

The economics and financial benchmarking of Riverland Grape production, and potential benefits of Vitivisor technology

Prepared for Wine Australia and Riverland Wine

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Glossary

Term	***Explanation***
Capital value	Value of a parcel of land including improvements such as: buildings & structures, wells, dams & reservoirs, planting of trees for commercial purposes (SA Auditor General 2019b)
Contractor expenses	Expenditure incurred for labour and services provided under contract other than those in the nature of salaries and wages (ATO 2019a)
Current assets	Includes cash on hand, short-term bills receivable, inventories and trade debtors (ATO 2019d)
Current liabilities	Total obligations payable within the coming year (ATO 2019f)
Depreciation expenses	Deduction for the decline in value of all depreciating assets (ATO 2019a)
EBIT	Earnings before income and taxes (New Zealand Wine 2019)
Farm sizes for ABS BLADE data	For ABS Blade data (ABS DataLab 2020), we define small growers as businesses with the lowest 55% annual turnover, medium with the middle 35% turnover, and large with the top 10% annual turnover.
Farm sizes for Wine Australia data	For SA grape grower data (Wine Australia 1999 - 2020), we define small growers as as <10 ha grape area, medium as 10-50 ha grape area, and large as >50ha grape area
Gross-margin	Revenue minus variable expenses (Retallack 2015)
Interest expenses	Interest expenses incurred on money borrowed (ATO 2019a)
Lease expenses	Expenditure incurred through both finance and operating leases on leasing assets, including motor vehicles and depreciating assets such as plant (ATO 2019a)
Lot	Parcel of land as defined by the cadastre system in the land titles register
Motor vehicle expenses	Motor vehicle running expenses only. Includes fuel, repairs, registration fees and insurance premiums (ATO 2019a)
Net income	Total business income minus total expenses, adjusted by any reconciliation items (ATO 2019h)
Other expenses	All other expenses including losses on the disposal of depreciating assets (ATO 2019a)
Rent expenses	Expenditure incurred as a tenant on rental of land and buildings used in the production of

	income (ATO 2019a)
Repair and maintenance expenses	Expenditure on repairs and maintenance of plant, machinery, implements and premises (ATO 2019a)
Site value	Value of a parcel of land excluding structural improvements, but including improvements such as: draining, filling, retaining walls, excavating, grading or levelling of land, removal of rocks, stone, sand or soil, and the clearing of timber, scrub or other vegetation (SA Auditor General 2019b)
Total assets	Includes fixed, tangible, intangible and current assets (ATO 2019e)
Total business income	Includes sales of goods and services, gross distribution from partnership, gross distributions from trusts, gross interest, gross rent and other leasing and hiring income, and total dividends (ATO 2019h)
Total expenses	Includes contractor, sub-contractor and commission expenses, superannuation expenses, bad debts, lease expenses within Australia, lease expenses overseas, rent expenses, unrealised losses on revaluation of assets to fair value, all other expenses (ATO 2019a)
Total liabilities	Including other creditors and deferred liabilities, such as loans secured by mortgage and long-term loans (ATO 2019g)
Turnover	All ordinary income earned in the ordinary course of running a business for the income year (ATO 2020)
Warm inland regions	Riverland, Riverina and Murray-Darling – Swan Hill (AWRI 2019)

Executive Summary

This report details some of the contribution of the economics team to the development of Vitivisor, an open-source information, prediction and advisory dashboard platform developed for viticulture in the Riverland. The contribution to the dashboard is not documented in this report per se, and readers are referred to the main report instead. This report provides detail of the background research that went into the work on the dashboard. It includes both our review of secondary and existing information (e.g. farm and grape growing benchmarking and analysis of grape farm data from ATO and other sources); and our primary data investigation of University of Adelaide held irrigator survey data and 25 in-depth grape grower case studies. We also undertook a financial analysis to study the net social benefits to growers from adoption of the platform.

Riverland grape growing farm financial characteristics and benchmarks - existing data

A detailed review of commonly cited benchmarks and indicators used in farm business and grape growing was undertaken. Utilising benchmarking theory, the report recommends avoiding overreliance on snapshot indicators but suggest and indicator results over multiple years can be seen as best practice. Whole of farm benchmarks should only be used to identify general business viability and potential problem areas, whereas process focused benchmarking allows for a better understanding of causality and corresponding management approaches.

Actual specific grape growing financial benchmarking studies are found to be limited. The studies that do exist show that whilst cost of production seems to have been falling from 2009/10 – 2015/16, this has coincided with low grape prices over the same period and therefore a substantial number of grape farms are found to have had operative losses from 2009/10 onwards. This project addresses this knowledge gap by undertaking benchmarking analysis of the most recent available secondary data sets for Riverland grape production based on sources including the ABS DataLab (2020) microdata which has information on all grape growing businesses that lodged a tax return, the SA Auditor General (2020) and Wine Australia (1999 - 2020), findings including:

- Average farm assets for medium-sized Riverland grape farms rose from $660,000 in 2001/02 to $930,000 in 2017/18;
- Capital values of SA grape properties fell consistently from 2005/06 to 2017/18. However, this does not include water entitlement value, which increased over the same period;
- Riverland grape farms held too few assets compared to liabilities, as indicated by a low equity to asset ratio: ratio was 40%, 35% and 32% for small, medium, and large grape farms respectively and ratios indicate business solvency issues.

Irrigator survey analysis – existing data

We also applied regression analysis of two representative telephone surveys of 1,946 southern MDB irrigators from 2010/11 (946) and 2015/16 (1,000) ending up with a final cross-sectional dataset of 593 southern MDB horticultural irrigators -- of which 258 were SA Riverland grape farms. It was found that:

- farm size and water entitlement ownership were the most important influences on horticultural and grape irrigator net farm income. While larger farms and farms with more water entitlement ownership have higher net farm income in SA and for MDB grape farms, farm size had a negative impact on net farm income for grape farms outside SA, and

negatively impacts net farm income per hectare on SA grape farms.

This points towards that large, likely more automated farms, have larger net farm income than small family farms. The negative influence of farm size on net farm income per hectare might indicate that there is a size ceiling for grape farms, above which further size increases will have a negative marginal income effect. There is also a negative influence of water consumption rate on net farm income which can be explained by the savings of water costs associated with efficient irrigation. The negative influence of a high debt to equity ratio on net farm income is not surprising, given that businesses with high dept levels tend to be less financially viable, and often have to spend considerable resources on debt servicing.

Farm financial case studies – primary data collection

Twenty-five grape growers were selected by contacts, information and criteria provided by Riverland Wine and CCW Co-operative. Interviews with the research team and 25 growers were undertaken on-farm between July 2020 and April 2021 – with updated again in 2022 - with questions aimed at collecting detailed information about yield and varieties, growing practices, water use and trading strategies, farm income and costs. Interview and farm financial records were combined to create an in-depth assessment of growers' income and cost positions, with findings including that for the year of 2019-2020:

- Growers had an average of 31 hectares of red grapes and 26 hectares of white grapes, and their total average grape area was 57 ha.
- Average water use per hectare was 7.61 ML, and average grape yield was 21.8 tonnes per hectare red, and 23.4 tonnes per hectare white grapes.
- Growers received on average a grape gross margin of $6,269/ha. Grape revenue was on average $13,197/ha, roughly double of average variable expenses per ha.
- Profit was on average $3,883/ha with an average operating margin of 12%. Interestingly, operating margin was not found to be significantly associated with farm size, as there were small farms with high operating and large farms with negative operating margins.
- Average total variable grape cost per hectare for case study irrigators was $6,928/ha and average total fixed costs per hectare $3,815/ha.
- Average water costs were the largest component of total variable grape costs per hectare, representing 28% of total costs and $2,221/ha, followed by contract & labour costs at 16% of total costs and $1063/ha. Variable cost analysis reveals that contract & labour, and water costs were very different across growers, mirroring the different water ownership, labour and trading strategies.

Case study participants were invited to provide their historical farm financial records for the years 2016/17- 2018/19, and updated data for 2020-21 was also sought in the past few months of the project. Some findings included:

- Historical median grape gross margin per ha (on average) was $3,618/ha and $495/ML. Median grape revenue was $390/tonne or $9,158/ha, with variable grape expenses per hectare roughly 53% of revenue, at $4,891/ha. Median fixed expenses per hectare represented $4,842/ha;
- The largest single variable grape cost position for the period 2016/17 – 2018/19 was water costs per hectare at a median of $450/ha and 17% of average total variable costs. Median other variable grape expenses also made up 23% of total variable grape costs at a median of $1,148/ha consistent across time periods;

In 2020-21, water costs fell to an average of 20% of total variable grape costs per hectare, and

average profit and gross margins increased.

