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Potential Technology Adoption for the Australian Grape Industry and Effects on the Value Chain

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Abstract

Being primarily an exporting nation it is vital that Australian grape and wine producers remain competitive into the future. In this analysis, some insights as to how technology adoption by Australian grape producers could positively improve their profit margins are provided. This can be achieved by either reducing cost, introducing advanced management practices, improving quality, preventative action in the case of disease and better management of weather events such as frost. Information has been outlined as the key factor in the value chain that needs addressing. At a producer level this review outlines how new technology could improve the efficiency and responsiveness of information. New technologies addressed are Normalized Difference Vegetation Index mapping (NDVI), Unmanned Aerial Vehicles (UAV's), private onsite weather stations, soil moisture probes and precision agriculture yield monitoring. In conclusion, it is recommended that all scales of viticulture production adopt this new technology.

***Key words*: grower**, information, technology, management, quality, efficiency

Introduction

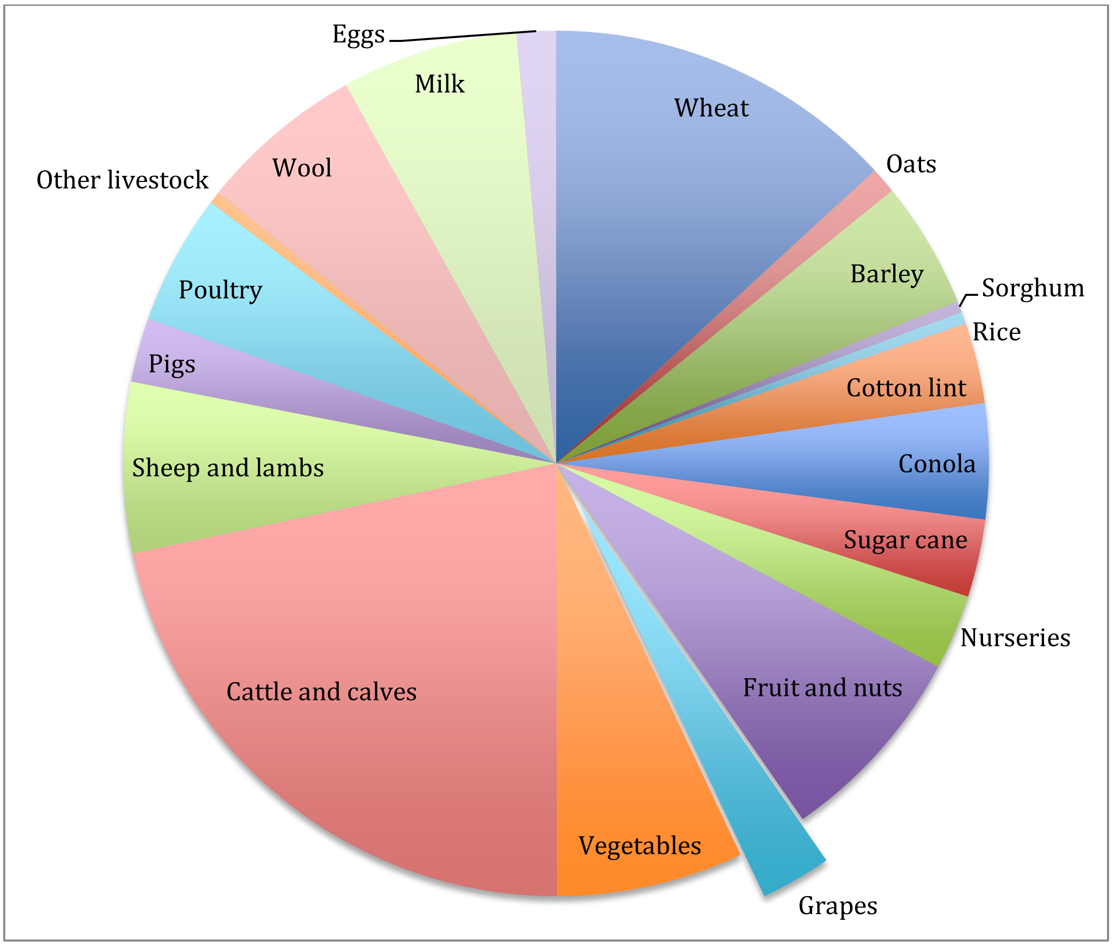
In this paper the Australian grape and wine industry is analysed and a case is made that it must adopt new technology in order to remain viable and globally competitive into the future. There are four major players in the wine processing industry that make up 40 per cent of the market. They are, in order of largest to smallest, Accolade wines, Casella Wines, Treasury Wine Estate and Pernod Ricard Winemakers (Wine Titles, 2017). From an outsider's perspective it would appear that technology adoption in terms of bottling and processing at the processor level has remained competitive with other beverage industries in terms of quality, quantity and variety. However, this does not appear to be the case at the producer level of the value chain. The common business model for grape growers is similar to that of many other sectors but particularly the dairy industry. Some producers process their own produce but the majority sell to processing companies where they have little to no control over the final product.

Like the dairy industry there are premiums that can be made on grapes but in even larger amounts. For grapes that possess certain qualities and characteristics that the processor requires to be used in certain wine labels, premiums upwards of 500 per cent can be achieved. For example, a Barossa shiraz that is classified as masstige will only fetch approximately $1,000 per tonne from Treasury Wine Estate but an A grade product of the same variety that is able to be produced into a luxury label can fetch upwards of $5,000 per tonne (TWE Global, 2012). New technology that is on the horizon or already implemented in other forms of agriculture, such as cropping, can assist producers achieve higher premiums notwithstanding the region they choose to produce in. This is in the interest of both the producer and the processor as it will contribute to achieving a higher quality product that is required by the global market today.

