specifically to use on a variety (of wine grape) we hadn't worked with before. We spoke to our suppliers and got their recommendation on a yeast that would suit the variety" (#27).*

When making a more complicated and potentially risky decision (in this case purchasing a cross-flow filtration system or planting a new grape variety), the information search reported by respondents was considerably longer, usually involving multiple types and sources of information. In the following (summarised) exert a winemaker from the Yarra Valley in Victoria described his information seeking in regard to purchase of a wine press:

> *'The first thing is to work out the general design of the press. I did some reading and jumped on the web to sort this out. Then I got in contact with all the press suppliers that I know, and the brands that I know and got their information, but then used, you know word of mouth and spoke to a lot of people that have them, or have that press or using them, and got their impression on it. Because, you know, people that sell presses have generally no idea how to run the bloody things or how to clean them…I also went to the wineries, just in the Yarra, and had a look at them' (#17).*

Another winemaker noted:

> *'If you are going to spend the money on a fairly integral piece of equipment that's going to be in your winery for a minimum of 10 years, you're mad if you don't go and have a good look' (#58).*

Patterns in use of sources

Many of the growers and winemakers appeared to have a pattern of use of information sources. This is consistent with observations by Case (2007) who suggest that people tend to follow habitual patterns, following 'tried and true' methods. For example, this winemaker from Tasmania said that when he hears about something he thinks may be of interest:

> *'I Google it first. I like to know a little bit about what I'm asking about first. Then I'd ring somebody' (#58).*

A winemaker in Margaret River followed a similar process for his searches; however he also had easy access to other expertise:

> *'If you were doing a Google search on X product and you wanted to know about it, and they (a supplier) came up first, they might be the first person you'd ring. It doesn't mean that they'd be the business that you'd use, but you'd then probably take away some information. You may have a look at a few other sites, gather up a chunk of information on it, and then have a chat to everyone else. There are four winemakers working here in different capacities, so there are a lot of ideas bouncing off. There are a lot of people that visit. All our contractors, they're all winemakers. So it's very easy to get information that way' (#53).*

Implications of Findings

Based on the Huffer (2012) "market, message, media" framework and on the research findings from this study, a model and a number of key questions have been developed to assist an extension provider in designing, evaluating or implementing an extension strategy. This model has been tested in a workshop forum with industry and extension specialists and the report presented as a separate part of this final report.

Case study: Soil Moisture Monitoring Systems

Benefit segmentation of the market

MARKET

Market segments can be described based on the benefits sought through adoption. Figure 6 shows the different benefits sought by growers adopting soil moisture monitoring systems.

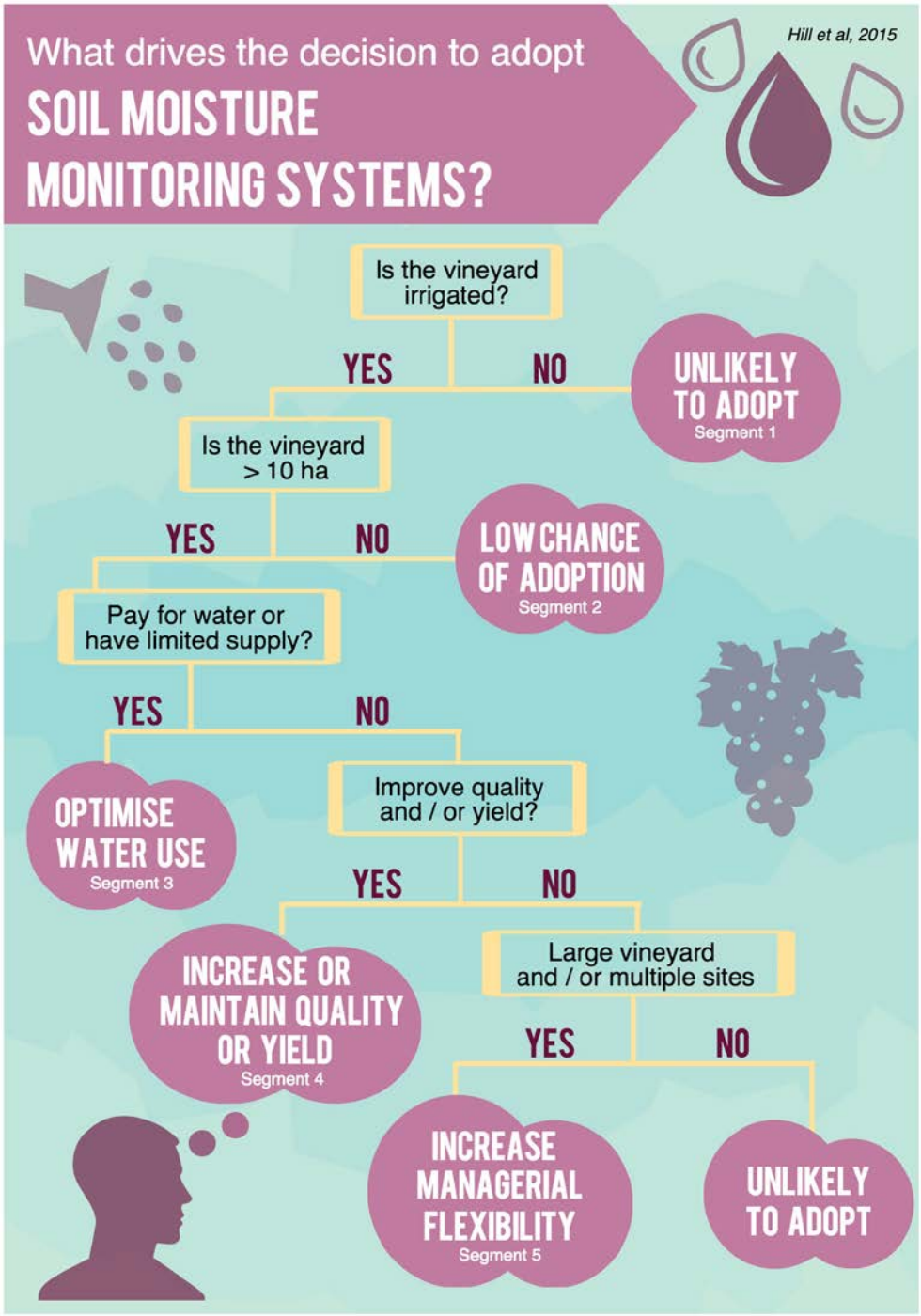


FIGURE 6 MARKET SEGMENTS DESCRIBING BENEFITS SOUGHT THROUGH ADOPTION OF SOIL MOISTURE MONITORING SYSTEMS.

Examples of interview data for people in the various market segments:

Segment 1: **Unlikely to adopt**

> *(Facilitator) 'Do you have any use for soil moisture monitoring?' (Grower) 'Not particularly because I'm not irrigating and there's nothing I can do about it if the soil's dry' (3ha vineyard, Tasmania).*

11% of respondents were on non-irrigated vineyards.

Segment 2: **Relatively low chance of adoption**

> *'I don't need a system to tell me what the soil moisture is doing, my vineyard is so small I can walk around and look at every vine' (5 ha vineyard, Yarra Valley).*

35% respondents with vineyards >10 ha had adopted. At least 50%, and up to 90% of respondents in the other scale categories had adopted.

Segment 3: **Optimise water use**

> *'I have growers who are paying over $3000 a megalitre on a private pipeline which they've funded themselves. So they're well out of pocket and they're very tentative to turn the taps on, but they know that they have to turn them on at critical stages because they can't dry grow vineyards very easily in the Clare. (Viticultural consultant, McLaren Vale)*

Segment 4: **Increase or maintain quality or yield**

> *'Depending on the variety, if it's at that crucial time at ripening, if you miss a water then that can affect - stresses them out when they don't need to be stressed'. (150 ha vineyard, Griffith)*

Segment 5: **Increase managerial flexibility**

> *'We have got large pumps and long run times for our irrigation, and we manage a number of sites, so we need to have pretty good soil moisture information to get everything to work out' (200 ha vineyard, Griffith) .*

72% of respondents with vineyards 100-499 ha, and 85% with vineyards >500 ha had adopted SMMS. Within these segments, growers on expanding vineyards for whom increasing productivity is important and likely, are most likely to adopt.

MESSAGE CONTENT

The growers surveyed sought the following benefits from soil moisture monitoring systems:

- Help them produce the grapes to the desired specifications
- Reduce input costs
- Reduce risk of loss of yield or quality through water stress
- Maintain or improve grape quality
- Generate useful information to manage the vineyard
- Give them more flexibility to irrigate large vineyards and/or prepare for heat events

While growers found the systems easy to use, they also said that:

- Using the system initially required a lot of mental effort
- Using the system initially involved learning new skills
- They had to look for a lot of extra information to be able to use it

Key drivers of adoption – use in designing extension materials

The following example shows advertising material designed to encourage adoption of a soil moisture monitoring system. The dimensions of perceived usefulness addressed in the advertisement have been highlighted (blue colour).

SOIL MOISTURE MONITORING SYSTEM ADVERTISEMENT

Why do we have to monitor soil moisture?

Why monitor soil moisture? The answer: There are a number of possible goals in vineyard irrigation management: to reduce, maintain or increase vine vigour (manage yield- not found to be a key driver in this study), to prevent water stress in drought years (manage risk) or during critical vine development stages, to manage soil salinity, to attempt to target a high skin/juice ratio i.e. small berries or to attempt to alter fruit quality by influencing soluble solids, pH, colour etc (manage quality).

To achieve a particular goal in vineyard management, it is essential to understand plant-water relations at different vine growth stages, effective root zone of the vines, climate, soil type, irrigation system and irrigation system performance and soil water management (generate useful information).

You can't manage what you can't measure and/or you don't understand! Soil moisture monitoring and the knowledge about vine plant-water relationships therefore become essential management tools to achieve these set goals.

Source: http://peakmonitoring.com.au/Case_Study_Viticulture.pdf

An analysis of the messages in this advertising material shows that not all desired features are included. The additional features that have been shown from this research project to be important and have been omitted here are:

- to reduce input costs,
- give growers more flexibility in the vineyard

Information about system set up and ease of use would also be expected to be of interest to growers.

Extension providers could use the approach of identifying the dimensions of perceived usefulness and ease of use in the extension information (message content) and ensuring that the most important dimensions have been addressed.

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Appendix 1: Information sources and suitability for specialised use*

Ref number	Information source	Description of source	Type of information generally suited to convey[#]
1	Seminars	Speakers presenting information to groups	a, b
2	Visits by suppliers	Personal visits by suppliers to generate or support sales of product, equipment or services	a,b,c
3	Consultants	Fee for service consultants	a,b,c
4	Field days	Strong focus on practical application of machinery and equipment	a
5	Trade shows	Commercial focussed promotional days for innovations/new products	a
6	Conferences/symposiums	Large events with a state or national focus	a
7	Regional association meetings/ grower groups	Regular monthly/bimonthly get together to discuss regional issues or specific topics	a,b,c
8	Tasting events	Vary, with a strong focus on trade and sales of wine rather than production	a,c
9	Tours	Tours of vineyards, wastewater plants, wineries to see innovations already in action or used by others	a
10	Workshops	Seminars with a 'hands on' component	a,b
11	Web Search engines	Eg: Google,	a
12	Webinars	Web based information may be interactive	b
13	DVDs	Instructional (new equipment) or promotional (region/wine)	b
14	E-newsletters	Updates on technical and current issues via the web	a
15	Industry organisation websites	Eg: Australian Wine Research Institute, Australian Wine and Grape Authority	a,b
16	State department websites	Eg: SARDI or DEPI	a
17	Supplier websites	Eg: chemical suppliers, winery supplies	a,b
18	Social media	Includes twitter, Facebook, blogs	a
19	Smart phone Apps	Information and tools on phone or iPad	N/A

Ref number	Information source	Description of source	Type of information generally suited to convey[#]
20	On-line tools, calculators, databases	Web based tools used to calculate, find recommended products, or specifications	N/A
21	Helpdesk	Phone organisation for information or support	B,c
22	Journal articles	Peer reviewed articles on research findings	a,b
23	Trade journal publications	Not peer-reviewed, focussed on practical issues and current events eg. Australian and New Zealand Grape Grower and Winemaker	a,b
24	Visit other winemakers/growers	To look at new equipment or products	a,b,c
25	Talk to other winemakers/growers	Seek advice, exchange ideas and/or solve problems	a,b,c

**these extension tools were used in the "circles" study of usefulness of information sources (figure 5)*

[#]this rating is a generalisation and an exercise in testing an idea only.

KEY

a- suited to building awareness
b- suited to conveying complex information
c- suited for building confidence for high involvement decisions
N/A – not applicable

Appendix 2- interview data on why people value different information sources

TABLE 5: GROWER AND WINEMAKER DATA ON WHY THEY USE AN INFORMATION SOURCE.