Further analysis found that grape gross margin per hectare and grape revenue per hectare are associated with the level of new technologies irrigators use. Case study irrigators who use more (sophisticated) technology tend to achieve higher grape gross margins per hectare, though the relationship is not strong or highly statistically significant.

Financial analysis – new analysis using primary level data

A financial Benefit Cost Analysis (BCA) was conducted to estimate the net benefit of adopting Vitivisor. BCA is a widely used tool for evaluating alternative courses of action that enables costs and benefits to be monetised to enable direct comparison across the full suite of options under evaluation.

The expected net present value of adoption was estimated as $1,219 per hectare, or $69,749 per average farm enterprise. The benefit cost ratio was calculated as a conservative 1.5, indicating an expected net return on investment of $1.50 for every dollar invested.

The findings in the report show that the threshold initial cost of Vitivisor dashboard software packages beyond which the expected incremental net return from the investment would be negative was calculated for the average farm enterprise as $67,198 over the five-year lifespan. There were some limitations noted in the report but overall analysis shows potentially reduced overall decision-making times for some farmers, in addition to significantly greater savings in electricity, fuel and labour costs. Farmers that experienced greater water costs would also benefit a lot more than the predicted average.

Overall, the works provided in this report showcase that future economic and financial research may be warranted to address limitations and to advance necessary understanding of actual benefits of adoption of decision-making tools across grower groups. The findings demonstrate that the Riverland region's growers need improved farm outcomes including profitability, and that the adoption of Vitivisor dashboard technology can be expected to be beneficial for growers for improved on farm decision making.

1 Introduction and background

Riverland Wine, Wine Australia and the University of Adelaide are developing an open-source information, prediction and advisory platform for viticulture with the aim to support on-farm decision making, increase information transferability and access, and in so doing improve farm outcomes, including improved gross margins/profitability and sustainability. It is to be called Vitivisor.

Vitivisor is founded on the digitisation, organisation and visualisation of an unprecedented range of data related to all aspects of vineyard function, but the program will take a key focus around water usability and efficiency issues. These data, to be made available to growers through an intuitive and user-friendly dashboard, will enable the sector to:

- better track how key management actions (e.g. water, nutrient and spray application; canopy management) relate to vineyard outcomes (i.e. yield, quality measures, profitability), across varieties, patches and time;
- share information between growers within a vineyard enterprise;
- benchmark management actions against outcomes relative to other 'similar' growers;
- interact with agronomists to obtain targeted advice; and
- support communication with banks and financial advisors when considering financial viability of vineyard enterprises.

The rigorous data integration efforts will also unlock a series of higher-level prediction and advisory services, which will be made available through the platform via a series of 'apps' that can build and improve over time. An early emphasis will be placed on providing guidance on water management given grower feedback and the recent increases in water prices; however other areas related to disease and canopy management also will be explored throughout the project.

The School of Economics and Public Policy was asked to undertake comparative farm financial and benchmarking analysis, water market forecasting and scenario planning. The team also supports the Vitivisor team with the architecture and conceptionalisation of financial data collection and benchmarking tools in the Vitisivor app.

Due to timelines, budget, and in consultation with industry partners, a representative farm survey was deemed impractical. Alternative methods have been devised, which include desktop analysis of all available grape growing financial benchmarking studies and secondary grape farm data (see sections 1.2 and 2), a pilot study of three farms (See Appendix 4), and 25 in-depth grape grower case studies including farm financial and benchmarking analysis. Financial analysis of the returns to growers from adopting Vitivisor and water market forecasting and financial scenario planning and support the design of corresponding modules in the Vitivisor app was also conducted, in addition to syncing with other farm financial tools, including Know Your Numbers (KY#) and Xero accounting software.

The objectives of this study include: 1) analyse existing secondary data about Riverland grape growing and grape growing financial benchmarking wherever possible to provide an overview of economics and financial performance of grape production in the Riverland (as compared to the Australian situation); 2) undertake a series of three case studies for a small, medium and large viticultural farm on the benefits and costs that they perceive with the new potential technology; 3) undertake 20 in-depth case studies to understand financial and structural challenges for Riverland grape growers, assess their financial situation and business viability using comparative farm analysis and benchmarking analysis; 4) farm financial scenario analysis

and forecasting; 5) water market predictions and price forecasting; and 6) broadly estimating the economics of the potential technology using standard benefit cost (financial grower) analysis.

1.1 Overview of Riverland Viticultural information

A review of the existing literature in this space revealed that there is a lack of consistent, up-to-date information on the economics of grape production in the Riverland.

1.1.1 Data sources overview and summary

Some important high level information that is available from sources such as ABARES (2019), AWRI (2019), ACCC (2019), ABS DataLab (2020), Wine Australia (1999 - 2020), SA Auditor General (2020), various consulting reports and the ABS agricultural census (ABS 2015) include:

- Yield (tonnes/ha) for 2015 and 2016 by region in Australia and tonnes produced for Australia from 1988-89 to 2015-16 (ABARES 2019);
- Yield (tonnes/ha) and Grape price (red/white/total) for 2015/16 - 2020/2021 by region in Australia (Wine Australia 2015 - 2021); South Australian Yield (tonnes/ha) and Grape price (red/white/total) for 1999/00 – 2020/21 (Wine Australia 1999 - 2020); Grape price (red/white/total) ($/tonne) for 2015/16 by region, and prices for Australia from 1988-89 to 2015-16 (ABARES 2019);
- Vineyard operating costs ($/ha) for some inland wine regions for 2006/07; 2008/09; 2010/11, and for Riverland from 2002/03 to 2006/07 (Retallack 2010, 2012, 2015);
- Farm cash income, rate of return, capital investment, adoption of irrigation infrastructure (%) of Murray-Darling Basin viticulture for 2006/07 to 2015-16 and proportion of total cash costs (average for time period) (ABARES 2019).
- Riverland, and other major Australian Wine Regions, grape farm turnover, net income, total business income, total assets, total liabilities, total expenses, interest expenses, contractor costs, depreciation costs, motor vehicle costs, repair and maintenance costs, and other costs from 2001/02 – 2017/18 (ABS DataLab 2020);
- Riverland grape farm numbers, average farm size, total grape area, and grape lot land values from 1985/86 – 2018/19 (Wine Australia 1999 - 2020; SA Auditor General 2020).

In particular, grape crush surveys from Wine Australia outline the volume of grapes by variety produced across Australia's wine growing regions from 2015/16 – 2020/21. Data on South Australian wine regions go back as early as 1999/00 – 2020/21 and also contains farm size and farm numbers for each year, separating growers into five different sizes: <10 ha; 10-24 ha; 25-49 ha; 50-99 ha; and >100 ha.

The SA Auditor General (2020) data comprises statutory property valuations of Riverland lots[1] classified as 'Vines'; 'Vines – irrigated'; 'Vines and others'; 'Vines and others – irrigated'; and 'Vines and Stock – irrigated'[2] from 1985/85 – 2017/18. The dataset comprises lot sizes, site values and capital values[3], both nominal and in 2017/18 prices.[4]

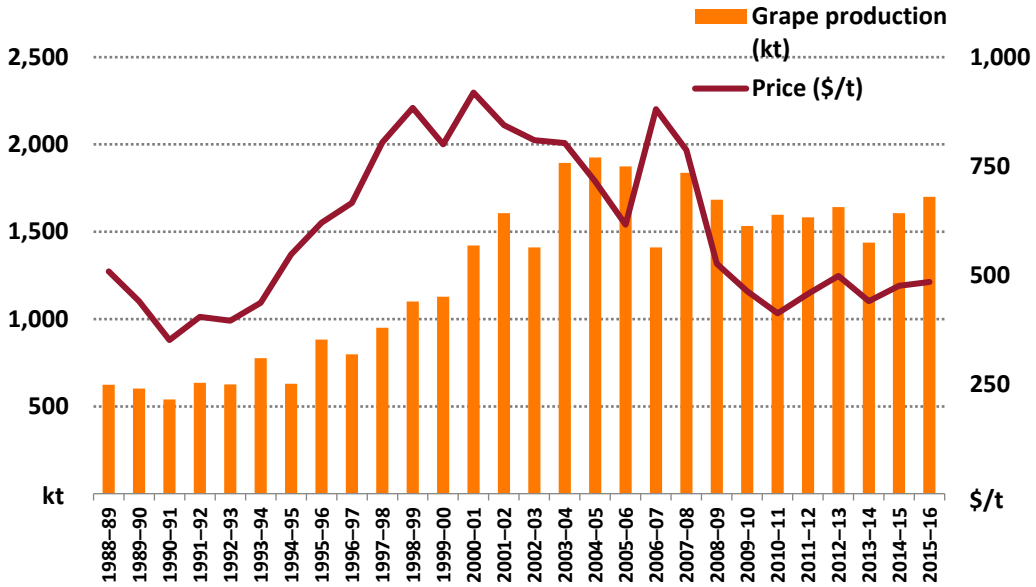
[1] A lot is a parcel of land as defined by the cadastre system in the land titles register.
[2] The corresponding land use codes are: 9300; 9301; 9360; 9361; and 9611 (SA Auditor General 2019a).
[3] For a definition of site and capital values, see SA Auditor General (2019b).
[4] Based on consumer price index data from ABS (2020).