The Australian Grape Industry

Grape production remains a relatively small industry in Australia that is, however, rapidly gaining in size. In the period 1991 to 2007 grape production grew threefold from 400 million litres per annum to 1.2 billion litres (Wine Australia, 2018b). That being said, when compared with other agriculture sectors in Australia, grape production is still a relatively small industry. Figure 1 shows that in 2017 grapes made up just 2.42 per cent of agricultural production in Australia with a farm gate value of $1.475 billion Australian (ABS, 2017). Cereal production makes up 17.76 per cent and livestock slaughtering 32.91 per cent, with farm gate values of $10.808 billion and $20.025 billion, respectively (ABS, 2017) (see also the appendix). Additionally, Wine Australia (2018b) estimate that in 2017 there were 2,468 wineries, 6,251 grape growers with a workforce of 172,736 people contributing upwards of $40 billion to the Australian economy.

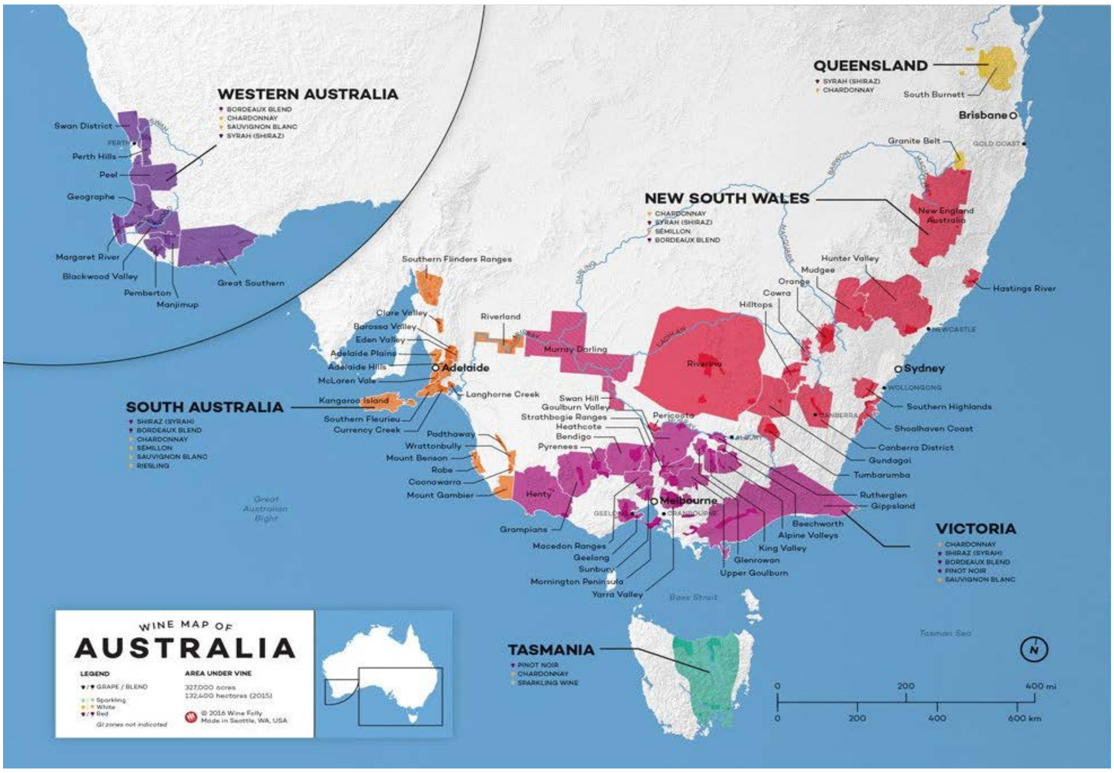
Figure 1. Australian grape production as a share of agriculture in 2017



Source: ABS (2017)

Wine Australia is the vignerons' industry body that producers and processors pay levies to. Levies are paid at $2 per tonne for uncrushed grapes and $5 per tonne for crushed grapes (Wine Australia, 2018b). These fees are used to fund research and development, control the export of Australian wine and increase the demand through promotional activities both in Australia and overseas (Wine Australia, 2018b). Grape production occurs in each state in Australia except Northern Territory. Figure 2 is a map of the current grape growing regions in Australia. The map highlights grape growing regions or district borders and does not imply that only grape production occurs in those areas.

Figure 2. Wine regions map of Australia



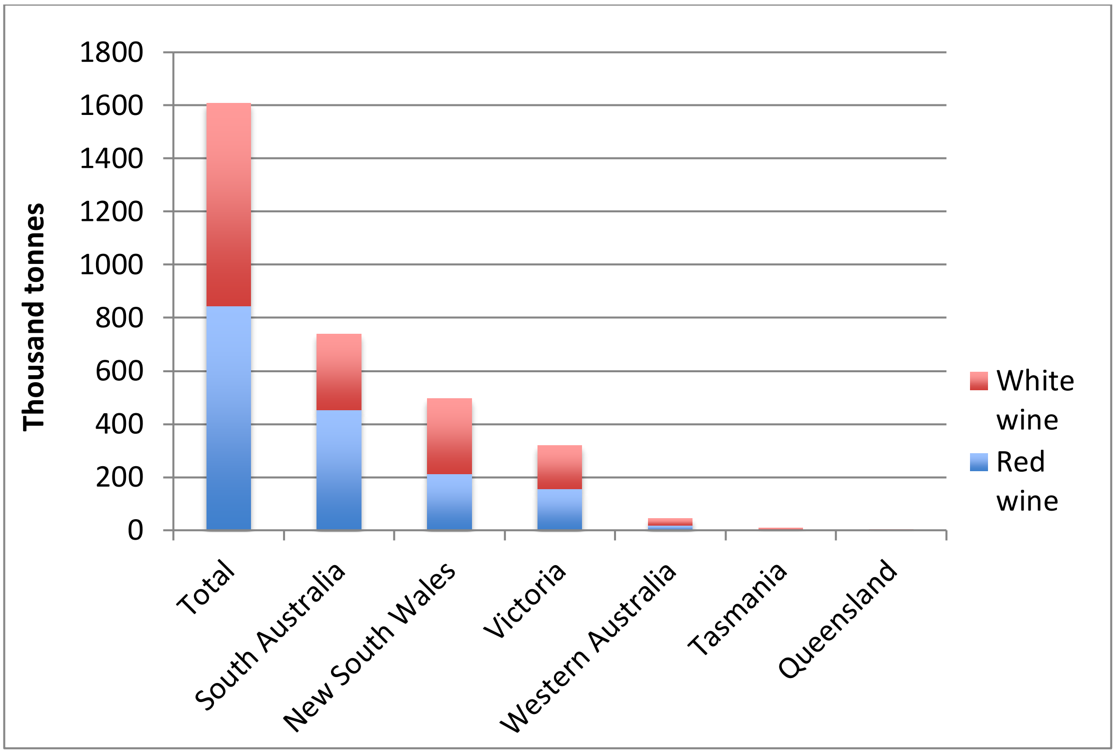
Source: Wine Folley (2018)