Source	Why do people use this source?	Illustrative interview quote
Trial	• To see how a technology will work in their own vineyard or winery	*'the data from the trials we ran ourselves are like the bible to us"*
Journals, industry magazines	• To keep up to date and see what's going on out there • The (industry magazine) often covers the basics- good to keep reminding you • They like this form of information • Information can be stored and is then readily available	*'You can look at it and read about it and feel it'* *'I look through old issues to find information'*
Other winemakers or growers	• They have practical experience • They can interpret and explain complex information • Unbiased, trusted source of information and opinions • To bounce ideas off and exchange ideas • They are knowledgeable • You can get information in a low pressure situation • You can look at the new technology in situ… • To get regional information • They have credibility and respect	*'X took it up early and has been doing it for a long time'* *'You can go to them to understand what's happening'* *'It's confidence thing for me to have a second person that I can bounce ideas off'* *'They are good operators, XX has thought everything through'* *'We sit around and have a few beers and chat'* *'You really need to know how something applies in your region'* *'She is a really good operator'*
Group- specific interest)	• On-going forum for sharing information, experiences, ideas and support around a common, reasonably complex, area of interest. (eg: alternative varieties, wine quality, pinot noir)	*'We're all in a gang, it is quite powerful'*
Consultants	• Knowledgeable • For complex tasks such as data, analysis and comparison • Access unique research or knowledge. • Fresh eyes on things, new approaches, reassessing what we do and helping to improve it • Unbiased response to questions • Support in decision-making • Ongoing practical experience • Reducing the search for information • Build confidence in using new technologies	*'I get on the phone to XX, he is the most knowledgeable person in the Riverland (regarding disease)'* *'XX has run his own trials for years'* *'We have gotten to know him and has similar ideas about growing wine that we do. It's just little things that come up that - does this work, does that work, how does this work that we run past him'* *'Otherwise you've got to spend your time doing research and learning about things. We just haven't got time to do that'* *'He helped me choose sites, install, collect and interpret and use the data'*

Source	Why do people use this source?	Illustrative interview quote
Suppliers (positive)	• Provide research information on products • They can be reliable, provide good service • They'll tell you how many wineries are using their product and how successful they are at it • To get different opinions • Creating awareness about new products	*'Their company does a lot of research, a has huge research laboratories, and readily available data. They have done their own trials, and show you samples to back it up'* *'We have a good relationship with our supplier and have known him for years, he is very knowledgeable and I trust him to give us good information'*
Suppliers (negative)	• Sometimes they don't know "enough" about their products • Lack of credibility about the information provided • They are sometimes not used as a starting point in information search	*'People that sell presses have generally no idea how to run the bloody things'* *'You've got to take everything that they say with a grain of salt. A lot of their new stuff (re yeasts) is just smoke and mirrors'.* *'If I go to see a supplier first they're just going to give me the sales pitch'*
Seminar/ workshops/ conferences	• To keep abreast of technical knowledge and the latest developments • They are interactive with the presenters • Participants interact with each other as well • To get reasonably complex information by person, or sensory information • To network • For translating research information	*'I can put my hand up, ask a question. My situation's this, you spoke about that, how could I modify that for my business? I get a direct response on the day'* *'The discussions are stimulating and sometimes things come up and questions get answered about something you've been thinking about'* *'I want to have information delivered by a person rather than a website'* *'If you give us the vehicle to strengthen our local relationships because we all go and listen to you guys, you've actually done more than just present something to us, you've given us a chance to get us all together and the value on that you cannot put a dollar figure on it'* *'Extension is important for pulling information out of the lab and getting it into growers' heads'*
Independent expert advice (eg AWRI)	• It is an easy, efficient and informative way to get all the information from a professional, developed service. • To solve a specific problem no one else could solve • Researched and credible information rather than just simply commercial information. • They have credibility and history	*'I need some advice. I didn't know enough about the product to know whether there'd be any consequences of using it with this different winemaking style'* *'They are the authority and we contact them, we have always contacted them'* *'If i have an issue, I prefer to talk to people preferably about it than try to get graphs or work the way through research papers that are sort of and try to piece together a hypothesis on how my situation might work with that. Yeah, generally I like to just try to contact people'*
Visit other people	• To see how it works on different sites with different capabilities and flexibility and what wine they are making	*'I need to see the technology working, and see if it might be useful in my own business* *'I don't reckon anyone would buy it (expensive machine) sight unseen, with no trial'*
Conduct own trial	• To get see how the technology will perform in their own vineyard, winery	*'We did a trial on sparkling wine. Those results are viewed as gospel'*

Source	Why do people use this source?	Illustrative interview quote
Web based	• You can get a range of information • It is convenient and accessible • To look at demonstrations on YouTube • Access information as it is happening • Start information search with a search engine	*'There's so much you can do online, literature, advice, photos* *'Putting something on Twitter is like shouting out a question'* *'I just Google it and have a look. Then get a little bit of information, and slowly build a picture about what it's all about. Then I ring a company and get them to send me some information.*

Adoption of grape and wine R&D outputs:

Who, what and why?

Part D: Workshop report



Australian Government
Australian Grape and Wine Authority

Department of
Economic Development,
Jobs, Transport & Resources
State Government Victoria

Introduction

As a final component of this project a workshop was designed and delivered in Melbourne on the 18th March 2015. The workshop was designed in conjunction with Andrew Huffer within the following framework:

Current Situation	• Final project report recently released • Delivers outputs that may challenge current 'extension entrenched' approaches vs 'marketing approaches'
Focus	• Identify how the project outputs can be used in conjuction with the 'market, message, means of communication' framework to guide the design of extension strategies for the grape and wine industry
Stakeholders	• AGWA • AWRI, WGGA • DEDJTR (ex DEPI)
Core assumptions	• There is room for improvement in current approaches • Staff look for the opportunities from the project outputs
Key considerations	• What outputs of the project can we adopt? • Who should we test this with?
Workplan	• Workshop with key stakeholders • Test project outputs • Identify options to test outputs

Workshop participants

Fifteen participants attended the workshop. These participants were subject experts (information-seeking behaviour, adoption theory and marketing), extension providers, stakeholders and project team members. A full list of attendees is provided in table 1 below.

Attendees	**Participating organisation**
Jodie Conduit	Adelaide University
Adrian Loschiavo	Australian Grape and Wine Authority
Anne Duncan	Australian Grape and Wine Authority
Geoff Cowey	Australian Wine Research Institute
Paul Petrie	Australian Wine Research Institute
Mark Krstic	Australian Wine Research Institute
Lisa Given	Charles Stuart University
Roger Wilkinson	Department of Economic Development, Jobs, Transport and Resources
Neil Barr	Department of Economic Development, Jobs, Transport and Resources
Megan Hill	Department of Economic Development, Jobs, Transport and Resources
Carole Hollier	Department of Economic Development, Jobs, Transport and Resources
Cathy Botta	Facilitator
Darren Fahey	NSW Department of Primary Industries
Sandy Hathaway	Wine Grape Growers Australia

TABLE 1: WORKSHOP PARTICIPANTS AND ORGANISATIONS

Workshop objectives

The workshop objectives were as follows:

- To communicate project results to the project team and a broader industry audience
- To obtain expert input into the project results
- To answer participant questions relating to the results and their application
- To test the framework with workshop participants using a case study topic and identify gaps.

Workshop content



The workshop was divided into four sections with the first three following the 'market, message, means of communication' framework.

Section 1: Market

Presenter Megan Hill

Section 2: Message

Presenters: Neil Barr and Roger Wilkinson

Section 3: Means of communication

Presenter Lisa Given

Section 4: Case study

Presenter: Sandy Hathaway

Tables 1, 2 and 3 contain the key messages from the presentations, the practical implications and relevant questions raised by participants.

Table 4 details the biosecurity case study information.

Appendix 2 provides the presentation slides and handout material.

Key message- MARKET	Practical implications	Questions/ comments raised by participants
The wine and grape industry is diverse and includes vineyards of a range of scales, vineyard and winery businesses, wineries of a range of sizes and business models including multinational through to hobby and service providers	When thinking about adoption of technology or other changes social and market research can be used to identify which business and who is being considered. Thinking something will be 'adopted by industry' is too vague for effective program design, target market identification and evaluation of success	It is important to understand the 'value proposition' of the technology to the target audience (i.e what's in it for me?')
Market segmentation is the process of identifying a target audience. This can be based on a number of variables such as geographic, psychological, benefits sought or use characteristics	How a market is segmented depends on the topic (i.e technology, event etc) and how the segmentation is to be used	Tailor/target the message to different segments- not one size fits all
Grapegrowers and winemakers in expanding business were found to be adopting capital intensive technologies to support their aim to increase production or scale. They were also interesting in increasing efficiency.	Increases in productivity are important and likely to many of this group. They have the capacity and motivation to adopt technologies, and represent the largest target market for capital intensive changes (i.e. wine presses, tanks, barrel stores, alternative grape varieties)	
Those in businesses staying steady in size or production were interested in increasing business efficiency.	These people are interested in technologies that provided clear short to medium term benefits (i.e. flotation, energy saving technologies)	The personal characteristics of the decision maker, their philosophy in regard to their business will influence their adoption behavior
People in contracting businesses were not investing capital but some were still using some new products. Over 50% of this group were uninterested in increasing productivity.	People in this group are unlikely to invest in new technologies, but were purchasing products with short term benefits (i.e novel yeast, new chemical sprays)	

Key message- MARKET	Practical implications	Questions/ comments raised by participants
People in each of these groups can be found in all wine regions, scale business and age groups. Though the expanding group contains more young people and larger scale business than the other groups, while contracting business tend to be owned by older people in smaller businesses	While people in the expanding group are the most likely target audience for emerging, particularly capital intensive technologies, it would be difficult to work with them exclusively. Rather these figures enable one to start gaining an idea of potential overall market size, and more detailed market information will be required to design and evaluate an extension strategy	
Benefit segmentation is a commonly used marketing tool that provides a means of identifying what benefits a novel technology, product or practice change may provide, and hence who will be in the market for this innovation.	Benefit segmentations are an effective way of identifying a target audience and the benefits they are seeking- 'What's in it for me' which informs the extension messages likely to be effective Each technology must be considered individually, though there may be common benefits sought (i.e saving labour, increasing quality)	The role of 'farm context'- which includes: business outlook, region, previous adoption, number of employees and structure of business, in determining relevance and potential benefit

TABLE 2: KEY MESSAGES, PRACTICAL IMPLICATIONS AND PARTICIPANT QUESTIONS OR COMMENTS IN RELATION TO THE 'MARKET' COMPONENT OF THE FRAMEWORK.

Key message- MESSAGE	Practical implications	Questions/ comments raised by participants
The history of the field of adoption research including the Technology Accept Model 2	Adoption of innovations has been studied over many years. There are a range of possible approaches. A robust model (TAM2) that seemed best suited to this study was selected	
The TAM2 model- its commonality of constructs with Everett Rogers 'relative advantage', 'trailability'	TAM2 is a practical model to use, grounded in enduring concepts from the field of adoption research	
The key concepts of TAM2- the roles of perceived usefulness, ease of use, experience, social norms etc. in influencing adoption behaviour	The application and testing of these concepts/ variable on case study technologies in the wine industry will enable key drivers of adoption to be identified	The variables of cost and business scale need to be included directly in the model
Perceived usefulness (ie. relative advantage) emerged as the key driver for all technologies	The dimensions of perceived usefulness varied between technologies (i.e saving labour, increasing quality). Business scale emerged as a key determinant of perceived usefulness for cross flow filtration and soil moisture monitoring	Can we identify perceived usefulness and perceived ease of use for a new innovation? How will the user view the innovation? Do (mis)perceptions need to be changed? (e.g., influence of non/dis-adopters?). Provide proof to correct these.
However the correlation between 'intention' to adopt and 'actual' adoption was relatively poor leading to further analysis identifying the important drivers at each stage of the decision process	Social norms (i.e opinions of respected people) emerged as a significant factor separating the 'intending' from the 'actual' adopters	How can social norms be influences through an extension program?

TABLE 3: KEY MESSAGES, PRACTICAL IMPLICATIONS AND PARTICIPANT QUESTIONS OR COMMENTS IN RELATION TO THE 'MESSAGE' COMPONENT OF THE FRAMEWORK.

Key message- MEANS OF COMMUNICATION	Practical/ project implications	Questions/ comments raised by participants
The field of information behaviour research is well established and considerable research has been conducted in other industries	This field of research offers a range of methods and results that will be relevant to the design of information for the wine and grape industry	
Dervin's 10 myths of information seeking were presented (see Appendix 1)	Provide information in various formats to suit various needs Tailor content to suit specific contexts Match source to user "value" criteria	Are we falling into the "10 myths" traps?
People use a range of sources when seeking information. Choice of source depends on various factors e.g. familiarity, past success, ease of access	People tend to use fewer sources when the decision is not risky or important. When it is highly involving (i.e. risky or important) one key source of information was seeing the technology in action and talking to other growers or winemakers who had adopted	'Point of need' communication activities are suited for low involvement decisions 'Point of need' also required for seasonal or event specific topics (e.g. smoke, pest incursions)
Human contact is vitally important, with 'talking to or visiting other growers or winemakers' listed as important in information seeking. The content of the information shared may be secondary to emotional support and reinforcement of existing beliefs. People go to trusted sources that are closest to them, particularly if they have found them helpful in the past	This correlates with interview data that demonstrates that people not only go to extension events for the formal, presented information, but to network, exchange ideas and hear other peoples questions and comments	Ensure there is sufficient time and opportunity for participants and speakers to make links and connections at events. Set up small groups within extension events to enhance the message? Set up clusters or networks to focus on topics
Many of the growers and winemakers surveyed participate in local groups	Extension providers already work through local groups.	
The majority of survey respondents look on the web for research information on new products and technologies	Provision of some types of information via the web will be effective	

Key message- MEANS OF COMMUNICATION	Practical/ project implications	Questions/ comments raised by participants
Many other sources of information were identified e.g. industry organisations, peer-reviewed journal articles, seminars	Extension information is one of many sources of information used by people in the wine and grape industry. Yet when considering new technologies people are still looking for 'what's in it for me'. Credible, objective, trustworthy information to help them identify this is valued	

TABLE 4: KEY MESSAGES, PRACTICAL IMPLICATIONS AND PARTICIPANT QUESTIONS OR COMMENTS IN RELATION TO THE 'MEANS OF COMMUNICATION' COMPONENT OF THE FRAMEWORK.

Biosecurity case study

The case study looked at the adoption of a wash down bay. A wash down bay is a sealed area with a pressure hose. A wash down bay allows vineyard employees, contractors and visitors to clean their vehicles and equipment in an easily managed area where wash water is contained. The aim is to ensure that plant material, insects and soil are not moved into or out of the vineyard.

The format for this session was for the presenter to provide some background on the purpose of the washdown bay (the "technology" to be adopted) and the proposed extension strategy. Each workshop participant then took turns to ask a question around the 'market, message, means of communication' information that could be applied to the design of an effective extension strategy that would encourage adoption. Following that, the participants each gave a recommendation relating to the proposed program design.

The questions and recommendations by the interview participants have been sorted under a number of themes (Table 4).