A special data request for the ABS Business Longitudinal Analysis Data Environment data (BLADE) (ABS DataLab 2020) contains Riverland grape growers' average turnover, net income, total business income, total assets, total liabilities, total expenses, interest expenses, contractor costs, depreciation costs, motor vehicle costs, repair and maintenance expenses and other costs (see Glossary for more details), from 2001/02 to 2017/18 in 2017/18 prices, collected by the Australian Taxation office (ATO). The dataset also includes the number of observations (growers) for each item each year.

1.1.2 Historic grape yield and prices

The Australian grape growing industry has experienced a prolonged period of low grape prices, combined with increasing production (see Figure 1.1).

Figure 1.1 Australian grape production and prices from 1988-89 to 2015-16



Source: created from data within ABARES (2019)

The ABS 2015-16 census estimated 23,784 hectares of Riverland grapevines (and 21,925 hectares watered with 144,119 ML for an application rate of 6.6 ML/ha). Yield was estimated at 21 tonnes/hectare. Based on Wine Australia data, Riverland average yield has increased from 14.7 tonnes/ha in 2007/08 to 25.6 tonnes/ha in 2020/21 (Wine Australia 1999 - 2020).

Table 1-1 and Table 1-2 illustrate specific yields and prices of Australian grape growing regions for 2015/16 and 2020/21. The Riverland in particular achieved 84% higher yields in 2020/21 (tonnes/hectare) than the Australian average yield overall, but received 29% lower prices than the average Australian price in the same period.

Table 1-1 Australian grape production yields in 2014/15, 2015/16 and 2020/2021 by region

Region	*Yield (t/ha)*		
	Total 2015/16 survey yield	***Total ABS 2014/15 yield***	***Total 2020/21 survey yield***
Adelaide Hills	10.1	8.7	7.8
Barossa Valley	6.5	5.2	5.5
Clare Valley	7.2	5.4	4.0
Coonawarra	7.0	5.8	9.5
Eden Valley	5.3	5.8	4.6
Great Southern	5.8	3.4	3.3
Heathcote	7.5	6.4	5.4
Hilltops	6.8	7.1	1.9
Hunter	5.4	3.3	1.5
Langhorne Creek	13.6	7.9	8.8
Margaret River	6.7	5.3	4.3
McLaren Vale	8.8	6.0	5.1
Mornington Peninsula	4.9	4.2	5.7
Murray Darling - Swan hill	24.5	23.6	11.4
Orange	8.6	6.7	2.9
Riverina	15.7	15.4	18.3
Riverland	21.0	23.0	25.6
Rutherglen	6.1	5.4	3.8
Tasmania	9.1	5.8	6.3
Wrattonbuly	9.5	7.1	12.3
Yarra Valley	8.5	6.4	4.0
Cool/temperate	7.9	6.6	10.7
Warm inland	21.1	20.5	21.0
Australia	13.3	12.1	13.9

Source: Created from data within AWRI (2019) and (Wine Australia 2021); based on ABS yield survey and census data, and Wine Australia grape price data

Table 1-2 Australian wine grape prices by region for 2015/16 and 2019/20, in 2019/2020 prices

Region	*2015/16 Grape price indexed to 2020/21 price levels ($/t)*			*Grape price ($/t) 2020/21*		
	Red grapes	***White grapes***	***All grapes***	***Red grapes***	***White grapes***	***All grapes***
Adelaide Hills	1,649	1,402	1,475	1,864	1,631	1,717
Barossa Valley	2,204	824	1,981	2,373	949	2,279
Clare Valley	1,402	1,070	1,258	1,648	1,359	1,562
Coonawarra	1,627	643	1,576	1,351	884	1,306
Eden Valley	2,364	1,431	1,879	2,517	1,699	2,152
Great Southern	1,605	1,186	1,410	1,939	1,186	1,596
Heathcote	1,258	976	1,244	1,532	1,207	1,451
Hilltops	969	687	860	1,266	1,405	1,280
Hunter	1,605	1,236	1,294	1,783	1,390	1,523
Langhorne Creek	882	637	839	987	752	948
Margaret River	1,663	1,308	1,431	1,657	1,278	1,429
McLaren Vale	1,857	882	1,749	2,009	1,235	1,960
Mornington Peninsula	3,043	2,660	2,812	3,881	3,415	3,677
Murray Darling - Swan hill	354	325	340	524	459	487
Orange	1,070	1,092	1,078	1,542	1,663	1,600
Riverina	397	311	347	536	409	467
Riverland	376	304	333	548	408	489
Rutherglen	1,192	1,569	1,286	1,203	1,434	1,234
Tasmania	3,181	2,827	2,963	3,291	3,003	3,154
Wrattonbuly	1,150	737	1,056	1,096	954	1,069
Yarra Valley	1,909	1,649	1,763	2,244	1,991	2,149
Cool/temperate	1,439	1,048	1,308	1,575	1,196	1,386
Warm inland	376	311	347	552	423	488
Australia	709	441	571	838	541	690

Source: Created from data within AWRI (2019) and (Wine Australia 2021); based on ABS yield survey and census data, and Wine Australia grape price data. Rounded to the next full dollar

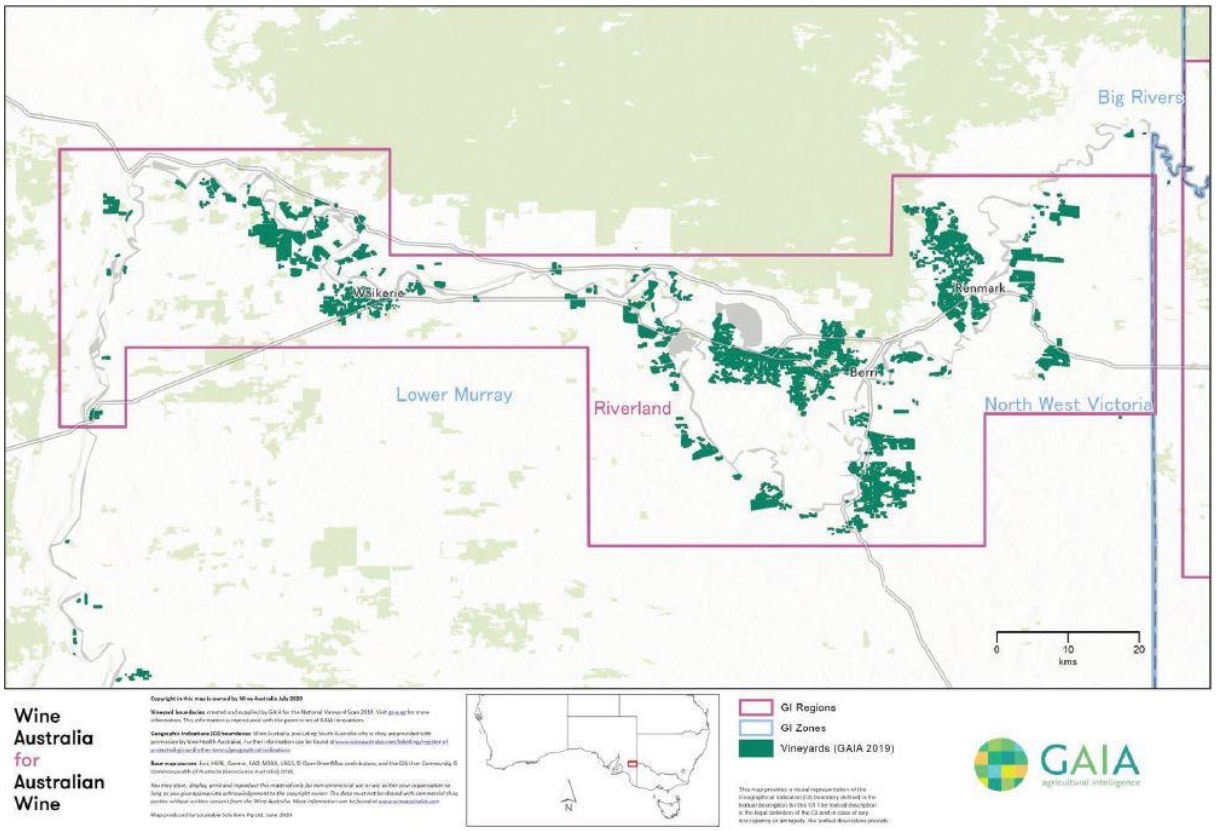
1.1.3 Domestic and international wine markets and corresponding implications