Wine production primarily occurs in the cool climate regions of Australia with almost all production occurring in the southern side of the continent. Wine Australia estimate that approximately 135,000 hectares is devoted to wine production in Australia, making Australia the fifth largest producer of grapes by area and the largest in the southern hemisphere (Wine Australia, 2018b). South Australia produces the bulk of the wine: in 2017, 51 per cent of Australia's total production (Wine Australia, 2018b). Figure 3 provides useful insights as to which states produce wine by variety.

Australia produced approximately 1.2 billion litres of wine in 2017, of which 52 per cent was red wine (Wine Australia, 2018b). Of the 1.2 billion litres, the Australian domestic market consumed 500 million litres leaving a total of 811 billion litres for export (Wine Australia, 2018a). This makes the Australian domestic market the biggest single consumer of Australian wine. Figure 4 details the five biggest importers of Australian wine by volume with mainland China now consuming the most at 33 per cent (Wine Australia, 2018a).

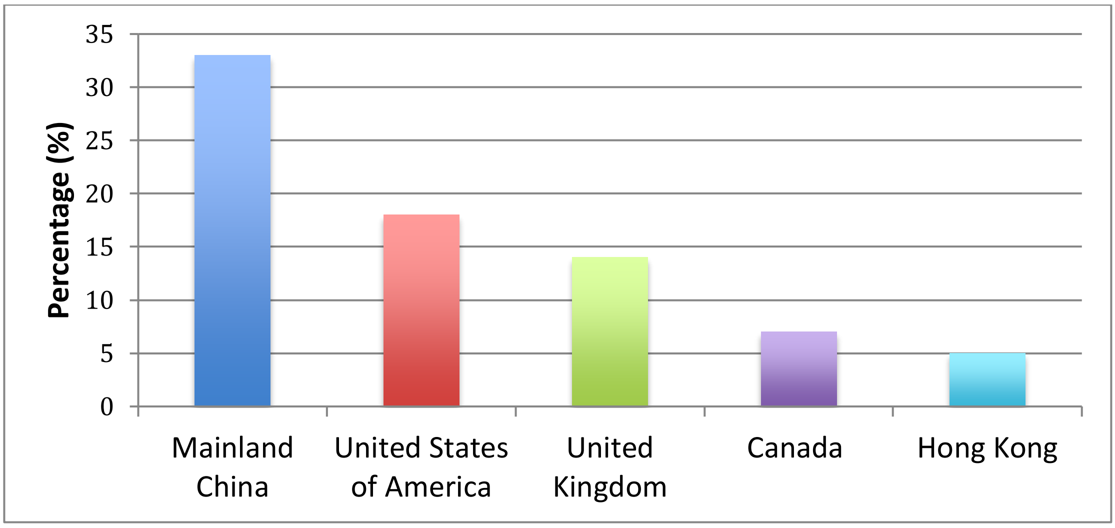
Figure 5 shows that Australia's domestic consumption of wine is made up of 80 per cent Australian product, and that, of the 20 per cent that is imported, two thirds comes from New Zealand (Wine Australia, 2018c).

Figure 3. Australian wine production by state



Source: Statista (2018)

Figure 4. Australia's top five wine export markets in 2017



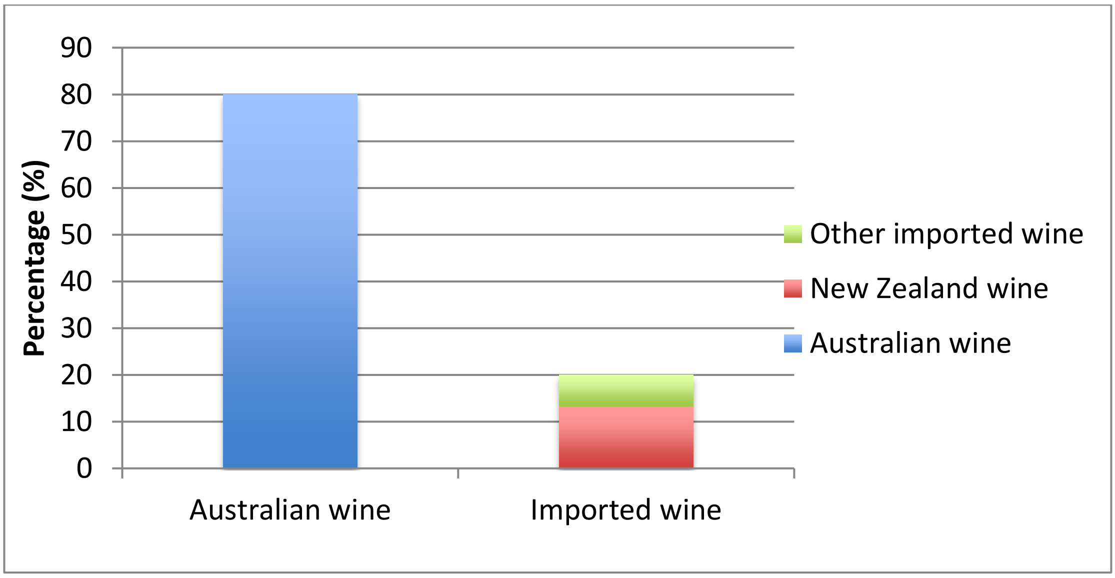
Source: Wine Australia (2018a)

Value Chain Analysis

When assessing a value chain like wine production, it is important to consider all aspects in order to establish a competitive strategy. Although logistical drivers do play a vital role in the success of a value chain, they were not considered as the primary concern of this study. Cross-functional drivers (in particular information) are vital to Australian grape producers as the consumer demands value for money. The world being a more globalised market than ever before means that Australian grape producers are in direct competition, potentially, with every other grape producer in the world.