Theme	Workshop participant question/ recommendations relating to adopting wash-down bays
Market questions	What is the target audience/s?
	Where are they located? Where are the phylloxera or high risk areas?
	What does 'success' look like?
Market recommend-ation	Identify the target audiences and market segments for this practice change and information
Message questions	What steps does the grower need to take to install a wash-down bay (i.e access plans, identify location, seek council permission etc.)
	What are the benefits of adopting?
	What other benefits might adopting a wash down bay provide?
	How many other growers have a wash down bay?
	What pests will it stop you getting in your vineyard?
	Why does it need to be done now?
	What is the current practice? Are existing systems using pressure hoses on the driveway satisfactory?
	What is the risk and how much will it cost?
	Are community facilities available? Provide alternative options

Message recommendations	Develop a business case for adoption
	Change the name 'biosecurity' to something more catchy and clear to the target audience
	Include an emotional aspect in the message eg. 'My vines were ruined by this pest'
	Develop different messages and strategies for the different market segments
Means of communication recommendations	Use case study information and grower testimonials on these topics: • the negative aspects of a pest infestation • what works and what doesn't in building, siting and using a wash down bay
	Link with existing industry information
	Provide technical information (written) on bay design and building
Other recommend-ations	Look at other industries for examples of how they have encouraged practice change e.g. Recycling. Look for ideas and approaches that might be relevant
	Explore opportunities to link with other programs ie. Entwine or Quality Assurance programs

TABLE 5: BIOSECURITY QUESTIONS AND RECOMMENDATIONS GENERATED BY WORKSHOP PARTICIPANTS.

Conclusion

The workshop took the approach of:

1. presenting the information and

2. working through a case study to enable participants to apply the information

This approach was found to be effective in demonstrating the use of the 'market, message and means of communication' framework for identifying the key elements of, and information required to design an extension strategy.

A process of working through selected questions associated with this framework is presented in Appendix 1. This process could be applied to most technologies, products or practice changes.

It was also found that having the workshop participants collaboratively work on a case study generated an extensive range of opinions, approaches and ideas. It is recommended that this approach be further tested to determine its applicability for general use in extension program design.

Appendix 1: Market, message, means of communication questions



General

1. What is the specific and adoptable technology, product or practice (the innovation) the strategy is being designed for?

2. What will success look like?

Market

3. Who might adopt the innovation?

- Who/ where is the innovation likely to be relevant?
  - Grape grower, winemaker, both, other
  - Specific regions, climatic zones or disease areas
  - Growers/ winemakers with specific qualities or styles
  - Large, medium or small businesses
- Who will obtain benefits from adopting the innovation?
- Describe market segments based on these benefits
- Can these segments be quantified (industry data, survey data)?

Some approaches to market segmentation were outlined. Who is 'in the market' for the innovation? What does that mean for program adoption targets and evaluation? What will 'success' look like?

Message

4. Does the information enable the grapegrower or winemaker to identify the potential benefits and costs of the innovation to their business?

Benefits identified in this project as key drivers include:

- workplace safety
- managerial flexibility
- reducing input costs
- saving time
- increasing quality

In this project some key drivers of adoption and dis-adoption were identified. How can this information be applied to the development of extension messages?

5. Does the information enable the grape grower or winemaker identify the potential costs in terms of:

- Financial cost
- Ease of installation, set up and ongoing use
- Obtaining or developing new skills and knowledge
- Lost opportunity cost
- Investment of time

Means of communication

5. Which media or package of communication methods would be best suited to communicating the required information?

> **There are a number of information 'myths' and principles for information design. Bearing these in mind, along with the target audience, messages to be communicated and available resources, which means, or combination of communication and extension methods will be most effective to achieve program and innovation adoption goals?**

Will adoption be a low or high involvement decision to most people?

If low involvement people will seek less detailed information, and use fewer sources than high involvement decisions.

Social norms were found to be very important; can this provide an opportunity for you?

What is the best combination of communication tools in relation to the complexity and nature of the information to be communicated?

Experiential information (seeing the innovation, trialling it) is also important when considering highly involving innovations.

Does your web site meet source criteria around accessibility, clarity etc.?

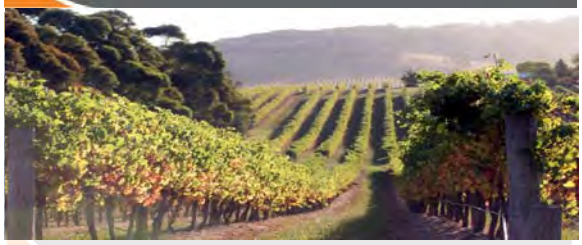
The web was found to be a popular starting point for new searches.

What can you do to get your means of communication on people's information horizons and pathways?

Appendix 2 Workshop presentations and handout

THE MARKET FOR R&D OUTPUTS

Megan Hill



Workshop presentation Attwood 18th March 2015

Department of Environment and Primary Industries, Victoria

Wine industry is diverse



- i.e. large, medium and small wineries
- Wineries and vineyard businesses
- Multinational, Group, Family owned
- Therefore when talking about adoption of innovations it is helpful

to drill down and think about who might adopt…











Market and Social Research

- Market- population of actual and potential consumers/ adopters
- Market segmentation- the process of dividing a potential market into distinct subsets of consumers based on common features
- Create market segments based on observable or measurable characteristics
- Bases and variables for segmentation- geographic, demographic, psychological, benefit etc..
- This presentation will look at an industry wide and an individual technology segmentation

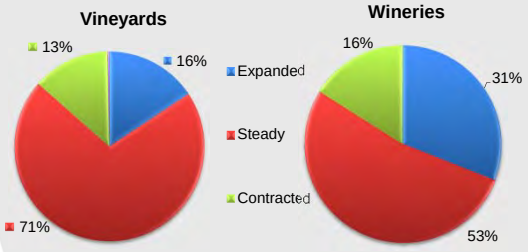
Industry wide segmentation- who is most likely to adopt technologies?

Wineries and vineyards that are **expanding** in size or production- capital expenditure on new tanks, presses, varieties of grapes, irrigation, machinery

If they are staying **steady**, purchasing technologies to reduce costs or increase quality e.g. flotation, energy saving technologies

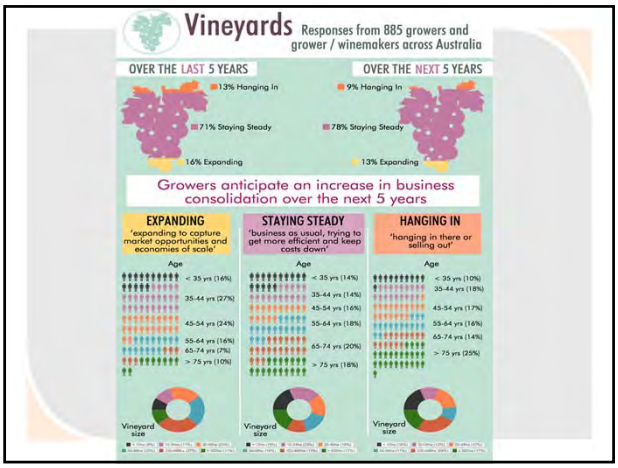
If **contracting**- no capital investment, some products with short term benefits e.g. yeasts, chemicals

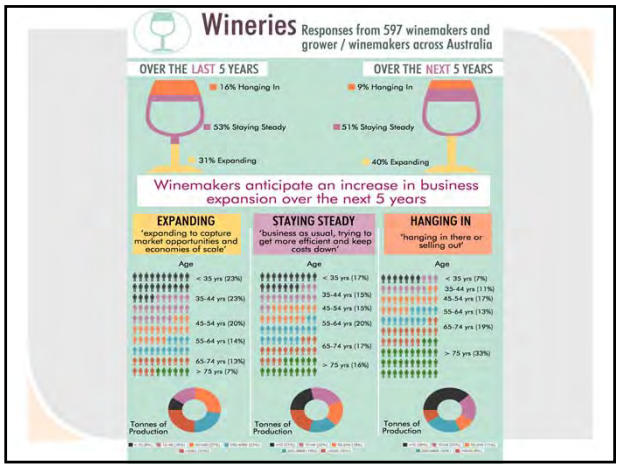
Business outlook- last five years



People in the 'expanding' vineyard and winery group are:

- More likely to say that increasing productivity is important and that they are likely to achieve it
- Are found in all wine regions
- In all age groups and scale business as shown in the next two slides…





Differences?

		Expanding	Steady	Contracting
Are involved in a local group?	**Growers**	**76%**	**70%**	**66%**
	Winemakers	78%	73%	63%
I look on the web for research information on new products and technologies	**Growers**	**92%**	**85%**	**87%**
	Winemakers	99%	92%	94%
More likely to see colleagues daily	**Growers**	**23%**	**14%**	**12%**
	Winemakers	26%	15%	11%
I often contact state or national organisations for information	**Growers**	**6%**	**6%**	**4%**
	Winemakers	7%	8%	7%
I often contact industry organisations for research information	**Growers**	**12%**	**9%**	**17%**
	Winemakers	19%	13%	21%

So…

- Business outlook makes sense when thinking about the adoption of innovations at an industry level….
- But to identify the market and key messages technologies must be considered on an individual basis.
- The following slide gives information (from interview data) on drivers for adopting soil moisture monitoring

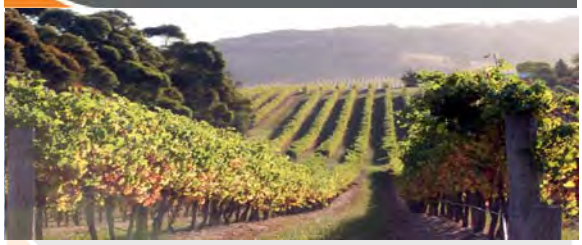
Soil moisture monitoring



In conclusion

- Business outlook can be used to inform overall estimates of market size
- But to get to know the market for your specific innovation, information or brand you need to get more detailed information for example – benefit segmentation
- Which tells you about the messages……

THE MESSAGE-
Roger Wilkinson and Neil Barr



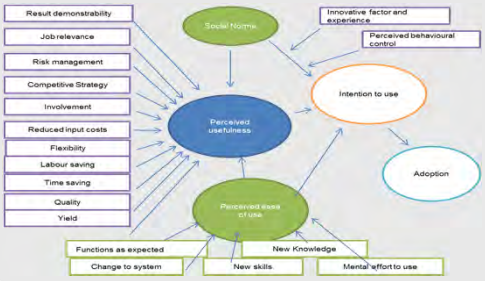
Workshop presentation Attwood 18th March 2015

Department of Environment and Primary Industries, Victoria

The extension message must appeal to the target audience

- And it is useful to know what are the key drivers of adoption?
- To identify this a published adoption theory- the Technology Acceptance Model 2 was used and analysed using structural equation modelling

The Technology Acceptance Model 2 with various wine industry dimensions of perceived usefulness



Influences on intention to use

	Soil moisture monitoring	New chemical sprays	Cross-flow filtration	New yeasts
Perceived usefulness	0.71 ***	0.65 ***	0.65 ***	0.73 ***
Social norms	0.084 *	0.36 ***	0.32 ***	-0.21 **
Perceived behavioural control	0.095 **	0.24 ***	0.36 ***	
Perceived ease of use	0.050 **		0.10 ***	
Experience			0.36 ***	-0.12 ***
Innovative factor			-0.29 ***	0.17 ***

Perceived usefulness

SOIL MOISTURE
1. Reduce input costs
2. Risk management
3. Improve grape quality
4. Generate useful information
5. Management and flexibility

NOVEL YEASTS
1. Improve or maintain quality
2. Save time
3. Demonstrability of result
4. Risk management

CROSS FLOW
1. Reduce input costs
2. Safety
3. Improve or maintain quality
4. Management and flexibility

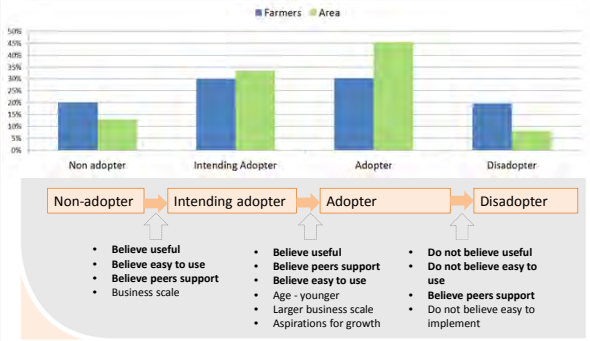


However…

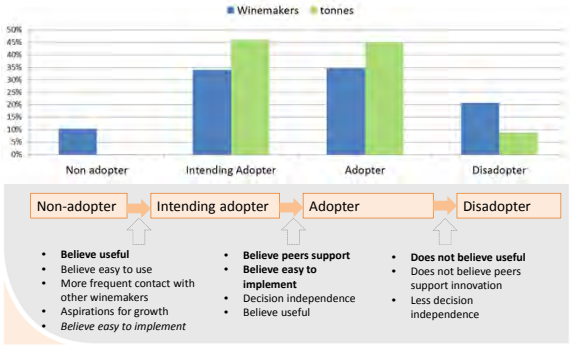
The structural equation modelling resulted in reasonable (according to the literature) results in relation to 'intention to adopt' however poor results in relation to actual respondent adoption…

So Neil Barr reanalysed the results and divided the respondent population into four groups. The following slides are examples of this analysis. The variables presented are the statistically significant drivers

New chemical sprays



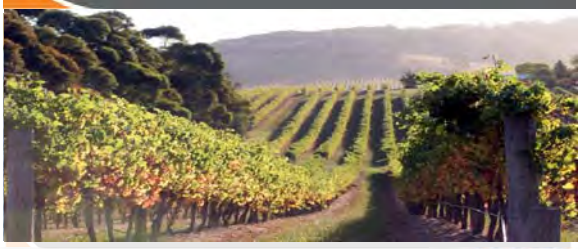
Novel yeasts



In conclusion…

- Perceived usefulness is the key driver of adoption
- Business outlook (i.e expanding, steady or contraction) influences adoption
- Social norms and frequency of contract with other growers or winemakers emerged as significant
- The messages, based on benefits sought, for each technology can be identified and used to underpin extension
- People seek information to determine perceived usefulness and ease of use of a technology

THE MEANS OF COMMUNICATION
Lisa Given



Workshop presentation Attwood 18th March 2015

Department of Environment and Primary Industries, Victoria

Information Behavior Research

- "Umbrella Concept' that takes a user-centred approach to the study of people's:
- Information needs, gaps…
- Information seeking, searching, retrieval…
- Information avoidance, serendipity, overload…
- Sources, channels, technologies, formats…

•Holistic – and attends to human complexities:

- Emotion, affect, personality…
- Situations, contexts…

Study – Information Behaviour of Grape Growers & Winemakers

- Asked the questions:
- What information sources do they use to inform decision making related to adoption or purchase of technologies?
- How much information is sought?
- Why do they use a particular source – and what are they looking for?
- What does this mean for design of extension?