With domestic wine demand relatively stable (Centaurus 2013), the majority of Australian wine produced (63%) goes into export, with 849 million litres worth $2.8 billion exported in 2017/18 (ACCC 2019). The top five export markets in 2017/18 were China, the US, the UK, Canada and New Zealand. Despite its high degree of mechanization and technical advances in term of yield and natural resource use, Australia generates no superior gross margins compared to other major wine growing regions (Davidson 2010). This is likely at least partially related to Australia's export product segments: 52% of exported wine volume retailed for 7-10 $/litre and 33% for below 7 $/litre in 2012 (Centaurus 2013). This reflects a high percentage of bulk wine export in the low value segment, as opposed to boutique bottled wines at high prices. With international customers regarding bulk wine as a homogeneous product, price is the only differentiating product criteria, making Australian wine exporting producers price takers on the international markets (ACCC 2019). Together with often high

concentration of grape processors and the associated bargaining power (only one or two dominant grape buyers in the Riverland), grape growers become price takers by extension, highly exposed to the international market price for bulk wine. This situation has led to a period of protracted low grape prices and unprofitable production for over a decade, contributing to industry consolidation with a reduction in number of Australian growers by 35%, a reduction in total Australian vineyard area by 19% and an increase of average vineyard size by 25% between 2008-2015 (ACCC 2019).

1.1.4 Average farm size and number of Riverland grape growing businesses

Figure 1.2 Riverland vineyard areas

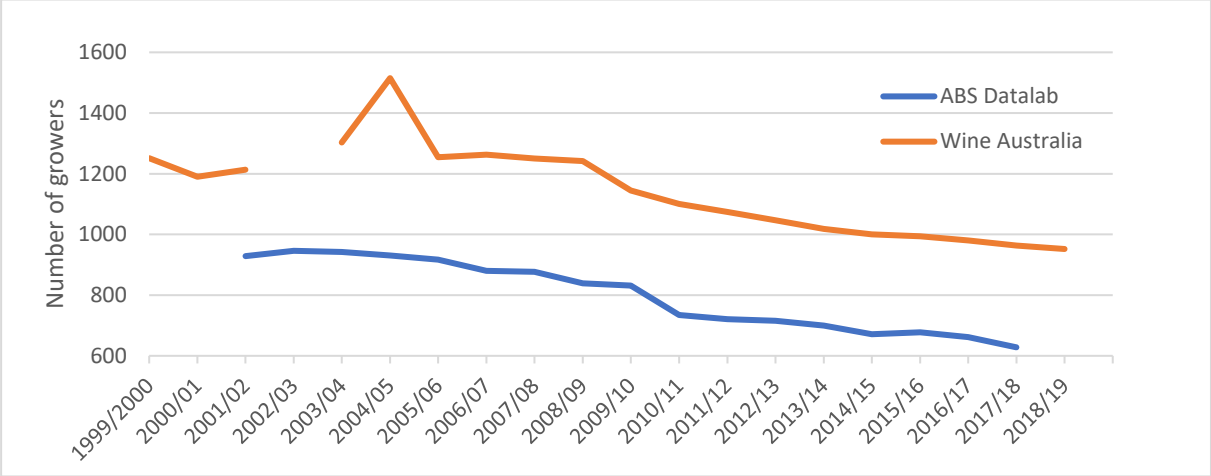


Source: Wine Australia (2020a, p. 35)

Following the trend in most Australian warm inland wine regions,[5] there has been a consolidation of Riverland grape growing businesses over the last 15 years. The ABS 2015-2016 census estimated that there were 786 businesses in the South Australian Murray-Darling Basin region growing grapes, while Wine Australia estimates 994 businesses growing grapes on 20,612 ha in the Riverland in 2016, and 936 businesses growing grapes on 20,575 ha in 2020 (Wine Australia 2016, 2020b). Figure 1.3 shows that the number of Riverland grape growing businesses has been decreasing in both the ABS BLADE and the Wine Australia data set, from 929 and 1213 respectively in 2001/02, to 628 and 963 in 2017/18.

[5] Warm inland regions are the Riverland, Riverina and Murray-Darling – Swan Hill (AWRI 2019)

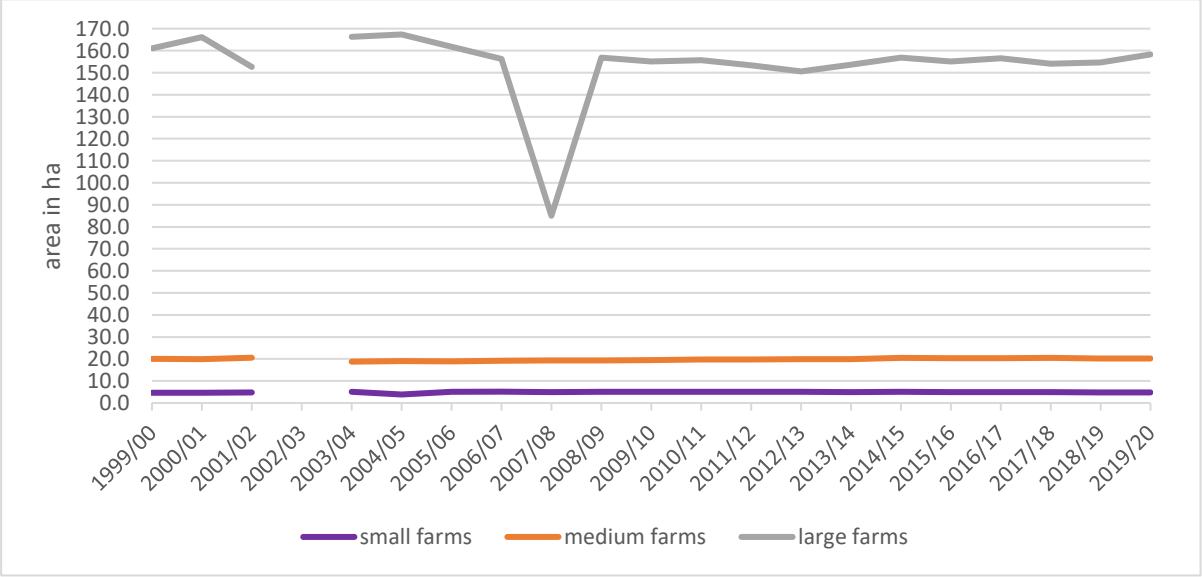
Figure 1.3 Number of Riverland grape growers from 1999/2000 to 2019/20



Source: created from ABS DataLab (2020) and Wine Australia (1999 - 2020)

However, based on Wine Australia (1999 - 2020), the average size of Riverland grape growing businesses has remained largely constant during the same period. This extends to the average size of small, medium and large farms (see Figure 1.4).[6]

Figure 1.4 Average farm size for small, medium and large Riverland grape growers 1999/2000 – 2019/20



Note: We categorise small farms as <10 ha grape area, medium as 10-50 ha grape area, and large as >50 ha grape area.

Source: created from Wine Australia (1999 - 2020)

In contrast, area planted to grapes in the Riverland has contracted by 1,881 ha from 22,456 ha in 2007/08 to 20,575 ha in 2019/20 (PGIBSA 2008; Wine Australia 2020b). This points towards that grape area from farm closures has not been absorbed by other grape businesses, but rather went to other horticultural crops, such as almond and nut trees, which expanded their Riverland area from 5,000 ha in 2015 to around 9,000 ha in 2018 (HARC 2020).

[6] We categorise small farms as <10 ha grape area, medium as 10-50 ha grape area, and large as >50ha grape area.