Producers need to establish niche markets in order to attain premiums for their products. New technology must be adopted in order to attain the information required to create products of higher value, reduce inputs and prevent disease infestation to minimise losses. It is said that good information improves responsiveness, yet simultaneously lowers costs (Chopra and Meindl, 2013).

Figure 5. Australia's domestic consumption of wine in 2017



Source: Wine Australia (2018c)

Strategic fit

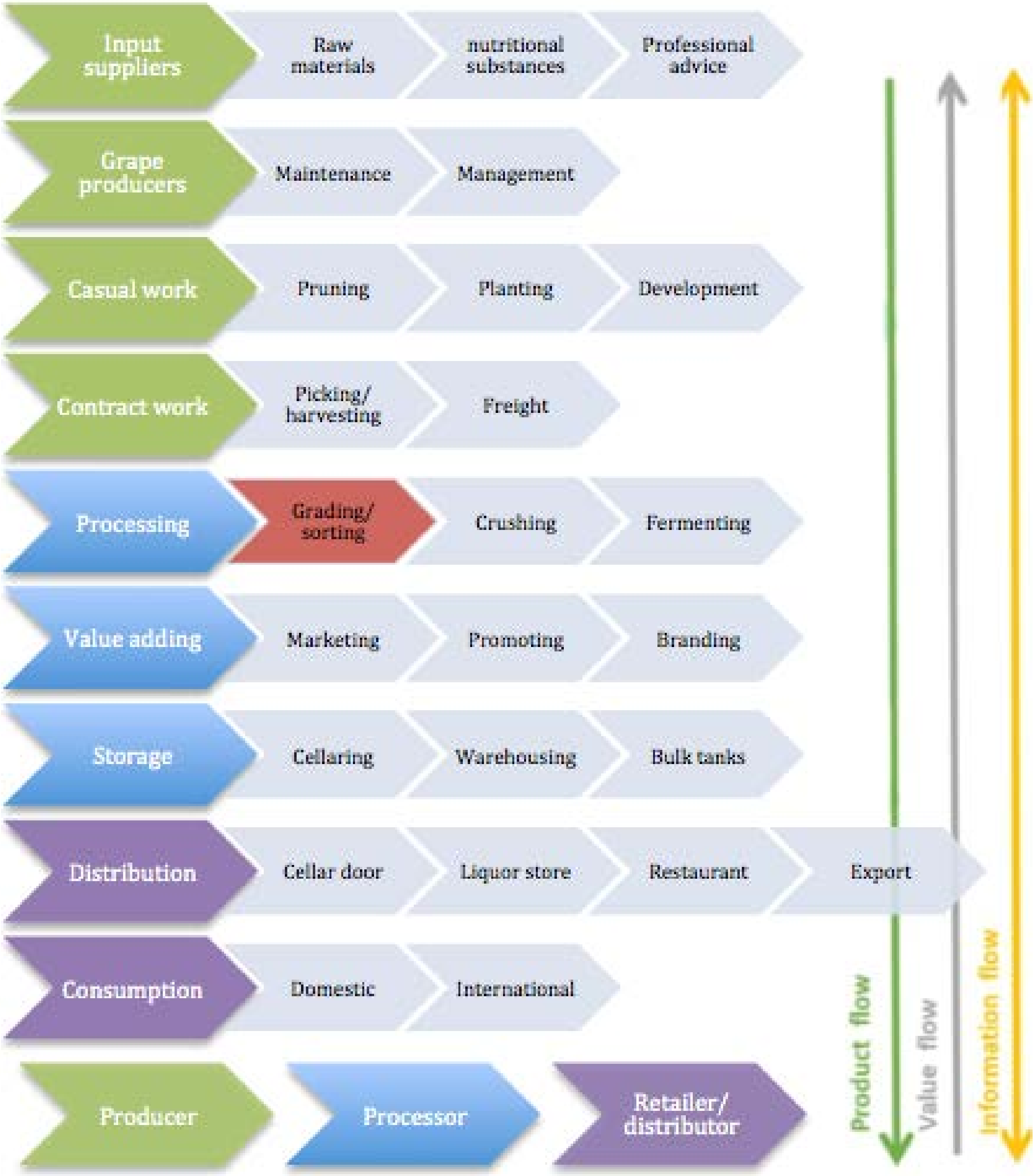
Currently the Australian producers of grapes for the wine industry do not, on average, have a good strategic fit. In 2015, 85 per cent of grape producers suffered a loss with Tasmania performing best with 99 per cent of its producers achieving a profit (Benslon Slebert, 2015). Tasmania on its own is matching its resources and capabilities with the opportunities being presented and for that reason they would be said to have a good strategic fit. The rest of Australia does not. For that reason Australia should look to alter its competitive strategy. Information could prove to be the key to achieving a viable industry.

Value chain map

Shown in Figure 6 is a value chain map of the Australian wine industry. It starts with input suppliers before grape producers, as the inputs are the beginning of the cost chain in developing a bottle of wine. The value chain ends with the consumer, whether that be domestic or international as the consumer ultimately pays the price for the whole value chain.

Different producers control varying amounts of the value chain with some remaining just grape producers and others with their own cellar door. If these producers also operate their own processing line then they control a portion of the whole value chain. This gives the producer more ability to add value through branding and marketing. The important piece of information to note is that with new technology even a producer that only controls those areas of Figure 6 highlighted in green can improve quality or quantity with other technologies reducing cost.