Key Findings: What do they Use?

1. All respondents listed talking to or visiting other growers or winemakers as most frequently used source of information
   - Information shared by experienced colleagues, friends, etc. = significant driver of adoption
2. All but one used web search engines frequently
3. Next – industry organisation websites, peer-reviewed journal articles, regional association meetings and seminars
4. Majority never used DVDs, social media, state department websites, phone apps, webinars

Key Findings: How Much is Sought?

•From qualitative study:

1. Less time/effort spent on low risk case study technologies (e.g., new chemical sprays; novel yeasts)
2. More time/effort for more expensive or complex technologies (e.g., soil moisture monitoring)
   - Various information sources used
   - Longer search period

Key Findings: Example – Wine Press Purchase

"The first thing is to work out the general design of the press. I did some reading and jumped on the web to sort this out. Then I got in contact with all the press suppliers that I know, and the brands that I know and got their information, but then used, you know word of mouth and spoke to a lot of people that have them, or have that press or using them, and got their impression on it. Because, you know, people that sell presses have generally no idea how to run the bloody things or how to clean them…I also went to the wineries, just in the Yarra, and had a look at them."

Key Findings: select a means of communication depending on….

1. Ease of access/availability – which can be greater in large corporations
2. Ease of use
3. Interpersonal connections – especially through known and trusted contacts
4. Previous experience/familiarity
5. Source credibility, trustworthiness – especially free from (commercial) bias

Overall – Key Elements for Information Seeking & Adoption

•Perceived Usefulness

•Perceived Ease of Use

- In context of their business – location, scale, mix of existing physical and technical resources
- In context of their goals (business and personal)
- In context of their skills

Implications for Design of Extension

1) Need to look beyond "source type"
   - They "use a range of information sources, some more often than others"
   - Very common – as source use is linked to various factors, not just information (e.g., familiarity; past success; ease of access)

2) Human contact is vitally important
   - Most frequent activity was "talking to or visiting other growers or winemakers"
   - Very common – people tend to go to trusted sources that are closest to them, particularly those who have been helpful in the past
   - The content of the information shared may be secondary to emotional support, reinforcement of existing beliefs, etc.

Implications for Design of Extension

3) Take broader context into account

- There was “a relationship between business size and frequency of contact with other growers or winemakers”
- Context – geographic, social, technological, affective, business size, etc. – all play a role in source availability, selection and use
- And – contexts change over time (e.g., social media use among newly trained individuals)

Conclusions……

- Extensive research has been conducted on understanding people’s information seeking behavior
- People use a range of formal and informal sources of information
- More sources are used when a decision is complex, risky or important
- The means of communication should suit the type of information required (i.e. technical, experiential)
- People choose sources based on their personal source criteria-these can/ have been identified

Charles Sturt University

SCHOOL of INFORMATION STUDIES
FACULTY of EDUCATION

Locked Bag 588
Boorooma Street
WAGGA WAGGA NSW 2678

Tel: +61 2 6933 4092
Fax: +61 2 6933 2733
Email: lgiven@csu.edu.au
www.csu.edu.au/sis

Prof Lisa Given (lgiven@csu.edu.au)

Dervin's 10 Myths of Information Seeking
As cited in: Case, D.O. 2012. *Looking for Information, pp. 7-10*. Emerald Press.

1. ***Only "objective" information is valuable***
People tend to rely on easily accessible information, including from family and friends & settle for the first satisfactory (not best) solution

2. ***More information is always better***
Overload leads to shutting down; problem is in interpreting, understanding and applying information that exists

3. ***Objective information can be transmitted out of context***
People tend to ignore isolated facts & need to see connections to other facts, personal beliefs, emotions, etc.

4. ***Information can only be acquired through formal sources***
Common presumption – but very rare; people tend to rely regularly on friends, family and other "informal" sources

5. ***There is relevant information for every need***
Information cannot substitute for human needs – such as desire to learn, understand – or to connect on an emotional level

6. ***It is always possible to make information available or accessible***
People's needs are vague, ambiguous and constantly changing; formal systems of information are limited in what they can provide

7. ***Every need situation has a solution***
Sometimes people are looking for something that a canned response (e.g., a report) cannot solve – such as reassurance, understanding, empathy, etc. However, information systems (such as web search engines) will deliver a response – whether it's useful or not to the person

8. ***Functional units of information (e.g., books; webinars) always fit the needs of individuals***
People's "functional units" are responses, solutions, ideas, friendships, etc., which are not always addressed by information sources

9. ***Time and space — individual situations — can be ignored in addressing information seeking and use***
The individual's perception/definition of the situation (rather than the situation itself) shape information needs

10. ***People make easy, conflict-free connections between external information and their internal reality***
Change in focus needed from "what" or "how" people read or view information to "why" they do what they do. We lack understanding about how people inform themselves, how this shifts over time, the sense they make of their worlds, etc.

Key Project Findings – Information Behaviour of Grape Growers & Winemakers

What do they Use?

All respondents listed talking to or visiting other growers or winemakers as most frequently used source of information

Information shared by experienced colleagues, friends, etc. = significant driver of adoption

2. All but one used web search engines frequently
3. Next – industry organisation websites, peer-reviewed journal articles, regional association meetings and seminars
4. Majority never used DVDs, social media, state department websites, phone apps, webinars

How Much is Sought?

From qualitative study:

1. Less time/effort spent on low risk case study technologies (e.g., new chemical sprays; novel yeasts)
2. More time/effort for more expensive or complex technologies (e.g., soil moisture monitoring)

Various information sources used

Longer search period

Why Use a Particular Source?

From qualitative study:

1. Ease of access/availability – which can be greater in large corporations
2. Ease of use
3. Interpersonal connections – esp. known, trusted contacts
4. Previous experience/familiarity
5. Source credibility, trustworthiness – esp. free from (commercial) bias

Key Elements for Information Seeking & Adoption

Perceived Usefulness

Perceived Ease of Use

- In context of their business – location, scale, mix of existing physical and technical resources
- In context of their goals (business and personal)
- In context of their skills

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Adoption of grape and wine R&D outputs: Who, what and why?

Part E: Literature review



Ben Rowbottom and Megan Hill

Department of Environment and Primary Industries, Tatura.

August 2013

Australian Government
Australian Grape and Wine Authority

Department of Economic Development, Jobs, Transport & Resources
State Government Victoria

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Introduction

This review has been compiled to support the Australian Grape and Wine Authority funded project: "Adoption of R&D outputs in the wine industry" project.

The key research question for this component of the project is: **why does a winemaker or grape grower adopt (or not adopt) an innovation?**

To answer this research question, an adoption theory (and model) needed to be selected that was most suited to understanding the process of adoption of selected innovations in the grape and wine industry. These innovations were: cross flow filtration and novel yeasts in the winery, and soil moisture monitoring and precision viticulture in the vineyard.

Why select a theory/ model to underpin this section of the work? A theory is a group of ideas or statements to explain something. If sound a theory will have predictive power. A model is a diagram showing the relationship between the components of the theory. By basing the research on a published theory/ model it will be grounded in the existing literature and thinking, ensuring it has research rigour and credibility.

The models reviewed in this paper all seek to describe and predict behaviour change in regard to the adoption of technological innovations and have been published in peer-reviewed journals, ensuring their rigour and quality. In order to determine which model would best suit the project needs, the models were assessed against the following criteria:

1. amenable to phone survey techniques for data collection
2. simple enough to be tested using a practical sample size (ie <1000 samples)
3. included the majority of the key concepts considered to influence adoption (eg social norms etc)
4. predictive power determined in previous research applications
5. previous successful use on agricultural and agribusiness technologies

This paper provides a brief overview of the models that were considered in making the selection. The discussion and conclusion section at the end of the paper identifies the chosen model and the rationale for the decision.

The models described in this paper are:

✶ **Diffusion of Innovations (DOI)**	Rogers 1962; Rogers 2003
✶ **Theory of Reasoned Action (TRA)**	Fishbein and Ajzen 1975
✶ **Theory of Planned Behaviour (TPB)**	Ajzen 1985
✶ **Technology Acceptance Model (TAM)**	Davis 1985
✶ **Technology-to-Performance Change Model**	Goodhue and Thompson 1995
✶ **Perceived Characteristics of Innovating**	Moore and Benbasat 1991
✶ **Model of Consumer Action**	Bagozzi 2006b; Bagozzi 2006a
✶ **The Kaine Framework**	Kaine and Bewsell 2005; Kaine 2004; Kaine 2008

This paper begins with a diagram showing the relationships between these models. Each model and how it has been applied is then described along with some general conclusions about their use. Their relevance to the "Adoption of R&D outputs in the wine industry" project, and selection criteria is summarised at the end of this paper.

Evolution of adoption theories

The adoption of innovations has been studied by many disciplines including social psychology, rural sociology, marketing, economics and sociology; and from a range of perspectives: the individual, groups, organisation or industry. There are over 60 different models of behaviour and behaviour change that have been covered in previous reviews (Jackson 2005; Darnton 2008b; Darnton 2008a).

The illustration on the following page (Figure 1) depicts the evolution and divergence of behaviour change models over time.

Theories are displayed in boxes containing their name and key foundational publications. Initial founding theories are depicted towards the left of the diagram, with newer theories towards the right; however the time scale from left to right is not intended to be linear. The theories are grouped vertically into five broad paradigms that relate to behaviour theory — social psychology, attitude theory, sociology, cognitive response paradigm and systems theory. The arrows between theories depict the evolutionary paths of the theories, where newer theories have borrowed, developed or evolved from one or more previous theories. Arrows that do not emerge from any particular box are imply that the theory the arrow points towards is founded in broad thinking from the paradigm in which the arrow begins.

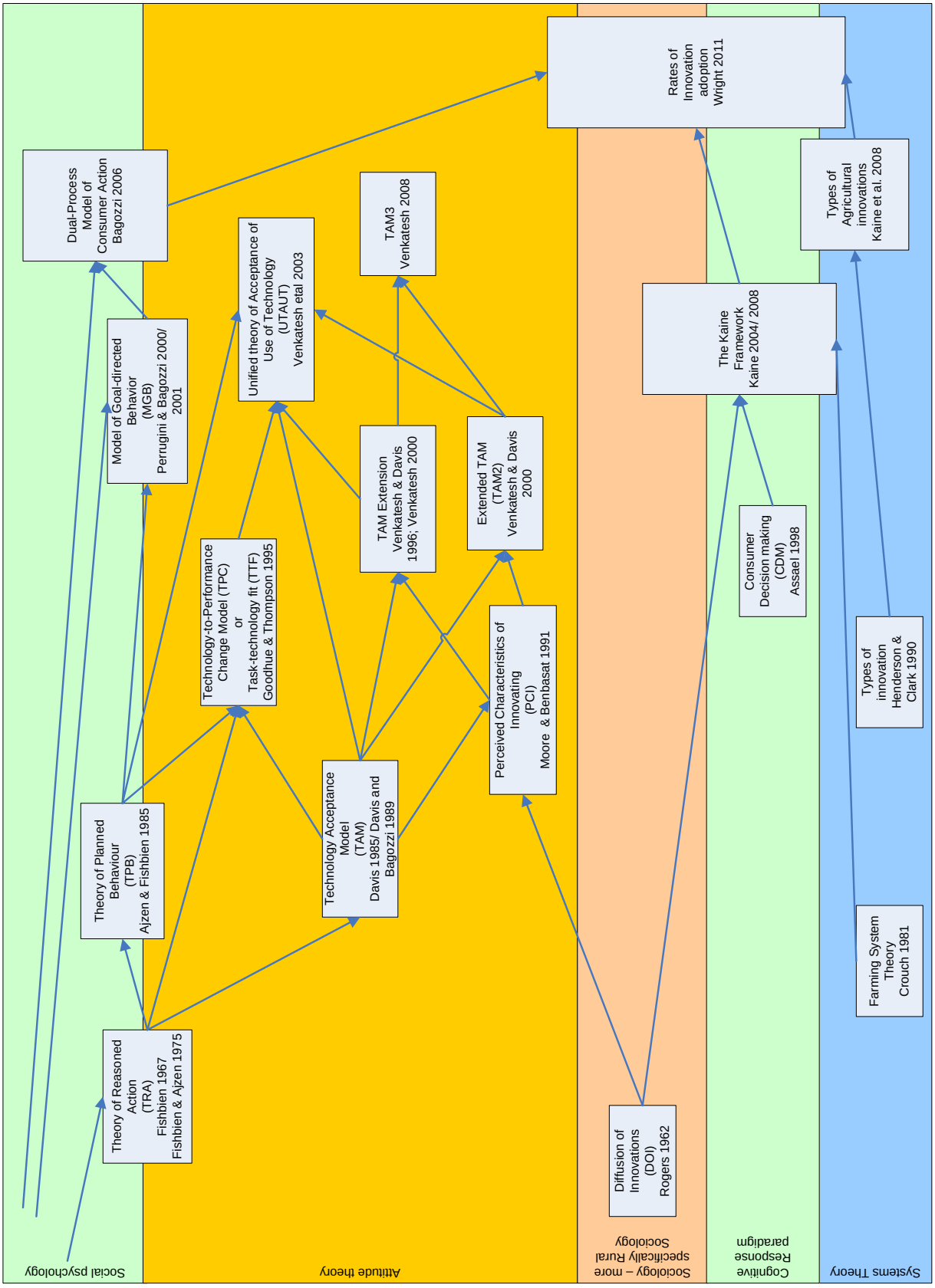


FIGURE 1 KEY ADOPTION THEORIES, THEIR EVOLUTION AND RELATIONSHIPS

Summary of the main theories of behaviour and adoption

The diffusion of innovations (DOI) theory – Rogers 1962

There are four components of Rogers' (1962) theory, which each answer different questions regarding adoption:

1. *How does information about an innovation spread through a population?*
2. *Who in a social system will adopt an innovation, and when?*
3. *What characteristics of an innovation make it more readily adoptable?*
4. *How do individuals make a decision about adopting an innovation?*

The four components described by Rogers are:

1. Diffusion of an innovation through a population

Rogers suggested that new information, such as that associated with an innovation, diffuses through a population through communication channels over time – e.g. via explicit word-of-mouth recommendations, implicit social norms or visible behaviour such as innovation use. More recently the diffusion process has been conceptualised as a social contagion spreading throughout a population (Langley et al. 2012).