1.2 Farm business analysis and benchmarking literature review

While it illustrates the state of the grape industry, the previous section does not provide detailed analysis of the financial viability of Riverland grape businesses. To allow for detailed financial analysis, this section introduces the theory, approaches and tools of farm business analysis and benchmarking which are commonly used in many sectors to examine and compare the viability and competitiveness of businesses. They are seen as easily accessible and useful approaches to understand and implement best practice business management.

1.2.1 Benchmarking theory

Benchmarking first appeared in the 1980s in the US private sector, with the seminal work of Camp (1989, p. xi) defining it as " the search for best practices that lead to superior performance". Cowper and Samuels (1997, p. 1) define: "Benchmarking as an efficiency tool is based on the principle of measuring the performance of one organization against a standard whether absolute or relative to other organizations". Benchmarking has become an integral part of performance analysis and improvement processes for many public and private enterprises (Isoraite 2004) and can take different forms. A common typology is to distinguish between subject and scope of benchmarking. The subject of benchmarking determines *what* indicators to look at, while the scope of benchmarking determines *with whom* to compare to. Process, performance and strategic benchmarking are concerned with the subject (Camp 1989), whereas internal, competitive, functional and generic benchmarking are concerned with the scope (Andersen 1995) of benchmarking (see Table 1-3 for an overview and examples).

Table 1-3 Benchmarking typologies and examples

Topic	***Name***	***Approach***	***Example***
Subject	Process benchmarking	Benchmarks company operation processes	Time taken to prune one hectare
	Performance benchmarking	Benchmarks indicators of company success	Production costs per bottle of wine
	Strategic benchmarking	Compares business strategies against best practice applied by competitors	Selling wine only at cellar door compared to also selling online
Scope	Internal benchmarking	Compares within company unit or over time	Water use costs at different growing locations
	Competitive benchmarking	Compares to direct competitors	Profit compared to regional market leading business
	Functional benchmarking	Compares to companies across different fields	Profit per tonne of wine grapes compared to profit per tonne of citrus
	Generic benchmarking	Compares across different industries	Profit per wine bottle compared to profit per bottle of whiskey

Sources: adapted from Andersen (1995), Camp (1989), Isoraite (2004) and Terziyska (2017)

While benchmarking is widely used in practice, its application often lacks a standardized, consistent and rigorous approach, reflected in a large variety of benchmarks and indicators reported across different studies (see next section). This partly stems from the type of analysis (e.g. strategic versus process benchmarking), the data available, and the discipline involved. For example, Ronan and Cleary (2000) highlight that there are different ways of calculating the unit cost of production, a commonly used benchmark, depending on whether accounting, economic or banking methodology is used. Similarly, while economic benchmarking studies tend to use stochastic frontier analysis, data envelope analysis, or regression analysis to examine economies of scale and efficiency rankings (e.g. (Manevska-Tasevska and Hansson 2010; Nakana and Mkhabela 2011; Guesmi et al. 2012; Coelli and Sanders 2013; Delord et al. 2015)), consultancy and private sector studies utilise simple input-output ratios to compare the bottom with the top quartile, and the median/average of businesses in a given year (e.g. (Galitsky et al. 2005; Lagura and Ronan 2010; Retallack 2015; WFA 2015; Barber et al. 2016; Deloitte 2019; New Zealand Wine 2019)).

This practical application in the private sector has drawn criticism both on methodological and philosophical grounds. Ronan and Cleary (2000) criticize benchmarking through aggregate measures of whole farm physical and financial performance (e.g. yields, gross margins, efficiency) as being the differently termed comparative farm business analysis of the 1960s, lacking systemic linkage to the underlying processes and drivers of business competitiveness. In particular, not accounting for the full financial performance of the farm and component enterprises (e.g. excluding overheads or debt-servicing) are identified as significant weaknesses of historic and current benchmarking practice.

Deane and Malcolm (2019) postulate that current benchmarking practice wrongfully assumes that differences between farm profits are due to differences of managerial skill, although farm profits are mainly influenced by producer prices and seasonal conditions. Further, the gap between farm performance and the average performance of the top fraction of farms (e.g. 75% quartile) is implicitly assumed as the potential benefit from better farm management. This is particularly problematic when only comparing a one-year snapshot, as profit differences are likely a manifestation of favorable/unfavorable seasonal and market conditions. Other criticisms include the inability to derive marginal productivities from average data, the inability to determine causal links of input-output ratios to farm profit, the sensitivity of farm benchmarks to data and measurement inaccuracies, and the common mix of subjective and objective data (Deane and Malcolm 2019).

Both Ronan and Cleary (2000) and Deane and Malcolm (2019) argue that benchmarking is historically and philosophically process focused, suggesting that whole of farm indicators (e.g. profit per hectare) are more appropriately called comparative farm analysis. However, these criticisms and distinctions have had little influence on the terminology used, with comparative farm business analysis and process-focused benchmarking routinely labeled benchmarking, and methodological weaknesses rarely addressed. Indeed, Deane and Malcolm (2019) recognize that comparative farm business analysis yields important and useful information for managers, but suggest careful interpretation, longer data periods of at least 5-7 years, and recognizing the effects of seasonal variability and relative farm differences, is needed to more robustly identify farm management best practice through benchmarking studies. Additionally, Aupperle and Dunphy (2003) contend that solely focusing on snapshots of profitability ratios (e.g. return on assets) can be misleading. Instead, they advocate benchmarking studies should include indicators of business risk (e.g. total debt to total equity,

long term debt to total equity ratio), profitability, and sales growth developments over time. These can then be compared to other businesses in order to receive a qualitative assessment of the current company's position, its strengths and weaknesses. This is supported by Deane and Malcolm (2019) who argue that benchmarking needs to recognize that greater risk is associated with greater return potential and it is therefore important to track the payoff of risk and return over time, potentially in form of comparing average return on capital with the variance of returns over time.

This report acknowledges the aforementioned criticisms and cautions that the importance of one-year snapshot benchmarks and indicators should not be overestimated, and analysis over multiple years should ideally be undertaken. However, due to data availability issues, practicality, and accessibility considerations for growers, this report will adopt the term "benchmarking" for both process and whole of farm indicators, and also assess simple input-output ratios, rather than more complicated economic analysis methods (e.g. stochastic frontier analysis).

1.2.2 Commonly used benchmarks and farm business indicators

This section introduces a number of benchmarks and farm business indicators which have been used in various benchmarking studies, with special focus given to studies from the grape growing sector. Note that given the large amount of benchmarking studies across different sectors, we are not striving for a comprehensive representation of all available benchmarking tools and indicators.

Benchmarks and indicators are organized by whether they focus on the whole business, or are expressed in units of inputs or outputs. We also provide an overview of data components and terms required to calculate particular benchmarks (see Table 1-4).

Table 1-4 Definitions and calculations of important factors for Benchmarking

Term	*Calculation/definition*
Operating costs/variable costs	Farm labour costs + Contract labour costs + Fruit transport costs + Levies + Cost of chemicals + Nutrition/fertilizer costs + Vineyard floor management costs + Sundry materials and supplies costs + Machinery Expenses + Machinery Fuel costs + Machinery, Plant & Equipment hire + Water and drainage costs + Costs of water leases, etc + Vineyard repairs & maintenance costs
Overhead costs/fixed costs	Permanent management costs + Owner's labour cost + Land Rates and Taxes + Power costs (buildings) + Insurance costs + Cost of professional services + Office/administration costs + Lease or rent payments + Costs from OH&S requirements + Staff development costs + Environment costs + Overhead repairs & maintenance costs
Debt servicing	Interest payments and finance cost for company debt
Current Liabilities*	Trade payables and accruals + Other current liabilities
Term Liabilities	Long-term debt + Other non-current liabilities
Total current assets*	Cash + Receivables + Inventory + Other current assets
Total fixed assets*	Land + Vineyard/biological assets + Plant and equipment
Total assets*	Total current assets + Total fixed assets + Other non-current assets
Gross vineyard income/ revenue/ sales	Proceeds from Grape payments + Other vineyard income - Levies
Total income/revenue	Gross vineyard income + Other income
Capital expenditure/expense	Capital expenditure is the money a business spends to buy, maintain, or improve its fixed assets.
Operating assets	Total assets - Excess cash and cash equivalents - Financial assets
Operating liabilities	Accounts payable + Accrued/deferred operating expenses + Reserves for operating expenses + Accrued/deferred taxes on operating profit + Reserve for taxes on operating profit

Invested capital	Operating assets - Operating liabilities

Note: * Often averaged between the start and the end of one financial reporting period. Alternatively, calculated from data at the end of the financial reporting period.