Figure 6. Value chain map of Australian wine production



Cost reductions are being achieved constantly with machinery advancements in terms of pruning and harvesting. New transport laws are coming into place from 2017 onwards, for example in South Australia, 96 tonne road trains are now allowed where before only 68 tonne B-doubles were allowed (DPTI, 2018). This represents a cost saving on freight for those that are in the specified districts. Neither transport nor machinery has been included in this study as they are logistical drivers and not specifically technology advancements aiding information transmission. In Figure 6 grading and sorting is highlighted in red as for the producer to achieve higher returns they should adopt new technology that allows them to produce grapes of a higher grade and attain the premium price that comes with it. These premiums are vital in order to approach the profitability in Tasmania where 99 per cent of farmers achieve a profit (Benslon Slebert, 2015).

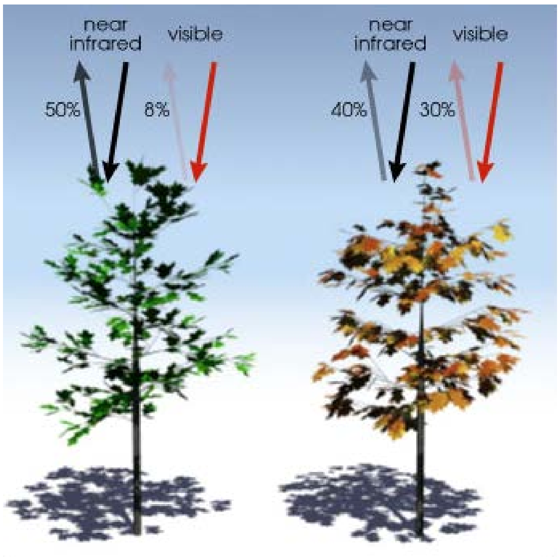
Potential Technologies

As discussed above, the wine industry in Australia does not generate sufficient profit to warrant large investment in new technological innovation. For that reason a more practical solution would be to either adopt technology already being used abroad or modify proven technology from other fields of agriculture. The cost of modifying technology to suit the needs of grape producers should prove to be substantially cheaper than the R&D required to develop innovations.

NDVI mapping

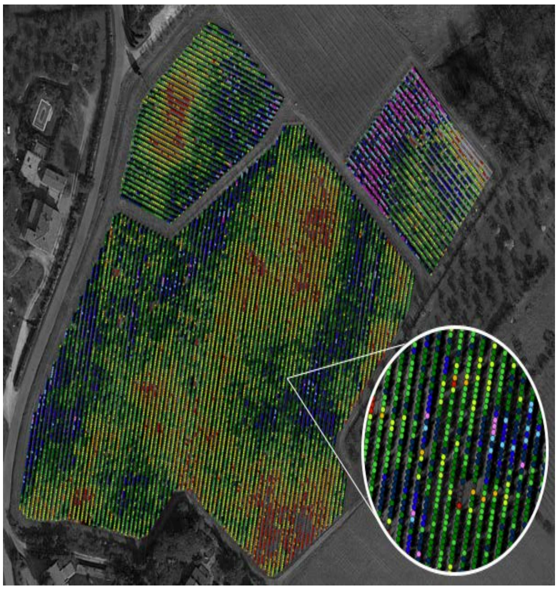
NDVI (Normalized Difference Vegetation Index) images are captured by satellites a number of times over a given season. These images measure the difference between near infrared and red light which vegetation either strongly reflects, if it is considered healthy, or absorbs, it if it is unhealthy (GIS Geography, 2018). The ratios of light reflection and absorption to healthy and unhealthy vegetation are given as an example in Figure 7 where it is clear that the more healthy vegetation reflects more near infrared light. Companies like Vine View in America are using these images and applying a series of algorithms to compensate for atmospheric distortions to generate images like that seen in Figure 8 (Vine View, 2018). Vine view claim to be leading the market with over 15 years of experience in the industry. This technology is already well adopted by the cropping and forestry industry where they have a more uniform crop with only one plant variety present (GIS Geography, 2018). That being said, Vine View (2018) claim they have already developed more advanced algorithms than their competitors to allow for row orientation and cover-crop distortion.

Figure 7. How NDVI works



Source: GIS Geography (2018)

Figure 8. Vine View with NDVI



Source: Vine View (2018)

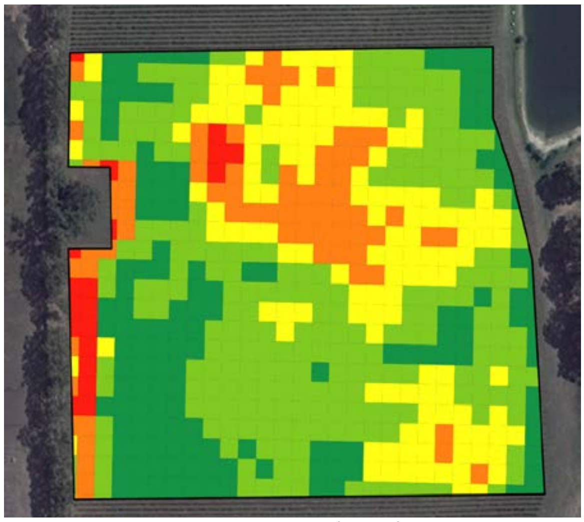
Landmark in Australia are trying to develop their own program called Echelon. Echelon has already proven itself to be a useful tool in the cropping industry with additional features like paddock-specific weather, multi-year yield data analysis and full season NDVI imagery (Landmark, 2018). Typically, innovation in the cropping industry seems more successful as they make up 17.76 per cent of agriculture in Australia opposed to viticulture's 2.42 per cent (ABS, 2018).

With the NDVI images, Echelon generates an image like that seen in Figure 9. This image displays the vine block in a variety of colours depending on the health of the vegetation (vine canopy). Dark green means it possesses the healthiest vegetation while red means it is towards the unhealthy end of the spectrum. From these images, professional viticulturists or agronomists can assess where they should take soil or tissue samples to calculate whether there is a nutrient deficiency present or lack of water. If a nutrition deficiency is identified, Echelon can generate an image and corresponding data set like that seen in Figure 10. In the near future it is thought possible that these images can be linked to the automatic GPS system present on many new tractors and used for variable rate fertilizer application. Varying the rate of application saves money and increases efficiency by applying the fertilizer where it is needed most.