2. Characteristics of the individuals

Rogers allocated adopters into groups depending on their innovativeness and suggested that the more innovative individuals (the innovators) would be first to adopt an innovation, while "the laggards" would be the last. It is often assumed that innovativeness trait is an innate and permanent personality trait that is relevant to all the innovations considered; however others suggest innovativeness is innovation and social system specific (Rogers 2003; Kaine 2008a; Kaine 2008b).

3. Characteristics of the innovation

According to Rogers, an innovation is likely to be more quickly adopted if it:

- has a larger relative advantage – i.e. provides a benefit – compared with the innovation it is superseding,
- is compatible with existing technologies or systems,
- is easy to observe and trial and
- is not too complex to use.

4. Adoption decision-making process

The adoption decision-making process was first described by Rogers (Rogers 2003; Kaine 2008a) as following four stages:

I. **awareness**
   the individual is exposed to the innovation and develops some understanding of it
II. **persuasion**
   the individual gathers information and forms an attitude towards the innovation
III. **decision**
   the individual then makes a decision to adopt or reject the innovation and

IV. **confirmation**
the *individual seeks information to confirm that they have made the correct decision*

The model has since been expanded to include an additional stage prior to confirmation, called implementation, in which the individual solves any problems associated with actually using the innovation.

Applications of the theory

The Diffusion of Innovations theory was originally developed in agriculture and has since been used to study the adoption of a number of innovations:

- in a range of fields including agriculture, health and information technology,
- on individual and organisational adopters,
- in a number of countries.

Studies have included hybrid crop varieties, the Dvorak keyboard and the adoption of pharmaceuticals (Rogers 2003). The social contagion aspect of DOI has been applied in areas such as telecommunications and the internet (Langley et al. 2012). DOI theory regarding characteristics of individuals has also been used to explain individual farmer behaviour; for example Wilkinson (2005), Fernandez-Cornejo et al. (1994) and Rollins (1993).

Conclusion

The adoption decision model remains one of the more simple models of an individual's decision to adopt, purchase or use an innovation, product, service or idea (Rogers 2003; Kaine 2008a). Rogers' classification of adopters is frequently applied in marketing and agricultural extension (Martin 2012). However, the classifications are innovation- and social system-specific (Rogers 2003; Kaine 2008b; Kaine 2008a) – i.e. Rogers' classification of adopters only applies to an individual adopter for a specific innovation in a specific social system; hence an innovator for one innovation may be a laggard for another. This classification of individuals is therefore not particularly useful as a market prediction or extension design tool.

Theory of Reasoned Action (TRA) – Fishbein and Ajzen 1975

Key question: How do individuals' attitudes, beliefs, and subjective norms toward an innovation influence their intention to adopt and their adoption behaviour?

The Theory of Reasoned Action (TRA) (Figure 2) is a model for predicting an individual's behaviour based on the assumption that someone's *intention* to do something, such as to adopt an innovation, is the immediate determinate of their actual behaviour. An individual's behavioural intention is determined by their attitude towards the behaviour and their subjective norms. Their attitude is determined by their beliefs about the consequences of performing the behaviour multiplied by their evaluation of those consequences, which may be positive or negative (Fishbein and Ajzen 1975; Davis et al. 1989; Widing et al. 2003; Chuttur 2009).

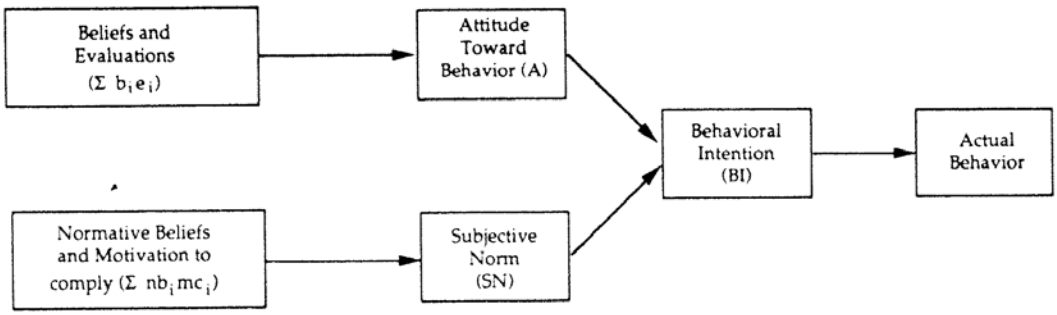


FIGURE 2 THEORY OF REASONED ACTION (DAVIS ET AL. 1989).

Subjective norms have been acknowledged to be the least understood part of this and related theories, due to number of theoretical and measurement problems (Davis 1985; Armitage and Conner 2001; Chuttur 2009). In a recent update of their approach, Fishbein and Ajzen (2010) replaced subjective norms with injunctive (what people "ought" to do) and descriptive (what people "are" doing) norms to try to address some of the theoretical and measurement issues surrounding norms.

Applications

The Theory of Reasoned Action has been applied to a range of behaviours (Ajzen and Fishbein 1980; Sheppard et al. 1988; Davis et al. 1989; Smith and Paladino 2010) including:

- consumer purchases (e.g. detergent or coffee)
- health (e.g. dieting and condom use)
- social (e.g. blood donation and military service)
- environmental (e.g. conserving water and eating green) and
- voting.

The model has also been applied to the adoption of agricultural technologies by farmers, including dairy technologies in England (Rehman et al. 2007) and environmental practices in the wine industry in the United States and New Zealand (Marshall et al. 2010).

Conclusion

TRA has been shown to have strong predictive power even when used to study activities beyond the original scope of the model (Sheppard et al. 1988). Application of TRA has been shown to explain between 23% and 89% of variance in people's behavioural intention (Ajzen 1985; Sheppard et al. 1988), an excellent result by social science standards.

The most common and serious criticism of TRA and related theories is the assumed link between behavioural intention and behaviour. These models are often good at explaining behavioural intention, but may be relatively poor at explaining actual behaviour (Warshaw and Davis 1985; Bagozzi 2006b; Bagozzi 2006a; Bagozzi 2007).

Also, TRA and its associated theories assume that all individuals are potential adopters of an innovation; they do not provide any objective rationale for distinguishing between those who will never adopt (those not in the market) and potential adopters (those in the market that may adopt in future), nor for predicting when people are likely to adopt an innovation.

The wide range of applications of TRA and its (limited) use in agriculture suggest it is a framework that could provide valuable insights into the adoption of wine industry innovations. Some studies have suggested that subjective norms may be relatively more important in agriculture than in general society and that it is important to understand specific attitudinal beliefs of farmers when attempting change farmer behaviour (Rehman et al. 2007; Marshall et al. 2010).

Theory of Planned Behaviour (TPB) – Ajzen 1985

Key question: How do individuals' attitudes, beliefs, subjective norms and perceived behavioural control influence their adoption behaviour?

In the Theory of Planned Behaviour (TPB) (Figure 3) the concept of perceived behavioural control is added to the Theory of Reasoned Action (Bagozzi 2006b; Chuttur 2009). This refers to how much control individuals perceives they have over their behaviour. For example an individual may wish to quit smoking but feel that they have little control over their behaviour, and hence be unable to quit. Perceived behavioural control is a multiplication of the individual's belief regarding how much control they have over their own behaviour (control belief), and the perceived power of this the particular belief in facilitating or inhibiting performing the behaviour.

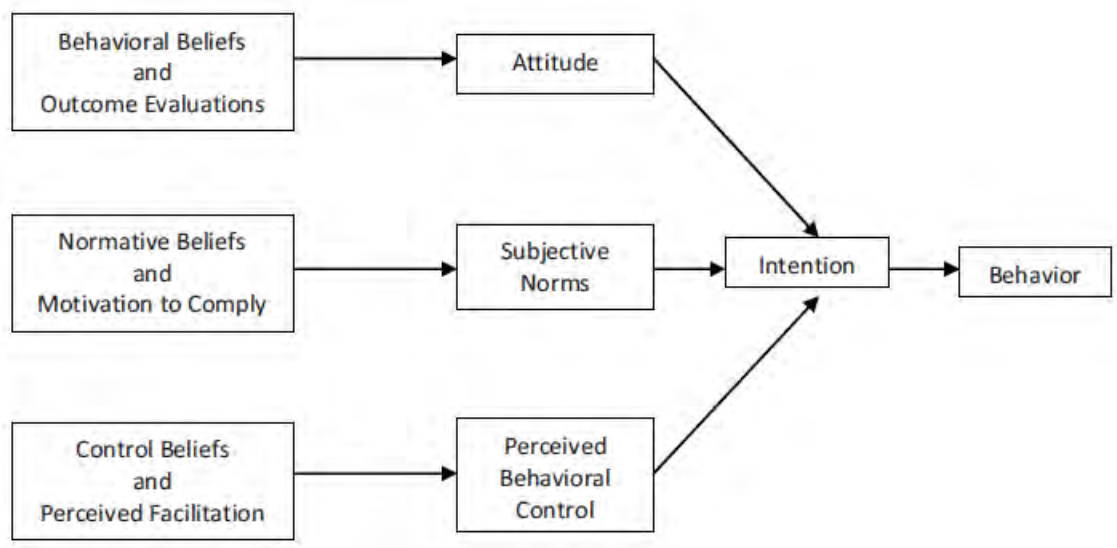


FIGURE 3 THE THEORY OF PLANNED BEHAVIOUR (MATHIESON 1991).

Applications

The Theory of Planned Behaviour has been applied to a similar range of behaviours as the Theory of Reasoned Action (Armitage and Conner 2001; Ajzen 2013). In agriculture, TPB has been applied to research the adoption of:

- organic agriculture in Queensland (Hattam 2006);
- entrepreneurial behaviour of Dutch dairy farmers (Bergevoet et al. 2004); and
- conservation and environmental sustainability practices in Europe, America and Australia (Beedell and Rehman 1999; Clark-Richardson 2003; Toric 2005; Fielding et al. 2008; Wauters et al. 2010).

Hattam (2006) found that conventional farmers had a negative attitude towards *converting* to organic production, despite having positive attitudes towards organic production. Subjective norms

were found to strongly influence the negative attitude towards conversion and farmers perceived it would be very difficult to successfully convert, hence demonstrating low perceived behavioural control.

Australian farmers with a higher perceived behavioural control, who strongly felt normative pressure to adopt riparian zone management practices, were found to have a stronger intention to adopt (Fielding et al. 2008). This suggests that in relation to environmental practices by farmers, attitudes are of general importance to intention, while the influence of perceived behavioural control and subjective norms is dependent on the specific practice and situation.

Conclusion

These successful applications of TPB in agriculture suggest that the theory could be applied to a range of wine industry innovations.

The Theory of Planned Behaviour and the Theory of Reasoned Action are similar in regard to the amount of variation in intention and behaviour they can explain (Armitage and Conner 2001; McEachan et al. 2011). So while this model provides more detail, use of it also requires additional data, sometimes to achieve only a modest increase in explanatory power. Many of the other criticisms of TRA are also shared by TPB.

Technology Acceptance Model (TAM) – Davis 1985

Key question: How likely is an individual in an organisation to use a specific piece of information technology?

The Technology Acceptance Model (Figure 4) is an adaption of the Theory of Reasoned Action, and was specifically tailored to model user acceptance of information systems in organisational settings, in a simple, user friendly way (Davis 1985; Davis et al. 1989). Like TRA, the TAM postulates that an individual's attitude to an information technology influences their behavioural intentions to use the technology and their actual behaviour regarding the technology (Davis 1985; Davis et al. 1989; Chuttur 2009). Davis (1985) proposed that the individual's attitude towards information technology is based on two key beliefs:

I. **perceived usefulness**
how potentially useful the individual believes the technology will be in their job and

II. **perceived ease of use**
how easy the individual believes the technology will be to use (Davis 1985; Davis et al. 1989).

More complex TAM models have since been developed to include drivers for perceived usefulness and ease of use; however these provide similar predictive power to the original TAM but lose the key advantage of the original model, namely its simplicity and ease of use.