Sources: adapted from Retallack (2015) and Deloitte (2019)

Although many of the items in Table 1-4 (or their averages) are used in consultancy and private industry benchmarking studies to compare businesses, they often do not consider business size and operation scale, and are therefore not considered benchmarks or indicators by this report. One of the most important indicators often used is gross margin.

Instead, these items are required to calculate a variety of different benchmarks, including whole of business benchmarks, input and output benchmarks. Whole of business benchmarks (Table 1-5) are based on data from the whole business, not distinguishing between different processes and business parts. These indicators allow for a quick assessment of business performance, but do not readily reveal underlying causalities and areas of potential improvement.

Table 1-5 Whole of business benchmarks and indicators

Benchmark/indicator	***Calculation/formula***	***Interpretation/comments***	***Source***
Asset turnover	Current revenue / total assets	Higher asset turnover indicates lower business risk (i.e. higher ability to cover fixed operating expenses)	(Aupperle and Dunphy 2003); Deloitte (2019)
Cost of production/growing costs	Operating cost + overhead cost + debt servicing	Generally, a lower cost of production is preferred	Retallack (2015)
Current ratio	Current assets/ current liabilities	Ability to pay current liabilities from available cash. Value less than 1 indicates short-term liquidity issues.	Deloitte (2019)
Earnings before income and tax (EBIT)	Vineyard return – depreciation – debt servicing + other income		New Zealand Wine (2019)
Equity to asset ratio	Total equity/total assets	Measure of business solvency. Any ratio less than 70% puts a business at risk and may lower borrowing capacity.	Kantrovich (2011); Deloitte (2019)
Fixed asset turnover	Current revenue / total fixed assets	Generally, a higher fixed asset ratio implies more effective utilization of investments in fixed assets to generate revenue.	Goncharuk and Lazareva (2017); Deloitte (2019)
Free cash flow	Cash from revenue – capital expenditures	Cash flow is a measure of the available funds over and above expenses that are available for discretionary use by the firm. (calculated from statement of cashflows)	Aupperle and Dunphy (2003)
Interest cover ratio	EBIT/debt servicing	Indicates how well a firm can pay the interest on	Deloitte (2019)

		outstanding debt. A higher coverage ratio is generally better	
Inventory to sales ratio	Monthly Inventory ($)/ monthly revenue ($)	Relates inventory to revenue, indicating how much produce is stored as compared to how much is sold	WFA (2015)
Irrigation water cost to cost of production ratio	(Water and drainage costs + cost of water leases)/ cost of production	Illustrates share of irrigation water costs to total cost	Authors
Labour productivity	Current revenue/full time employees	Higher ration means more productivity per unit of labour input	Goncharuk and Lazareva (2017)
Long-term debt to total equity ratio	Long-term debt/ total equity	Ability to repay long-term debt from available cash	Aupperle and Dunphy (2003)
Net profit (whole of farm)	Farm revenue – total cost of production (=variable + fixed costs) - taxes		
Net profit margin	(Net profits/ revenues) *100		Aupperle and Dunphy (2003)
Operating margin	(EBIT/ Revenue)*100	Shows proportion of revenues available to cover non-operating costs	
Proportion of variable costs to total costs	Variable costs / total costs	Illustrates diminishing returns of inputs to outputs, the closer this fraction is to 1. As more variable inputs are used, there comes a point when each extra input adds less to output.	
Rate of return	(Vineyard business profit + interest + lease and payments) / total vineyard capital	Represents the ability of the farm business to generate a return to all capital used by the business, including that which is borrowed or leased	Ashton et al. (2010)
Return on assets (ROA)	Total income/ total assets	Percentage of how profitable a company's assets are in generating revenue. ROAs over 5% are generally considered good	Aupperle and Dunphy (2003); Deloitte (2019)
Return on capital (ROC)	EBIT/ invested capital	Indicates how effective a business turns capital into profits	Lagura and Ronan (2010)
Return on equity (ROE)	Total income/ total equity	Measure of ability to generate income from the equity available. ROEs of 15-20% are generally considered good	Aupperle and Dunphy (2003)
Sales growth rate	[(Current revenue/previous period's revenue) – 1] *100	Percent growth in the net sales of a business from one fiscal period to another.	Aupperle and Dunphy (2003)

Total cash costs		payments made by the farm business for materials and services and for permanent and casual hired labour, excluding owner manager, partner and family labour	Ashton et al. (2010)
Total cash income		revenues received by the farm business during the financial year	Ashton et al. (2010)
Total debt to equity ratio	Total debt/ total equity	Ability to repay all debt from available cash	Aupperle and Dunphy (2003)
Total Equity	Total assets – total liabilities	Higher equity points to a more financially sustainable business and is seen as a risk averse business management.	Deloitte (2019)
Turnover	Revenue ($) / Inventory ($)	Indicated how quickly inventory is sold and replenished. A quick turnover usually indicates a higher sales volume and a greater profit on dollars invested in inventory. Turnover < 1 shows increasing inventory	WFA (2015); Deloitte (2019)
Vineyard business profit	Vineyard cash income + changes in stocks/inventory - depreciation – imputed value of family labour		Ashton et al. (2010)
Vineyard business return	Vineyard return – debt servicing OR Vineyard revenue - operating costs - overhead costs - debt servicing	Return after servicing all costs, including debt. Negative business returns paired with positive vineyard returns signal inability to cover cost of capital.	Retallack (2015)
Vineyard cash income	Total cash receipts – total cash costs	Vineyard cash income is the surplus vineyard-based income available after paying for cash operating costs.	Ashton et al. (2010)
Vineyard Gross Income	Vineyard revenue	Size can signal the ability of operation to cover operational expenses.	Retallack (2015)
Vineyard gross margin or Vineyard net income	Vineyard revenue – operating costs	Ability of operation to cover operational expenses. Negative gross-margins signify serious problems with the business.	Retallack (2015)

Vineyard income to total income	Vineyard revenue/ total revenue	Measures income diversification, with 1 as totally undiversified	Guesmi et al. (2012)
Vineyard return	Vineyard gross margin – overhead costs OR Vineyard revenue - operating costs - overhead costs	Ability to cover business expenses, but excluding financial liabilities.	Retallack (2015)
Working capital	Current assets - current liabilities	Represents operating liquidity, with negative working capital signaling short-term liquidity issues.	Deloitte (2019)

Another way of assessing business performance is by attributing whole of business benchmarks and indicators to the business input or output. The advantage of is that it allows to robustly compare businesses of different sizes and enables identification of potential areas of improvement. Table 1-6 exemplifies some common benchmarks in relation to business inputs.

Table 1-6 Benchmarks per unit of input

Benchmark/indicator	*Calculation/formula*	*Interpretation/comments*	*Source*
Application rate	Irrigation water use /planted area	A high application rate compared to similar farms may indicate inefficient irrigation technology and/or scheduling.	Authors
Cost of production per hectare	(Operating cost + overhead cost + debt servicing)/ planted area	Allows comparison of scale independent production costs between businesses	Guesmi et al. (2012); Retallack (2015)
Energy cost per hectare	Energy cost/ planted area		Manevska-Tasevska and Hansson (2010)
Family labour ratio	Family labour (FTE)/ total labour (FTE)	Smaller farms tend to have larger ratios	Guesmi et al. (2012)
Fertilizer and pest control cost per hectare	(Fertilizer cost + pest control cost)/ planted area		Manevska-Tasevska and Hansson (2010); Guesmi et al. (2012)
Gross vineyard income per hectare	(Grape payments (less levies) + other vineyard income)/ planted area	Signifies income streams per associated hectare of production	Retallack (2015)
Irrigation cost to cost of production ratio per hectare	(Water and drainage costs + cost of water leases)/ cost of production per hectare	Illustrates share of irrigation water costs to production costs per hectare.	Authors
Operating costs per hectare	Variable costs/ planted area	Costs payable to produce per hectare of production	Retallack (2015)
Overhead costs per hectare	Fixed costs/ planted area	Fixed cost directly attributable to vineyard area	Retallack (2015)
Vineyard business return per hectare	(Vineyard return – debt servicing)/planted area OR (Vineyard revenue - operating costs - overhead costs - debt servicing)/planted area	Return after servicing all costs, including debt per hectare	Manevska-Tasevska and Hansson (2010); Guesmi et al. (2012); Retallack (2015)
Vineyard gross margin per hectare	(Vineyard revenue – operating costs)/planted area	Contribution to cover operational expenses per hectare. Comparison between different varietals can identify underperforming assets.	Retallack (2015)
Vineyard return per hectare	(Vineyard gross margin – overhead costs)/planted area OR (Vineyard revenue - operating costs - overhead costs)/planted area	Contribution to cover business expenses per hectare, excluding financial liabilities	Retallack (2015)
Yield/ha (tonnes/ha)	Yield of grape variety/planted area	Allows comparison of growing performance with similar farms	New Zealand Wine (2019)

Alternatively, benchmarks can also be expressed in relation to business outputs (see Table 1-7).