Figure 9. Echelon NDVI image

Source: Landmark (2018)

Figure 10. Echelon data for variable rate fertilizer application



Source: Landmark (2018)

Unmanned Aerial Vehicles

The use of UAV's (Unmanned Aerial Vehicles) in agriculture is increasing as producers recognise their capabilities. NDVI imagery only recognises three colours (red, green and blue) as they typically use an RGB camera and produce lower quality images. However, UAV's like the one pictured in Figure 11 are equipped with a hyper-spectral camera that detects 270 colours and is more powerful than the human eye producing HD (High Definition) quality images (Australian Vignerons, 2017). UAV's can be used to assess vigour in the grapevines, as with NDVI imagery, but at a much higher cost due to hyper-spectral cameras currently costing $120,000 (Australian Vignerons, 2017). Where companies like Australian Vignerons see this technology evolving and becoming particularly useful in the future is in disease detection and prevention. Currently viticulturists must look for pests and diseases by 'scouting': walking rows at random and taking limited samples as a representation of the whole block. Hyper-spectral cameras could significantly improve this process and increase early detection of disease as instead of only assessing a small sample, the entire block would be photographed and analysed with a computer.

Private on-site weather stations

Many producers from various types of agriculture are purchasing private weather stations in order to predict and record weather events specific to their exact location.

Figure 11. UAV in viticulture

Source: Australian Vignerons (2017)

The benefits of having a weather station on a vineyard are considerable. Weather stations vary in price mainly due to build quality but even the most basic design will come equipped with a wide range of sensors. These sensors monitor air temperature, relative humidity, wind speed and direction, solar radiation, and precipitation.

Generally the system is connected to a computer either via cable or wirelessly so that the program may record evolving weather events. The system monitoring air temperature, wind speed and direction makes it easy and time efficient for the producer to record data in their spray diaries. Spray diaries are a compulsory requirement placed on producers. For example, use of Group 1 herbicides comes with a compulsory requirement that a complete and accurate record must be maintained for a minimum of two years from spray application (PIRSA, 2015). These are used to record weather events at the time of spray application to ensure quarantine control over certain chemicals with withholding periods.

Weather stations are also a very useful tool when it comes to frost prevention. It is particularly important to avoid frost as it can damage buds and young shoots, but also defoliate vines even once the canopy has been established, potentially losing the crop (Hellman, 2015). To avoid these affects weather stations can easily predict frost before it occurs by monitoring air temperature and relative humidity. If the weather station recognises that frost is about to occur then it can either notify vineyard managers or automatically trigger overhead irrigation or frost fans (Pregler, 2018). The weather station can also be used to calculate evapotranspiration (ET) where ET is the sum total of evaporation or water loss of the soil (Pregler, 2018). The calculation as to the amount of evaporation that has occurred in a given period is achieved by the weather station monitoring air temperature, relative humidity, solar radiation and wind speed. Being able to calculate this would give the producer better water-use efficiency which would result in significant cost saving due to the majority of Australian water use now being metered.

Soil moisture probes

Soil moisture probes are being used to make better use of allocated water in vineyards. Typically, a moisture sensor works by having two probes, both of which must be inserted in the soil, and then applying a current. It is the frequency of the current between the two probes that determines moisture level (Instrument Choice, 2018). Being able to use less water to achieve the required result represents a significant cost reduction. Sensoterra (2018) also point out that, on top of too little water affecting crop growth and production, too much water also washes away nutrients. It is critical that producers strike this balance in order to optimise production at minimum cost. Old systems generally required wires, which over large vineyards, were not economically viable. The more common moisture probe available now is a wireless alternative. Sensoterra have a product (Figure 12) that is stand-alone, has varying probe lengths for different applications, and just requires a solar powered base station in a central location and the user to have a smart phone or computer with their app (Sensoterra, 2018). The Department of Primary Industries and Regional Development W.A. tested various soil moisture probes and found that not all probes worked as effectively in every soil type (see Appendix), so it is important to consult with a professional before investing in soil monitoring technology.

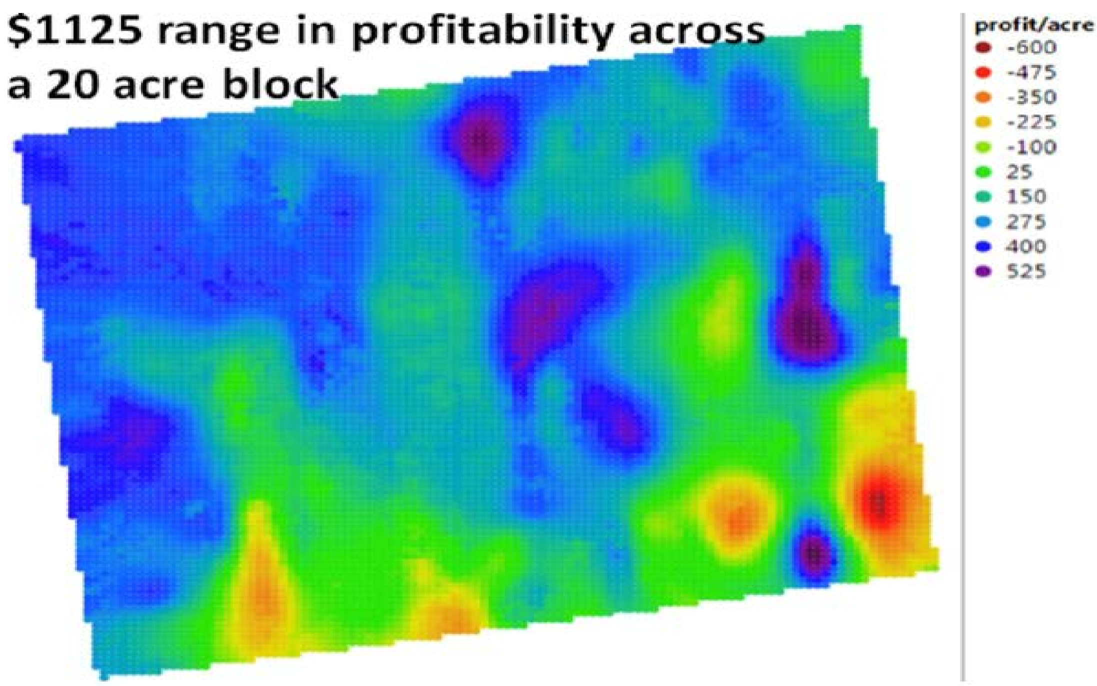
Figure 12. Soil moisture probe

Source: Sensoterra (2018)