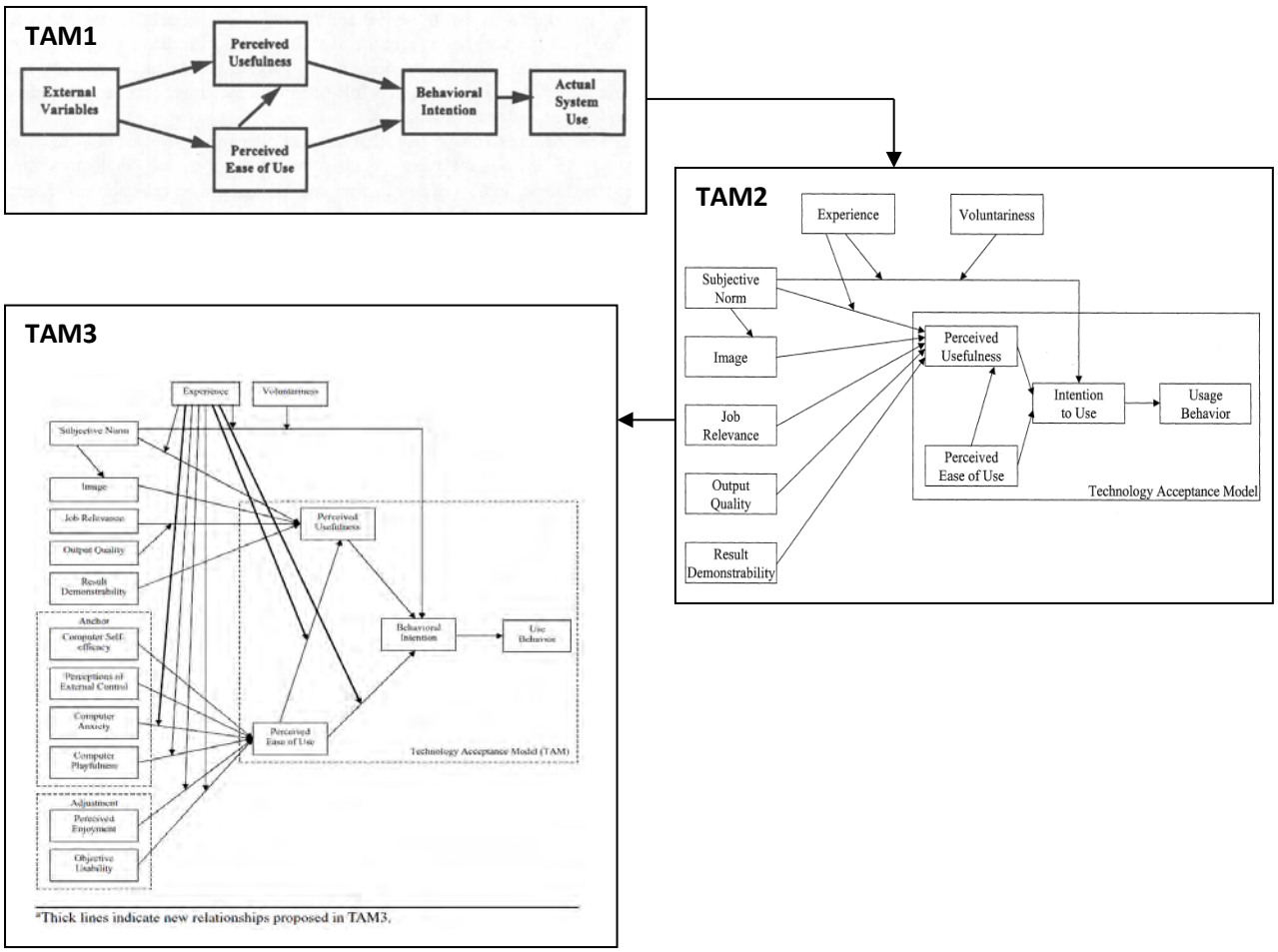


FIGURE 4 TECHNOLOGY ACCEPTANCE MODELS 1 TO 3 (VENKATESH AND DAVIS 1996; VENKATESH AND DAVIS 2000; VENKATESH AND BALA 2008).

Applications

The Technology Acceptance Model has been applied to a range of information technologies including email, faxes, word processors, databases, spread sheets, decision support systems and telemedicine technologies in a range of organisations in developed and third world countries (Chuttur 2009).

TAM has also been used to study the adoption of agricultural information technologies including:

- precision agriculture (including variable rate and site specific technologies),
- electronic libraries and
- decision support tools (Adrian et al. 2005; Folorunso and Ogunseye 2008; Park et al. 2009; Miller and Khera 2010; Rezaei-Moghaddam and Salehi 2010; Salehi et al. 2010).

These studies suggest TAM and it variants should be able to be applied to the adoption of information technologies in the wine industry by both individual grape growers and within corporate vineyards and wineries.

Conclusion

The applications of the Technology Acceptance Model in agriculture suggest it could be applied to the adoption of a range of technologies in the viticultural industry.

TAM requires fewer questions and is simpler to apply than TRA and TPB, and gives as good or better explanations of an individual's intention to use an information technology (Davis 1985; Davis et al. 1989; Chuttur 2009). The limited number of variables gives those applying the model little information on how they can improve individuals' intentions to adopt an information technology. Mathieson (1991) found both TAM and TPB were adequate predictors of technology use and while TPB provided more detail that explained an individual's intentions, the simplicity of TAM made it more attractive to use.

As for TRA and TPB, the link between intention and behaviour has been questioned by in many studies (Warshaw and Davis 1985; Bagozzi 2006b; Bagozzi 2006a; Bagozzi 2007). TAM also assumes all individuals are potential adopters of the technology under study and does not provide any information on the rate of adoption.

Technology to Performance Chain (TPC) Model – Goodhue and Thompson 1995

Key question: How does the fit of the task and the technology influence adoption?

The Task-Technology Fit (TTF) and the larger Technology-to-Performance Chain (TPC) model (Figure 5) are underpinned by the assumption that an individual will use a technology when it has features that support or "fit" the task being performed (Goodhue and Thompson 1995; Dishaw and Strong 1999; Hoehle and Huff 2012). For example a word processor may fit a journalist's task of writing an article better than a typewriter or hand written text would. The TPC model builds on this by including the individual's expected consequences of using the technology, social norms and a range of other variables.

Applications

The TTF and TPC models have been applied to a range of information technologies including:

- banking technologies and PDAs,
- wireless e-business tools,
- wireless internet and
- mobile police computing in a range of developed and developing countries (Ioimo and Aronson 2004; Lee et al. 2007; Junglas et al. 2008; Zhou et al. 2010; Zhou 2011; D'Ambra et al. 2013).

Application

These models do not appear to have been applied to technologies other than information technologies, or in agricultural industries.

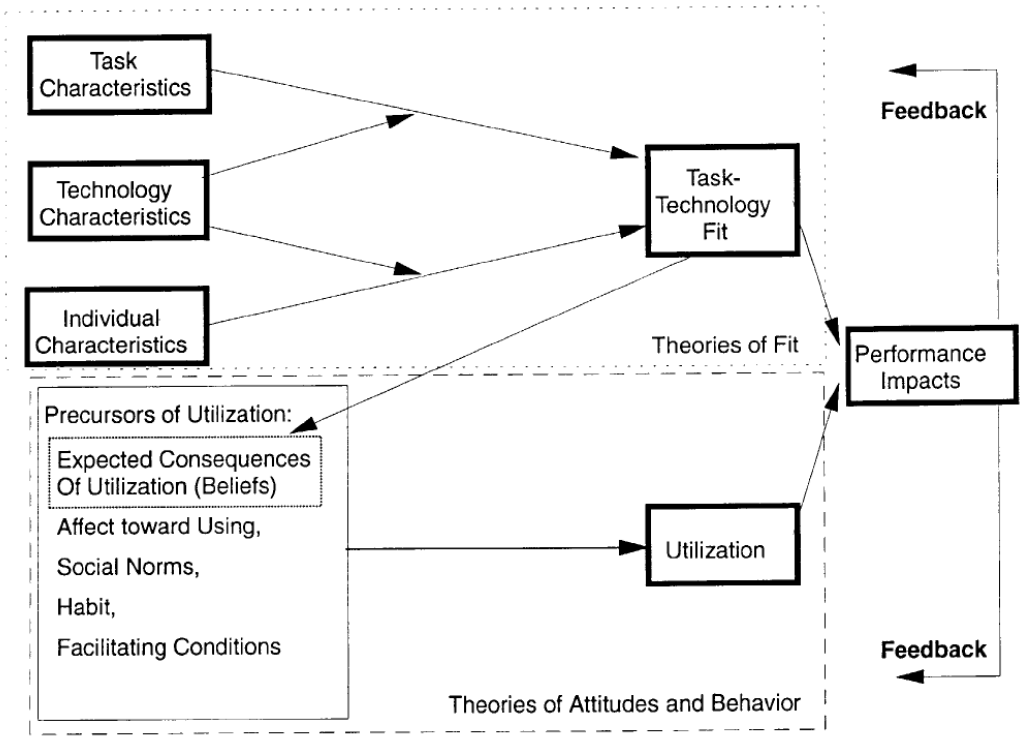


FIGURE 5 TECHNOLOGY-TO-PERFORMANCE CHAIN (THEORIES OF ATTITUDES AND BEHAVIOUR) MODEL, INCORPORATING TASK-TECHNOLOGY FIT (THEORIES OF FIT) (GOODHUE AND THOMPSON 1995).

Conclusion

Task-Technology Fit model was developed to overcome the lack of task focus in the Technology Acceptance Model, and when used in conjunction with TAM provides a better explanation of the variance in technology use than TAM or TTF alone (Dishaw and Strong 1999; Klopping and McKinney 2004), and has some predictive power (D'Ambra et al. 2013).

Criticisms of the model are that it is not well developed, with little standardisation of approach, making it more difficult to apply than other models (Hoehle and Huff 2012). Like the other models, TTF and TPC assume a strong link between intention and actual behaviour. TTF also assumes all individuals are potential adopters of the studied technology and does not provide any information on the rate of adoption.

Extensive testing would be needed to validate the theory in agriculture.

Perceived Characteristics Of Innovating (PCI) – Moore and Benbasat 1991

Key question: How likely is an individual to use an innovation in future?

Perceived Characteristics of Innovating (PCI) (Figure 6) builds on the Diffusion of Innovations model, to make it more applicable to behaviour modelling and adds the variable "voluntariness" of adoption. Like TAM, the PCI was developed to study information technology innovations. Eight variables are used in the model:

- relative advantage,
- compatibility,
- result demonstrability,
- image,
- visibility,
- testability and
- voluntariness (Moore and Benbasat 1991).

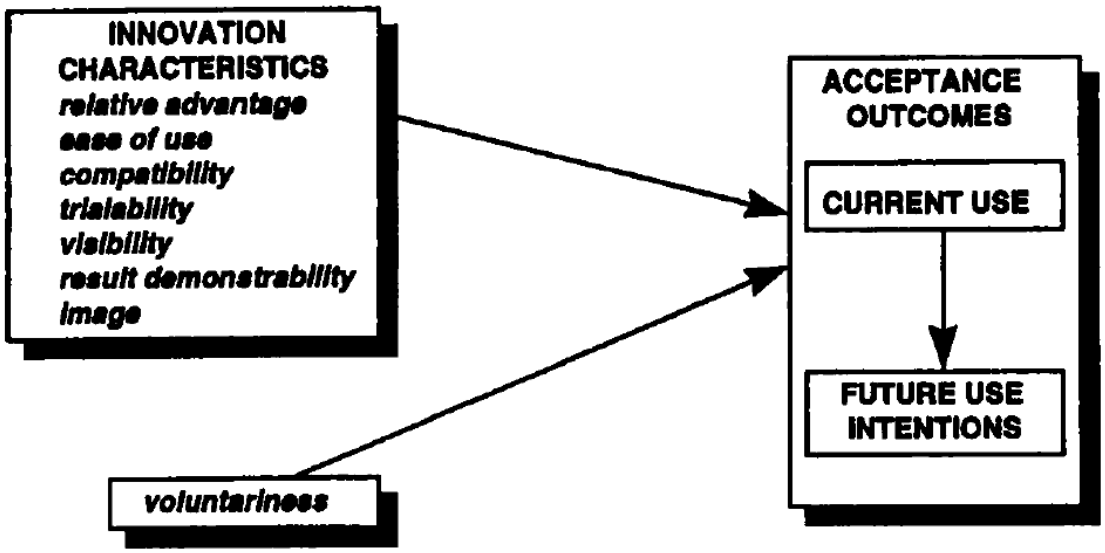


FIGURE 6 PERCEIVED CHARACTERISTICS OF INNOVATING (AGARWAL AND PRASAD 1997).

Applications

The Perceived Characteristics of Innovating model has been applied to a number of information technologies including:

- e-learning,
- e-government and e-commerce tools,
- the internet/ world wide web,
- smart cards and
- internet banking in developed and developing countries (Njuguna et al. ; Plouffe et al. 2001; Zhu and He 2002; Limthongchai and Speece 2003; Carter and Belanger 2004; Carter and Belanger 2005).

Conclusion

The PCI model has been shown to explain between 28% and 86% of intention to use specific information technologies (Plouffe et al. 2001; Zhu and He 2002; Limthongchai and Speece 2003; Carter and Belanger 2004; Carter and Belanger 2005).

These results suggest that the PCI has similar, or more, predictive power than TRA, TPB, TAM and TTF (Plouffe et al. 2001; Carter and Belanger 2005). PCI has two further documented advantages over TAM:

1. It provides managers with more detail regarding the drivers of technology adoption (Plouffe et al. 2001; Poong and Eze 2008).
2. It has been shown to be more robust across cultures (Poong and Eze 2008).

The main criticisms of PCI are that it is not as well developed and has not been as widely used as some of the other models (Plouffe et al. 2001).

While PCI specifically does not appear to have been applied in agriculture, the Diffusion of Innovations theory from which PCI was developed has been widely utilised in agriculture; hence it should be possible to extend PCI into an agricultural context subject to some testing to validate the approach.

Models of Consumer Action – Bagozzi 2006

Key question: What are the roles of subconscious and conscious behaviours in determining individuals' actions?

Bagozzi and colleagues developed a comprehensive model of consumer action comprising a number of individual models. Their models aimed to overcome many of problems in other models caused by their parsimony, assumed link between intentions and behaviour, and failure to acknowledge automatic, or unconscious, behaviours (Bagozzi 2006b; Bagozzi 2006a; Bagozzi 2007; Bagozzi 2011).

Model of Goal-directed Behaviour

The Model of Goal-directed Behaviour (MGB) (Perugini and Bagozzi 2001) reframed consumer behaviour in terms of goal desires, determined by attitudes, subjective norms, perceived behavioural control and anticipated emotions (Figure 8). Goal desires represent a motivational state of mind in which the individual's appraisals and reasons to act are transformed into a motivation to act (Perugini and Bagozzi 2001).

The MGB also added the concept of anticipated emotions – when an individual imagines the affective (emotional) consequences of goal attainment or failure to obtain a goal, before deciding to perform instrumental acts to active the desired goal (Bagozzi 2006b).

Dual-process Model of Consumer Action

The Dual-purpose Model of Consumer Action (Figure 7) incorporates the idea that some behaviour is not deliberate and voluntary (volitional). Some behaviour occurs via automatic processes that, once stimulated by the consumer's internal and external environments, happen without any conscious processes. Bagozzi (2006a) proposed that consumer action may occur through either deliberate, reflective processes or these automatic processes.