Table 1-7 Benchmarks per unit of output

Benchmark/indicator	*Calculation/formula*	*Interpretation/comments*	*Source*
Debtors to sale ratio (Accounts receivables to sales ratio)	Receivables/ revenue	Measures how much of a business' sales occur on credit. A larger ratio may indicate exposure to short-term liquidity problems.	Deloitte (2019)
Gross margin per tonne	(Vineyard revenue – operating costs)/ volume of grapes produced		Deloitte (2019)
Irrigation water costs per tonne	(Water and drainage costs + cost of water leases)/ volume of grapes produced	High ratios may indicate potential gains from different water trading or irrigation arrangements	Authors
Irrigation water use per tonne	Irrigation water use/ volume of grapes produced		Barber et al. (2016)
Sales expenses per tonne	Costs associated with revenue generation / volume of grapes sold	High ratios may indicate inefficiencies in delivery and supply networks	Deloitte (2019)
Vineyard profit per tonne	(Vineyard return – debt servicing)/ volume of grapes produced OR (Vineyard revenue - operating costs - overhead costs - debt servicing)/ volume of grapes produced		Deloitte (2019)
Vineyard return per tonne	(Vineyard revenue - operating costs - overhead costs)/ volume of grapes produced		Deloitte (2019)

Note: These benchmarks could be calculated by grape variety (e.g. Chardonnay) as well

It is important to keep in mind that the presented benchmarks and indicators may not be equally useful or representative for every individual grape grower. This overview also only includes a small fraction of benchmarks used in different sectors and studies and therefore not comprehensive.

Benchmarking is sensitive to the quality of underlying data and to seasonal variations. We recommend avoiding overreliance on snapshot indicators, but suggest cautious interpretation of within and across business benchmarking and indicator results over multiple years can be seen as best practice. Whole of farm benchmarks should only be used to identify general business viability and potential problem areas, whereas process focused benchmarking would allow for a better understanding of causality and corresponding management approaches.

As discussed in the previous section, benchmarking largely draws on analysis around averages rather than margins, implicitly assuming linear scaling and causal relationships. This is often not the case in reality, as agriculture is dominated by threshold effects and non-linear relationships. Benchmarking results can therefore not be used to predict farm business performance changes, relating to changes in processes and scales. For example, if a 50 ha

farm has operating costs of $3,000/ha, increasing that farm's size to 70 ha will not necessarily maintain $3,000/ha operating costs.

Benchmarking provides important information for farm managers. However, to identify farm management best practice methods, benchmarking results should be used in combination with a wider set of farm and business analysis tools, including qualitative indicators and expert opinion (Aupperle and Dunphy 2003; Deane and Malcolm 2019).

1.3 Existing Benchmarking study information on Murray-Darling Basin and Riverland Viticulture

Grape growing benchmarking studies are limited, with many studies examining the Murray-Darling Basin region but not specifically the Riverland. This section therefore presents findings from grape benchmarking studies from the Murray-Darling Basin or its regions, including the Riverland.

Within the wine areas of the warm inland regions of the Murray-Darling Basin, Scholefield Robinson (2008), drawing on data from 19 Sunraysia, 27 Riverland, and 20 Riverina grape businesses[7], illustrated that the nominal vineyard operating costs were highest for Sunraysia, then the Riverland and then Riverina. Median total operating costs (in 2006-07 dollars) were estimated at around $2,903 per hectare in the Riverland (Scholefield Robinson 2008) (or $3,558 in 2015 dollars). Table 1-8 displays estimated cost of grape production for selected wine regions in 2015, together with the estimated share of businesses being profitable, breaking even, or realizing operational losses under these costs (WFA 2015)[8]. Note that WFA (2015) defines profitability on a per tonne basis, with profitability as grape purchase price per tonne less growing costs per tonne. Growing costs are the costs directly attributed to growing grapes, i.e. variable costs. For our case study data analysis, we express profit on a per ha basis, as total farm income less total costs (variable and fixed), in chapter 3 of this report.

[7] Note that not all businesses provided data to all cost categories. Hence the confidence in individual cost categories is low, and we opt to report only the overarching cost figures.

[8] WFA (2015) used 2015 price dispersion data provided by Wine Australia (based on a survey of ~2,700 grape businesses and a response rate of >25%), average yield by wine region based on Vintage Surveys of 2006/2008/2010/2012/2014/2015, and estimated costs per hectare (adjusted for CPI movements) based on consultations with Wine Grape Growers Australia. Profitability levels are defined as: loss (growing costs per tonne > purchase price per tonne); breakeven (profit per tonne between $0-100); low (profit per tonne between $100-300); profitable (profit per tonne > $300).

Table 1-8 Estimated growing costs and profitability of businesses for selected Australian Wine regions 2015

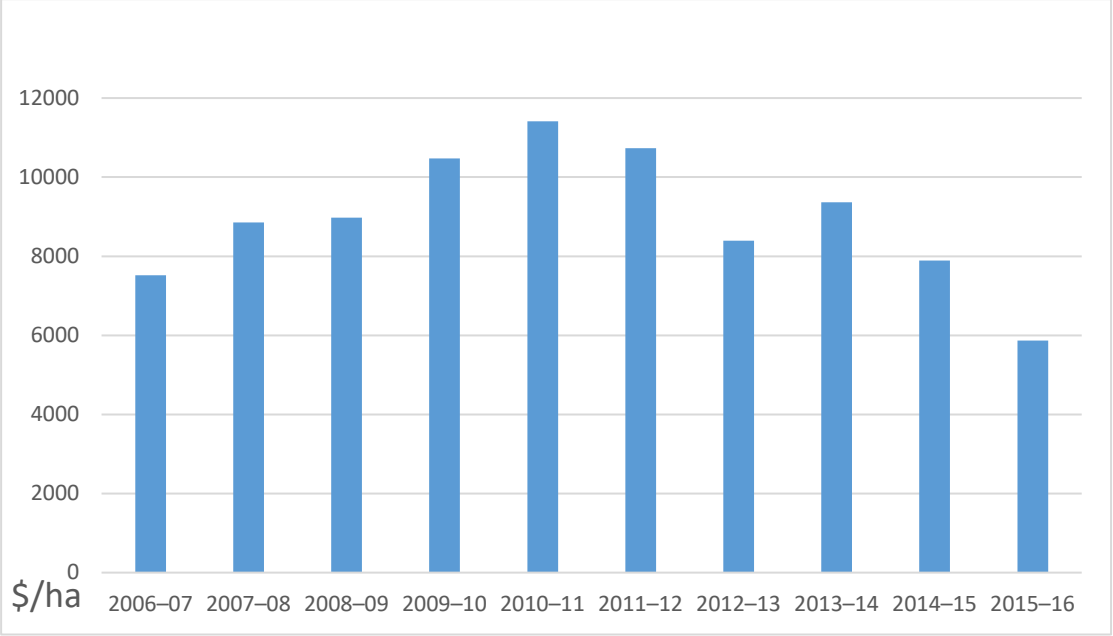
Region	*Growing costs ($/t)*	*Loss*	*Breakeven*	*Low*	*Profitable*
Barossa	1,247-1,497	28%	2%	13%	57%
Langhorne Creek	832-998	70%	9%	15%	6%
Mudgee	1,480-1,776	99%	0%	0%	1%
Riverland	380-456	92%	4%	3%	1%
Yarra Valley	1,210-1,452	15%	10%	39%	36%
Coonawarra	1,267-1,521	32%	16%	35%	17%
Hunter Valley	1,471-1,766	94%	1%	2%	3%
Margaret River	1,133-1,359	50%	8%	12%	30%
Mclaren Vale	1,123-1,348	34%	6%	11%	49%
Mornington Peninsula	1,498-1,797	2%	4%	3%	91%
Murray-Darling – Swan Hill	392-470	88%	8%	1%	3%
Riverina	512-614	97%	2%	1%	0%
Tasmania	1,315-1,577	0%	0%	1%	99%
Great Southern	1,353-1,624	61%	21%	2%	16%
Swan	1,109-1,331	98%	0%	0%	2%

Note: loss= growing costs (per tonne) are greater than purchase price (per tonne); breakeven= profit per tonne is between $0-100; low= profit per tonne is between $100-300; profitable= profit per tonne is above $300
Source: WFA (2015)

Growing costs of Riverland grapes at $380-456/tonne were estimated at being lower than the growing costs in the other warm inland regions of Murray Darling-Swan Hill and Riverina in WFA (2015). Note that growing costs are only part of overall vineyard operating costs: businesses breaking even or realizing a low profit may still achieve negative net income, after all costs are considered. Although it is difficult to directly compare the definitions of operating (cash) costs across various reports given a lack of information provided, there is some evidence to suggest that the total cash costs in Figure 1.5 may reasonably represent Riverland viticulture, but further investigation is needed.