Precision agriculture yield monitoring

Vineyard yield in the past was a simple calculation of total tonnes produced in a year divided by the area to achieve tonnes per hectare. In more recent times where vineyards have grown much larger and produce multiple varieties, it is common to calculate the yield per hectare for each block. Many variables can affect the yield of a vineyard such as soil type, row orientation, plant nutrition uptake, previous season crop stress, insect or disease pressure and cultural practices such as pruning (Efficient Vineyard, 2017). Due to individual blocks being quite large in Australia, with some as large as 20 hectares, research has shown variations in grape yield per metre of up to 8 or 10 times (TVS Precision Viticulture, 2014). Companies like Advanced Technology Viticulture (ATV) have developed a product that can be retrofitted to existing grape harvesters that will record exact yield amounts in real time and map it out using GPS (Advanced Technology Viticulture, 2018). With that information the producer can apply it to a programme like the one used by Efficient Vineyard in Figure 13 and work out profitability per hectare. In the case of the example given in Figure 13 there is $1,125 worth of variation in profit on yield across the block. It is in the interest of the producer to minimise this difference to create consistency and achieve the same grade at the processor to avoid devaluing some grapes. The other option is new technology on harvesters allowing them to sort the grapes into multiple bins based on product volume inflow. These new harvesters also have the ability to eliminate leaves and stems entering the bins (Hansen, 2015). Being able to sort the grapes into multiple grades would significantly increase profits. For example, in a scenario where the producer has a block with grade A, B and C grapes present, taking it all off in one batch would result in the producer receiving only grade C price, but if the producer was able to segregate grades 'on the fly' he would receive mixed ratios of A, B and C grape prices.

Figure 13. Yield monitoring to calculate profit



Source: Efficient Vineyard (2017)

Discussion

As within many industries, those members that fall behind or cannot differentiate themselves adequately risk going out of business. Grape producers should be looking to new technology as the next step forward in this ever-evolving industry. Large producers or corporates may need to lead the way in terms of UAV's and yield-monitoring technology due to the large cost that cannot be absorbed by the small-to-average scale producer. With time, as the technology is improved, it will come within reach of the average producer. The small-to-average scale producer should definitely be looking at NDVI imagery, private weather stations and soil moisture probes. NDVI imagery can give the producers vital information year after year assisting them in improving soil nutrition and creating a more uniform vineyard. Private weather stations can avoid the costly event of frost damage that has the potential to destroy an entire year's crop. Finally, soil moisture probes are a cheap tool that can be used for more efficient water use, thus avoiding increasing water charges, especially when prices are at their highest in a drought.

In an optimum scenario all these technologies would be adopted and work in harmony to recognise maximum efficiency. NDVI imagery would be used to assess the crop's progress throughout the season and rectify abnormalities with additional water or nutrients. UAVs allow producers to collect this information on demand although at a substantially higher price. Onsite weather stations can better predict rainfall and negative weather conditions and better water-use efficiency can be recognised with the use of soil moisture probes. Finally, any differentiation in produce quality can be mechanically sorted to achieve the best possible price.

The adoption of this technology would not only benefit the producers but everyone along the value chain. Higher quality control means fewer rejections at the processing facility reducing waste. Finally, the processor will receive greater quantities of higher-quality produce enabling them to satisfy global demand for increased quantities of quality wine.

Conclusion

This study has analysed the Australian grape production industry in comparison with other sectors of agriculture. The importance of the export market has been established as Australia is predominately a wine exporting nation. *Information* has been established as the cross functional value chain driver that technology can assist in improving. Information channels on vineyards need to be increased in order to improve Australian viticulture's strategic fit. Advanced technology is already available either in other agricultural sectors that have received more funding or overseas in larger grape growing markets. Five of these have been analysed in this study. Innovation, price and the consumer's demand for quality is the main driver that forces viticulture to continuously improve in order to create additional value in the eye of the consumer. Corporates are generally the first to adopt new technology as they have more revenue available to reinvest and the scale of their operation allows them to test new technology without severely affecting profit margins. For Australian grape producers, it is vital that they keep adopting these new technologies in order to remain globally competitive into the future. However it is important to stress the need for proper benefit cost analysis for every potential investment, as no two scenarios are the same and the requirements of individual vineyards may diverge somewhat from the recommendations given.

References

Advanced Technology Viticulture (2018), Grape yield monitoring. [ONLINE] Available at: http://www.atv.net.au/products.html. [Accessed 17 August 2018].

Australian Bureau of Statistics (2017), Value of agriculture products produced. [ONLINE] Available at: http://www.abs.gov.au/ausstats/abs@.nsf/0/58529ACD49B5ECE0CA2577A000154456?Opendocument. [Accessed 14 August 2018].

Australian Vignerons (2017), UAV's in viticulture. [ONLINE] Available at: https://www.australianvignerons.com.au/uavs-in-viticulture.html. [Accessed 17 August 2018].

Department of Primary Industries and Regional Development W.A. (2018), Soil moisture monitoring – a selection guide. [ONLINE] Available at: https://www.agric.wa.gov.au/horticulture/soil-moisture-monitoring-—-selection-guide. [Accessed 16 August 2018].

DPTI (2018), online map system. [ONLINE] Available at: https://www.dpti.sa.gov.au/ravnet. [Accessed 16 August 2018].

Efficient Vineyard (2017), Yield Monitoring in Bulk Juice Grapes. [ONLINE] Available at: https://www.efficientvineyard.com/spatial-data/yield-monitoring-bulk-juice-grapes/. [Accessed 16 August 2018].