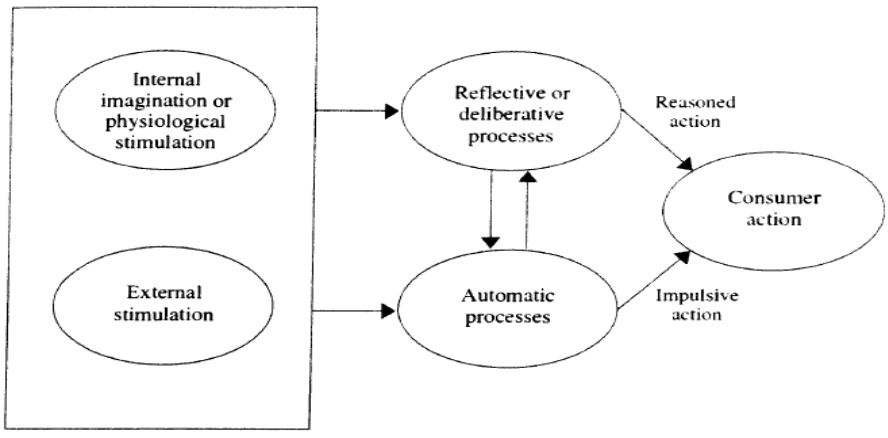


FIGURE 7 DUAL-PROCESS MODEL OF CONSUMER ACTION (2006A).

However Bagozzi (2006a)also suggests we currently have little means through which to study automatic processes and excludes automatic, habitual and past behaviour from his subsequent model of consumer action (Darnton 2008b).

Consumer action and consumer behaviour

This model distinguishes between consumer behaviour and consumer action. Consumer behaviour is defined as the psychological and neural processes that consumers undergo and experience, i.e. their internal, invisible behaviour (Bagozzi 2006b; Bagozzi 2006a), while consumer action is what a consumer does as an actor or agent in a self-regulative or wilful way to acquire, use or dispose of a product or service experience (Bagozzi 2006b; Bagozzi 2006a). This distinction between consumer action and behaviour aims to overcome the assumption that intention directly leads to behaviour.

Deliberative Model of Consumer Action

Bagozzi's Deliberative Model of Consumer Action (Figure 8) suggests that goal desires lead to goal intentions, goal intentions lead to behavioural desire which leads to behavioural intention. This model of deliberative consumer behaviour is underpinned by the concept of goal striving (trying to consume) or how an individual goes through the process of trying to perform a behaviour (Bagozzi and Edwards 2000; Bagozzi 2006b; Bagozzi 2006a; Bagozzi 2011).

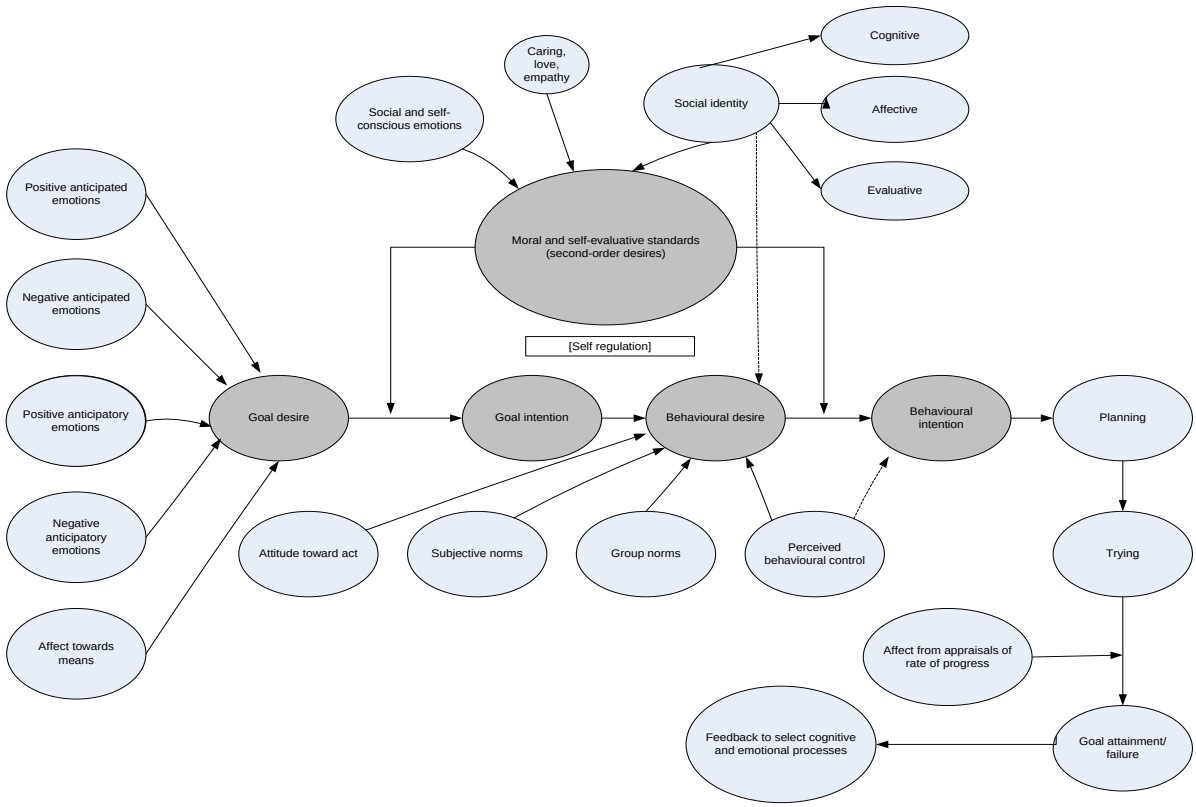


FIGURE 8 KEY VARIABLES AND PROCESSES IN DELIBERATIVE CONSUMER ACTION (BAGOZZI 2006A; WRIGHT 2011).

The antecedents of goal desire are:

- **Anticipated emotions**
- When an individual imagines the affective (emotional) consequences of goal attainment or failure to obtain a goal, before deciding to perform instrumental acts to active the desired goal (Bagozzi 2006b).

- **Anticipatory emotions**
  The emotions someone feels in response to a desired or undesired future event, usually hope or fear (Bagozzi 2006a; Bagozzi 2011).
- **Affect towards means**
  The overall personal emotional appeal of all of the alternative means/ actions or steps required to achieve the goal (Wright 2011). This is distinct from emotions regarding what it might feel like to *achieve* the goal (e.g. finishing marathon) or avoid an undesirable outcome (e.g. heart attack, obesity); it is the feelings regarding the process of achieving the goal (e.g. training many days a week, buying expensive running shoes, dieting, getting up early etc.).

Second-order desires or moral standards including love, empathy social identity and self-conscious emotions play a self-regulating role between goal desire, goal intention and behavioural intention (Bagozzi 2006a; Bagozzi 2011). Attitude towards the act, subjective norms, group norms and perceived behavioural control are also antecedents of behavioural desire, while behavioural desire and perceived behavioural control lead to behavioural intention (Bagozzi 2006a; Bagozzi 2011).

An individual may act on a behavioural intention straightaway, as for many everyday decisions, however many behavioural intentions will be activated at a later point though the steps of planning and trying. Planning refers to determining when and where and how to act on a behavioural intention. Trying refers to the mental and physical activities that are undertaken to overcome impediments to obtaining a goal. Consumers evaluate their progress in moving toward attaining a goal. If dissatisfied, they may increase efforts to hasten goal attainment, alter the goal or their definitions of success, or abandon trying to achieve the goal. After goal attainment or failure, there is feedback to all relevant variables in the model, to influence future desires and intentions (Bagozzi 2006a; Bagozzi 2006b; Bagozzi 2011).

Applications

The Model of Goal-directed Behaviour and other parts of the comprehensive model of consumer action have been applied to:

- consumer recycling,
- body weight management,
- voting,
- joining the army,
- managing hypertension,
- investment decisions and
- community participation (Bagozzi 2007).

The influence of anticipated and anticipatory emotions on goal desires has been tested in agriculture on a small sample of Australian grain producers (Kaine et al. 2012). The results indicated that goal desire plays an important role in the rate at which agricultural innovations are adopted and that the model shows promise for predicting the rate of adoption of agricultural innovations. It was found that scores for almost all anticipated emotions measured were quite high suggesting emotion plays an important role in the adoption of agricultural innovations (Kaine et al. 2012).

The concept of goal-directed behaviour was used to explain the results of a study on conservation by Dutch farmers (Lokhorst et al. 2010) and a study of mulesing in WA (Wells et al. 2011). Wells et al.

(2011) suggests the MGB would be a more appropriate model than the Theory of Planned Behaviour to study farmers' intentions towards ethical farm practices due to the goal-directed nature of farmers' behaviour.

Conclusion

The model of consumer action is the most comprehensive model of consumer behaviour, providing the most detail regarding underlying factors leading to consumer actions (Darnton 2008b; Wright 2011).

It appears that only the Model of Goal-directed Behaviour has been tested in its entirety, while other parts of the comprehensive model have been tested in sections. The MGB explains at least the same or more variance in behaviour than the Theory of Planned Behaviour.

However, the model is considerably more complex than the other models. Darnton (2008b) and Jackson (2005) actually suggest that the model is so large as to be effectively inoperable. The model also assumes all individuals are potential adopters of an innovation.

The model would have the benefit of providing a large amount of information on why grape growers and wine makers adopt innovations, which could be used to inform extension programs. However, the model's complexity will make it difficult to apply in full in the wine industry.

The Kaine Framework – Kaine 2008a

Key question: What is the population of potential adopters of an agricultural innovation?

Kaine (2008a) summarises in detail a framework for determining the population of potential adopters of an innovation in agriculture. The model aims to overcome problems in research, development, extension and policy programs where it is assumed that all individuals are potential adopters of the innovation. Such an assumption leads to an overestimation of the size of the markets for an agricultural innovations and in ability to tell when a market is saturated (Kaine 2008a; Kaine 2008b).

By combining farming systems theory (see below) and consumer behaviour theory, Kaine (2008a) describes a market segmentation process that can be used to understand the benefits sought by farmers from adopting agricultural innovations. Kaine (2008a) draws from the foundations of consumer behaviour theory (Assael et al. 1995; Assael 1998) to suggest that the adoption of farm innovations (technologies and practices) is important to farmers and farmers adopting innovations will exhibit similar behaviour to consumers making high-involvement purchases. High-involvement purchases are purchases that are perceived, by the consumer, to carry high levels of functional, hedonic, social or financial risk (Assael et al. 1995; Assael 1998). Therefore, providing sufficient time is available, farmers will use complex decision-making, a deliberate process of extensive information search and option assessment, to decide if adequate benefit will be gained from adopting an innovation. The population of potential adopters of an innovation is, therefore, the farmers for whom an innovation provides a net benefit over the currently used product or practice (Kaine 2008a; Kaine 2008b). As different farmers may receive a different benefit from adopting the same innovation, farmers may be grouped into market segments according to the benefit they perceive they will receive from adoption (Kaine 2008a; Kaine 2008b).

Farming systems theory

Farming systems theory is a broad area of research, and will only be discussed in terms of what is relevant to the Kaine framework approach outlined above.

There are many different definitions of what constitutes a farm system and farming systems theory (Dillon et al. 1978). Crouch (1981) suggests that farms are systems made of interrelated components — resources, technologies, practices and risk management options available to the farm manager. The components of the system are connected by causal relationships. These components and relationships constrain how farmers can manage their farm systems and the benefit they will receive from adopting an innovation. Kaine (2004) summarises the resources, technology, practices and risk management that make up components and relationships of a farm system as the 'farm context'. Therefore the benefits a farmer will receive from adopting an innovation will be determined by the farm context. In addition, in order to receive benefits from the practices, farmers have to adopt practices in a sequential pattern that begins at a different point depending of the farm's initial mix of resources (Crouch 1981). Thus an understanding of the farm systems, the resources available to the farmer and practices already in place can be used to help predict which practices a farmer might adopt or not (Crouch 1981).

Applications

The Kaine framework has been developed, tested and applied across a range of agricultural innovations, industries and countries (Kaine and Lees 1994; Linehan et al. 2001; Kaine and Bewsell 2005; Linehan et al. 2005; Bewsell and Kaine 2006; Strong and Jacobson 2006; Ambrosio et al. 2008; Kaine and Bewsell 2008; Hill et al. 2009). It has been used to study the adoption of a number of practices (innovations) in a number of agricultural industries in Australia and New Zealand, for example:

- Irrigation, water and water-use efficiency in the dairy and horticultural industries (Bewsell and Kaine 2002; Kaine and Bewsell 2002a; Kaine and Bewsell 2002b; Kaine and Bewsell 2002c; Bewsell and Kaine 2003; Kaine and Bewsell 2003; Kaine and Bewsell 2005; Linehan et al. 2005; Morse-McNabb et al. 2008; Kaine et al. 2009; Hill et al. in press).
- Adoption of once-a-day milking in the dairy industry, New Zealand (Bewsell et al. 2008).
- Sheep breeding and sire selection practices in the wool industry (Kaine and Niall 2001; Kaine et al. 2006; Hill et al. in press).
- Grapevine nutrition management in the horticulture industry (Hill et al. 2007; Hill et al. 2008; Hill et al. 2009).

All of the above studies aimed to determine why farmers adopted an individual innovation or change within their existing farm contexts. Individual farmers were also grouped into market segments according to the benefits they sought and their farm contexts. For example Hill et al. (2008) found wine grape growers used soil nutritional tests for different benefits according to the developmental stage of their vineyards, e.g. to determine nutrients required when starting a new vineyard or to monitor soil nutritional problems in established vineyards.

Conclusion

To date applications of the Kaine framework have provided estimates of the size of the market and market segments for innovations, rather than modelled the likelihood of adoption of an innovation by individuals within the market. The Kaine framework has not been used to create models to predict the likely behaviour of farmers as in the Theory of Reasoned Action, Technology Acceptance Model and other behaviour change models in this report. There is potential that the Kaine framework and behaviour change theories could be combined to provide better descriptions of both the market and the behaviour of individuals within the market for an agricultural innovation. Kaine could be used to provide, describe and estimate the size of the market for the innovation and a theory such as the Theory of Planned Behaviour could be used to predict the likely adoption of the innovation by individual farmers. Again, like other models, this one does not provide any information of the rate of adoption.

It seems there is no comparable framework to determine the population of potential adopters of innovations in the general marketing literature because the appeal of adopting many innovations or consumer products is unknowable and shifts over time (Wright 2011). It is the relatively consistent nature of the use of agricultural innovations and definable nature of some aspects of farm context that allows the population of potential adopters in the social system to be defined (Wright 2011).

The Kaine framework does not however include attitudinal measures, nor is has it been designed for, or applied to agribusiness.

Discussion and conclusion

As detailed in the introduction this review was a vital step in making and justifying the decision about which model to use to study the adoption of the case study innovations (cross flow filtration, novel yeasts, soil moisture monitoring and precision viticulture). By using a model to determine and test the key drivers in adoption of these technologies we could make informed recommendations about how to best design extension and adoption strategies to support change.

The criteria against which the models were assessed were that:

models were assessed against the following criteria:

1. amenable to **phone** survey techniques for data collection
2. **simple** enough to be tested using a practical sample size (ie <1000 samples)
3. included the majority of the **key concepts** considered to influence adoption (eg social norms etc)
4. **predictive power** determined in previous research applications
5. previous successful use on **agricultural** and agribusiness **technologies**

The various models are rated against the above criteria (Table 1). A summary for each theory follows.

Criteria/ Model	1. Suits phone	2. Simple	3.Key concepts	4. Predictive power	5. Agricultural technologies
DOI	yes	yes	no	no	yes
TRA	yes	yes	no	yes	yes
TPB	yes	yes	no	yes	yes
TAM2	yes	yes	yes	yes	yes
TPC	yes	no	no	no	no
PCI	yes	yes	no	yes	no
Consumer action	no	no	yes	no	no
Kaine	no	yes	no	no	yes

TABLE 1: MODELS ASSESSED AGAINST SELECTION CRITERIA.

Diffusion of Innovations (DOI). Parts of this theory, around the characteristics of the innovations, have been built into subsequent adoption models. While this theory is simple and has been used in an agricultural context this theory does not include many contemporary concepts such as 'social norms' or 'perceived behavioural control'. We did not find reference to this models predictive power.

Theory of Reasoned Action (TRA) and Theory of Planned Behaviour (TPB). Data for these models can be collected by phone and using a feasible sample size. Their predictive power is well published.

However these models do not include direct assessments around the characteristics of the innovations under study.

Technology-to-Performance Change Model. This model is more lengthy than some of the others, has not been used in an agricultural context, is missing key concepts and has not been well developed for application.

Perceived Characteristics of Innovating. While of a suitable length and being suitable for phone data collection, this model has not been used in agricultural and does not include some of the key concepts.

Model of Consumer Action. This model is too complex to be applied within the constraints of this project.

The Kaine Framework. Included because of its strong focus and extensive use on agricultural technologies, this model does not meet many of the selection criteria. However we suggest that some of the rational around farm context as a key driver of adoption will be a valuable addition to this project.

Technology Acceptance Model (TAM). Although the original TAM is considered too simple, and hence the findings not sufficiently detailed to adequately answer the research questions, and TAM 3 too lengthy and complex to be able to use in this study, TAM2 meets all of the criteria with the addition of 'perceived behavioural control' to the concepts.

TAM2 includes some concepts from Diffusion of Innovations, such as 'perceived usefulness' (relative advantage) and 'perceived ease of use' (complexity), while enabling a detailed picture to be developed around why an individual may perceive a technology to be useful. Additional detail may be required in order provide a more detailed description of market segments for an innovation and where some of the barriers lie to adoption.

TAM2 contains concepts from Theory of Reasoned Action and Theory of Planned Behaviour, in that attitude toward behaviour and behavioural intention is measured. It also uses 'subjective norms' found to exert a significant influence on intention to adopt in other models.

For this reason TAM 2 was selected for use in this project.

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Outcomes and Conclusions

Summary of outcomes

This research has established business scale as a significant influence on the adoption of technology – particularly 'high involvement' technologies such as soil moisture monitoring systems and cross-flow filtration. A number of contextual factors were also found to influence adoption, such as the region, site characteristics, competitive strategy of the business and characteristics of their business decision-makers.

The Technology Acceptance Model 2 (TAM2) was found to provide a solid basis for understanding the adoption of technology in the Australian wine industry, with all the original variables being found to be relevant, except that of 'image'. The 'perceived usefulness' of the technology to the grapegrower or winemaker was the key driver of intention, and in turn actual adoption behaviour of all the case study technologies. For the more expensive and complex technologies 'perceived usefulness' was found to be related to business scale and outlook (i.e. expanding, staying steady or contracting) and to be influenced by the businesses' decision makers' motivation and capacity to invest.

Grapegrowers and winemakers generally followed a structured process of decision-making leading to the purchase of new technology, which included information-seeking at every stage. A range of types and sources of information were found to be used when considering adopting a new technology. The more important or risky the decision, the more information collected and sources used.

Grapegrowers and winemakers were found to value information sources that provided them with credible, trustworthy, relevant information from knowledgeable, accessible sources. Of particular value was the extensive network of peers that most grapegrowers and winemakers have, which they used to obtain practical, trustworthy, independent information, especially in regard to new technologies.

Practical implications: Questions & Answers

The project results have a range of practical implications for providers of research and extension. The following Q&A section, derived from a range of questions the project team has been asked, may clarify some of these implications. These answers are derived from interview and survey data and experience.

Q: Do some states or wine regions adopt more technologies than others?

A: This project survey was not designed to measure adoption of every technology across the entire Australian wine industry. However, the qualitative data revealed that businesses that were expanding adopted more technology than others (see Part B). Therefore states or regions with a relatively high proportion of expanding businesses also had higher rates of adoption of the case study technologies.

Q: Do only big vineyard or winery businesses adopt new technologies?

A: No. Businesses that are expanding often adopt technologies to help them achieve and support their expansion. 'Steady' and 'contracting' businesses still adopt some technologies and practices (often around saving input costs and/ or increasing efficiency), but not as many as the 'expanding' market segment. Scale is a strong determinant of which technologies are relevant to an individual business.

Q: Do only young people adopt technologies?

Generally, people adopt technologies if their business is expanding or steady, regardless of their age. However, there was a higher proportion of younger aged people in the 'expanding and productivity confident' group than in other groups.

Q: Why are some technologies adopted while others are not?

A: The TAM2 work showed that perceived usefulness is the key for all the technologies investigated. Why the technologies were perceived to be useful varied between technologies, yet almost everyone was interested in reducing input costs and increasing quality. If a technology is difficult to install or use, that diminishes its perceived usefulness.

Q: What are the main factors that make someone move from 'intending' to actually adopting?

A: The main factors are perceived usefulness and ease of use, business scale and outlook and connectedness to other people in industry. For three of the four technologies studied, people who adopted a technology had more local contact with their colleagues, for example as part of a grower or winemaker group, than those who had not moved from 'intending' to adopting.

Q: What are the most important sources of information for raising awareness of innovations?

A: Information sources including seminars, salespeople, friends and trade magazines were all mentioned in interviews as sources of information about new technologies. In many cases, people could not remember exactly where or when they first heard about something.

However, people who were 'actively seeking' information could usually describe an active, conscious search for information.

With low involvement items, information presented as repetitive, bright, frequent, and simple in message content have been shown to be most effective. With high involvement innovations credible, trustworthy sources become more important.

Q: How important are other grapegrowers and winemakers as sources of information?

A: Social norms (the opinions or behaviour of valued people) were found to be a strong influence on adoption behaviour. Other grapegrowers and winemakers were also valued as sources of independent, experienced, practical information.

Q: How can extension be delivered to increase adoption?

A: Extension alone cannot cause or increase adoption. A person will only adopt a technology if they perceive it will be useful and that adoption will provide a benefit. A good extension strategy makes people aware of the technology and how it can benefit them if it is used. Only if the individual is interested will it lead to actual adoption.

Q: What do people like about websites as information sources?

A: Their accessibility, convenience, ease of use and range of available information.

Q: How can traffic to a particular website be increased?

A: Many people use search engines rather than visit specific websites, so relevant keywords in the content are important to ensure that sites rank highly in search engine results. There is an increasing trend for people to find information using social media, so an integrated social media presence (e.g. Facebook page, Twitter feed) supporting a website would be effective. People tend go back to sites they are familiar with and that have provided them with satisfaction in the past. There is also a range of source criteria they will use to evaluate a site, including ease of use in accessing the desired information, currency, credibility etc.

Q: Do you have to do a benefit segmentation for each different technology or product of interest?

A: While findings can often be generalized across a product class (eg. novel yeasts or new chemical sprays), benefits sought will vary between technologies, hence they must be considered individually.

Recommendations

Overarching

1. The 'market, message, means of communication' framework be used to guide the thinking and data collection for extension design and evaluation in relation to technologies, product or practices that are market-ready. This framework provides a logical approach to the thinking and data collection required to design, and later evaluate, an effective extension strategy and program.

Market

2. Market segmentation can provide practical insight into target markets and messages that will be effective to support adoption of a technology. It is recommended that this approach be replicated on additional technologies, products and practices, which would:

- Enable the data collection and analysis process to be refined and streamlined
- Build an understanding of the dimensions of perceived usefulness and ease of use for a larger range of innovations. These will be useful to enhance researcher and extension provider understanding of the range of considerations that lead to something being considered useful or otherwise
- Inform predictions of market size and composition for existing technologies, enabling extension efforts to be designed and targeted and effective evaluation to be conducted
- Provide data on current grapegrower and winemaker needs to inform predictions of their future needs and preferences in regard to emerging innovations. There are marketing tools (e.g. focus groups) and processes (e.g. forecasting) available to support this objective.

Message

3. The TAM2 model be improved through the inclusion of the additional variables which were found to be influential drivers of adoption during this research. These were business outlook and scale, age of the decision-maker, frequency of contact with other grapegrowers or winemakers and the initial cost of the technology.

It is also suggested that marketing approaches to predicting markets for an emerging technologies be further explored in order to ensure that tools from other disciplines that can provide value to the wine industry are identified.

Means of communication

4. Social norms emerged as key influences on adoption. Therefore identifying and working with opinion leaders would be an effective way to increase adoption. Opinion leaders tend to be gregarious, prepared to stand out from their peers and have access to higher levels of relevant media (Quester *et al.* 2010). Opinion leaders are likely to have an enduring interest in, and experience with a particular product category, making influence possible. For example, an opinion leader on making wines from alternative varieties was interviewed as part of this project in McLaren Vale. Experienced, innovative and happy to share information, this wine maker was mentioned a number of times by others grapegrowers and winemakers as a source of ideas, information and support.

Identification of opinion leaders can be done using sociometric techniques, key informants and self-designating questionnaires (Quester *et al.* 2010). As these people receive information and relay them to others, market research could be conducted in regard to their product use, message framing and media

preferences. The selected opinion leaders could be collaborate on trials to develop technologies, products or information, ensuring their input, favorable opinion and information dissemination.

5. These project results have demonstrated the importance of independent, expert people to translate science, provide advice and problem solve in order to support adoption of new technologies. Hence the value of some extension providers and organizations may lie in how 'connected' they are to industry and other networks. It is recommended that the range and size of extension provider networks be mapped to identify extension staff networks, and enable gaps in information flow to be identified.

Appendix 1: Communication

Presentations have been made to:

➢ Dookie students on adoption of technologies in agriculture featuring project	May 2013 and 2014
➢ Twenty staff at the Australian Wine Research Institute (with Dr Roger Wilkinson)	April 2014
➢ DEPI Horticulture Industry Network members	December 2013
➢ National Wine Extension Network (with Dr Neil Barr)	October 2014
➢ DEPI agriculture policy group 'Adoption of R&D outputs. Who, what and when' project results	August 2014
➢ DEPI directorate 'Adoption of innovations in agriculture' Project results and conference Insights	December 2014
➢ DEPI innovation and strategy group, Neil Barr presentation 10th December, Melbourne	December 2014
➢ A workshop was conducted on project results was run with staff from AGWA, AWRI, DEDJTR, CSU and NSW DEPI attending (see workshop report Part D)	March 2015
➢ Pending. Seminar with NWEIN and AGWA regional members	May 2015
➢ Pending. Research presentation at APEN conference, Adelaide	November 2015

Conference presentation and proceedings

Research forum, Product Innovation and Management Conference, Denver Colorado 24-26th October 2014

Articles pending

- 'Perspectives on adoption' Adoption of the Pellenc Selectiv' Process System.
- 'Business model innovation- creating custom-made wines' (An interview with Stuart Bourne, Chateau Tanunda)
- 'Innovation as a way of life' (An interview with Julian Alcorso, Winemaking Tasmania)

Appendix 2: Intellectual Property

All the methods, research reports and publications used or produced in this project are in the public domain and are intended for use by extension providers within the Australian wine sector, AGWA, DEPI and collaborators.

Appendix 3: References

The references are complete in the separate reports. References for the executive summary and background follow:

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Appendix 4: Staff

Principle investigator

Megan Hill
Department of Economic Development, Jobs, Transport and Resource, Private Bag 1, Tatura, Vic, 3616

Collaborators

Sandy Hathaway
Felix Business Consulting, 4 Rosella Close, Flagstaff Hill, SA, 5159

Roger Wilkinson
Department of Economic Development, Jobs, Transport and Resources, Warrnambool, Vic, 3280

Neil Barr
Department of Economic Development, Jobs, Transport and Resource, Bendigo, Vic, 3551

Geoff Cowey
Australian Wine Research Institute, PO Box 197, Glen Osmond, SA, 5064

Mark Krstic
Australian Wine Research Institute, Level 1 West, 262-276 Lorimer St, Port Melbourne, Vic, 3207.

Angela Paladino
Associate Professor, University of Melbourne, Department of Management and Marketing, Level 10, 198 Berkeley Street, Vic, 3010

Lawrie Stanford
Wine Grape Growers Australia, corner of Botanic and Hackney Rds, Adelaide SA, 5000

Contributors

Ben Rowbottom
Department of Economic Development, Jobs, Transport and Resources, Private Bag 1, Tatura, Vic, 3616

Eloise Seymour
Department of Economic Development, Jobs, Transport and Resources, 124 Chiltern Valley Rd, Rutherglen Vic, 3685

Contract services

Insightrix Research Pty Ltd, Firebrace St. Horsham Vic, 3400

- Avril Hogan (data collection), and conducted by
- Briana Brownell (structural equation modelling)

Appendix 5: other material

Raw data supplied electronically to AGWA

Financial reconciliation has been submitted to AGWA via CIMS

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