GIS Geography (2018), What is NDVI (Normalized Difference Vegetation Index)?. [ONLINE] Available at: https://gisgeography.com/ndvi-normalized-difference-vegetation-index/. [Accessed 16 August 2018].

Hansen, M. (2015), New grape harvester leaves MOG in the field. [ONLINE] Available at: https://www.goodfruit.com/new-grape-harvester-leaves-mog-in-the-field/. [Accessed 17 August 2018].

Hellman, E. (2015), Frost Injury, Frost Avoidance, and Frost Protection in the Vineyard. [ONLINE] Available at: http://articles.extension.org/pages/31768/frost-injury-frost-avoidance-and-frost-protection-in-the-vineyard. [Accessed 16 August 2018].

Instrument Choice (2018), Soil moisture sensors and how they work. [ONLINE] Available at: https://www.instrumentchoice.com.au/emails/Monthly%20Newsletter/10-5-16/soil-moisture-sensors-and-how-they-work. [Accessed 16 August 2018].

Landmark (2018), Precision Ag. [ONLINE] Available at: https://www.landmark.com.au. [Accessed 16 August 2018].

PIRSA. 2015. Comply with legislation. [ONLINE] Available at: http://pir.sa.gov.au/biosecurity/rural_chemicals/comply_with_legislation. [Accessed 8 February 2019].

Pregler, B. (2018), Do You Need a Weather Station in Your Vineyard?. [ONLINE] Available at: https://au-kestrelmeters.glopalstore.com/blogs/news/3457062-do-you-need-a-weather-station-in-your-vineyard?utm_campaign=oth_r&utm_source=https://kestrelmeters.com&utm_medium=wi_proxy&utm_content=en_US. [Accessed 16 August 2018].

Sensoterra (2018), Sensoterra for agriculture. [ONLINE] Available at: https://www.sensoterra.com/agriculture/. [Accessed 16 August 2018].

Slebert, B. (2018), Grape growers look to sell amid "vicious cycle. [ONLINE] Available at: https://indaily.com.au/news/2015/07/30/grape-growers-look-to-sell-amid-vicious-cycle/. [Accessed 17 August 2018].

Statista (2018), Amount of grapes crushed in Australia for wine production in 2014-2015, by wine variety and state (in tons). [ONLINE] Available at: https://www.statista.com/statistics/602779/australia-grape-crush-by-state/. [Accessed 14 August 2018].

TWE Global (2012), TWE analyst workshop "Supply 101". [ONLINE] Available at: https://www.tweglobal.com/-/media/Files/Global/Presentation/TWE-Analyst-Workshop-November-2012.ashx. [Accessed 8 February 2019].

TVS Precision Viticulture (2014), Precision Viticulture: Cutting Edge Solutions for Vintage Problems. [ONLINE] Available at: http://www.tvsprecisionviticulture.com.au/uploads/web_pages/TVSWhitepaperV10.pdf. [Accessed 17 August 2018].

Vine View (2018), Product overview. [ONLINE] Available at: https://www.vineview.com. [Accessed 16 August 2018].

Wine Australia (2018a), Market insights – Australian wine exports. [ONLINE] Available at: https://www.wineaustralia.com/au/market-insights/australian-wine-exports. [Accessed 14 August 2018].

Wine Australia (2018b), About us. [ONLINE] Available at: https://www.wineaustralia.com/au/about-us. [Accessed 14 August 2018].

Wine Australia (2018c), The Australian Domestic Market; Our Biggest Customer. [ONLINE] Available at: https://www.wineaustralia.com/au/market-insights/australian-wine. [Accessed 14 August 2018].

Wine Folley (2018), Wine regions map. [ONLINE] Available at: https://shop.winefolly.com/products/australian-wine-regions-map-poster. [Accessed 13 August 2018].

Wine Titles (2017), Australia's largest wine companies by wine grape intake. [ONLINE] Available at: http://winetitles.com.au/statistics/wine-companies/australias-largest-wine-companies-by-winegrape-intake/. [Accessed 14 August 2018].

Appendix

VALUE OF AGRICULTURAL COMMODITIES PRODUCED, Australia, year ended 30 June 2017

	Value $m	Change in value since 2015-16 %
CROPS		
Wheat	7 366	19.4
Oats	547	37.5
Barley	2 658	16.7
Sorghum	237	-51.8
Rice	252	120.0
Cotton lint (irrigated and non-irrigated)	1 681	25.5
Canola	2 412	63.5
Sugar cane cut for crushing	1 624	26.6
Nurseries, cut flowers and cultivated turf	1 572	21.3
Fruit and nuts (excl. grapes)	4 234	0.2
Grapes (total)	1 475	10.6
Vegetables	3 904	8.9
Total crops	*32 845*	*20.1*
LIVESTOCK SLAUGHTERINGS AND OTHER DISPOSALS		
Cattle and calves	12 139	-7.2
Sheep and lambs	3 565	10.0
Pigs	1 342	-0.8
Poultry	2 729	-0.7
Other livestock	250	28.4
Total livestock slaughterings and other disposals	*20 025*	*-2.9*
LIVESTOCK PRODUCTS		
Wool	3 458	16.6
Milk	3 695	-13.7
Eggs	820	4.7
Total livestock products	*7 972*	*-0.7*
Total agriculture	*60 842*	*8.7*

Source: ABS (2017)

A guide to water potential sensor selection according to crop and soil type

Soil Types	**Water potential/tension sensors**		
	Tensiometer	**Granular matrix**	**Gypsum block**
Coarse sand	Yes	No	No
Sandy loam, loam, loamy clay	Yes	Yes	Yes
Heavy clay	Yes	Yes	Yes
Suitable Crops			
Vegetables and strawberries	Yes	No	No
Perennial fruit and table grapes	Yes	Yes	No
Pasture	Yes	Yes	yes
Wine grapes	No	No	Yes
Maintenance required	Moderate	Low or none	Low or none

Source: Department of Primary Industries and Regional Development W.A. (2018)