Figure 1.5 and Figure 1.6 illustrate the total cash costs and the breakdown of costs of Murray-Darling Basin vineyards in the past decade, using data from ABARES (2019) of between 4,299 MDB irrigated grape farms in 2006/07 and 2,154 in 2015/16.

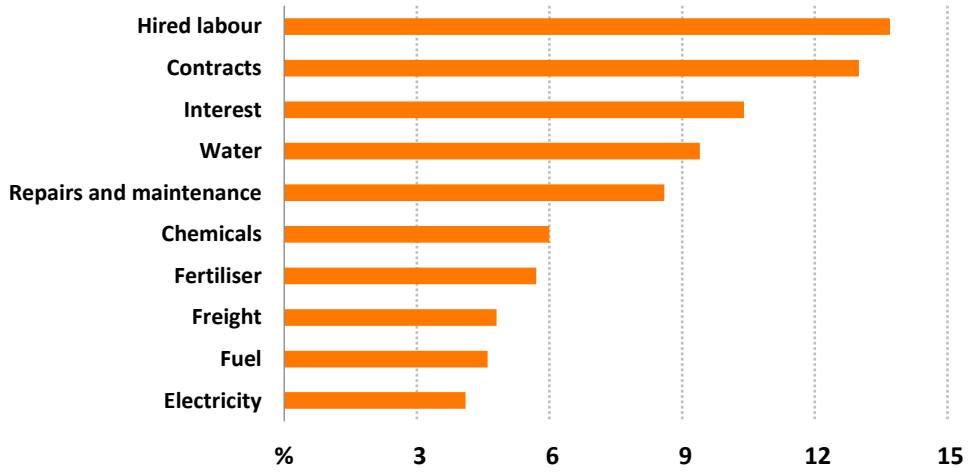
Figure 1.5 Murray-Darling Basin Vineyard Total Cash Costs ($/ha) from 2006/07 to 2015/16



Source: created from data in ABARES (2019), estimates are based on average farm sizes and average total cash costs (in 2015-16 dollars)

Figure 1.6 illustrates the percentage of total cash costs incurred by MDB vineyards (averaged over the time-period of 2006/07-2015/16). Hired labour costs made up the biggest cost on average, representing 14% of total cash costs, followed by contracts, interest payments, water and repairs and maintenance.

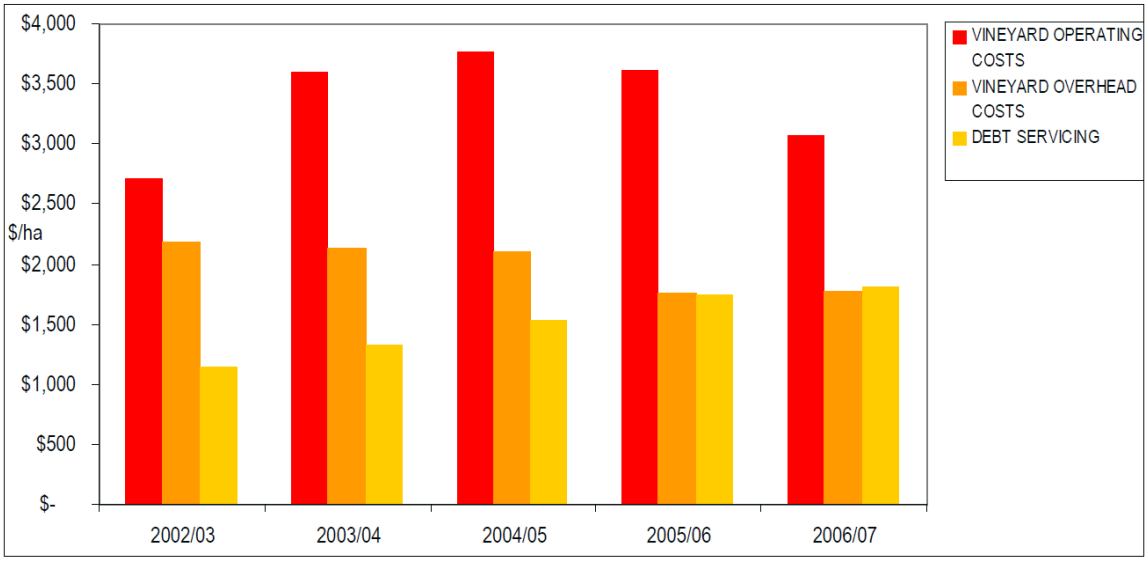
Figure 1.6 Murray-Darling Basin Vineyard Percentage of Total Cash Costs by Major Expense (%) average from 2006/07 to 2015/16



Source: ABARES (2019; Figure 6)

From available detailed Riverland benchmarking data in the 2000s, it can be seen that operating costs have been variable, while overhead costs have fallen over time, and debt servicing has increased over time (see Figure 1.7).

Figure 1.7 Riverland Vineyard Average Total Costs ($/ha) from 2002/03 to 2006/07 (in 2006/07 prices)

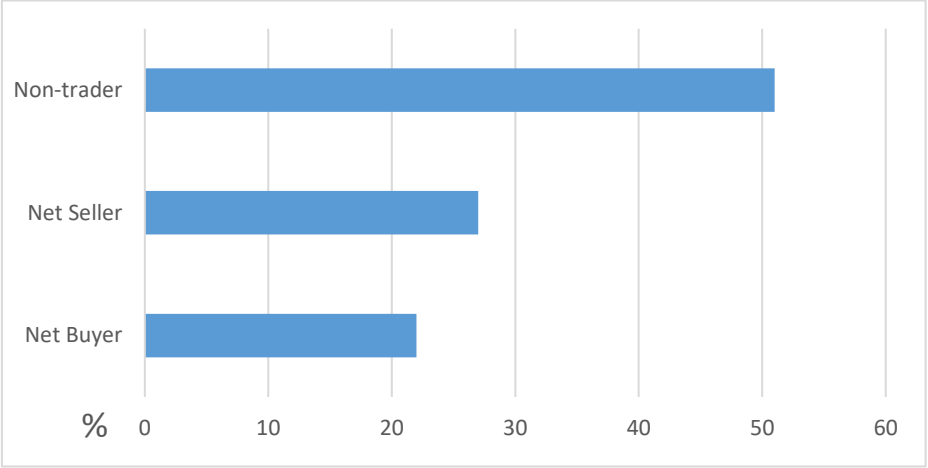


Source: Scholefield Robinson (2008, p. 19)

More recent data, albeit for the Murray Valley region suggests that operating costs have been fairly stable between 2008/09 and 2013/14, while debt servicing and overhead costs increased slightly over the same period (Retallack 2015). Given the high mechanisation of Australian vineyards (Davidson 2010), and the decade-long period of oversupply starting in 2005 (ACCC 2019), it is likely that possible reductions in operation costs have been achieved by large parts of the industry, probably manifesting in fairly stable operating costs in the Riverland, similar to what is observed in the Murray Valley.

Figure 1.8 illustrates that over the time-period from 2006/07 to 2014/15, around half the number of farms in the ABARES survey did not engage in any water allocation market trade, while slightly more (27%) were a net seller compared to being a net buyer (22%). Farms were much more likely to be net sellers in high rainfall years, and net buyers in drought years. These results highlight that on average, a static gross margin analysis should not include water leasing, however, sensitivity analysis should be conducted for wet and dry years. Figure 1.9 highlights the adoption of irrigation infrastructure technology, with drip irrigation increasing from 50 to 90% over this time-period and other forms of irrigation reducing in importance.

Figure 1.8 Murray-Darling Basin Viticultural farms' water allocation trade – average from 2006/07 to 2014/15



Source: adapted from data in ABARES (2019)

Figure 1.9 Murray-Darling Basin Vineyard Irrigation infrastructure adoption (%) from 2006/07 to 2015/16



Source: ABARES (2019; Figure 10)

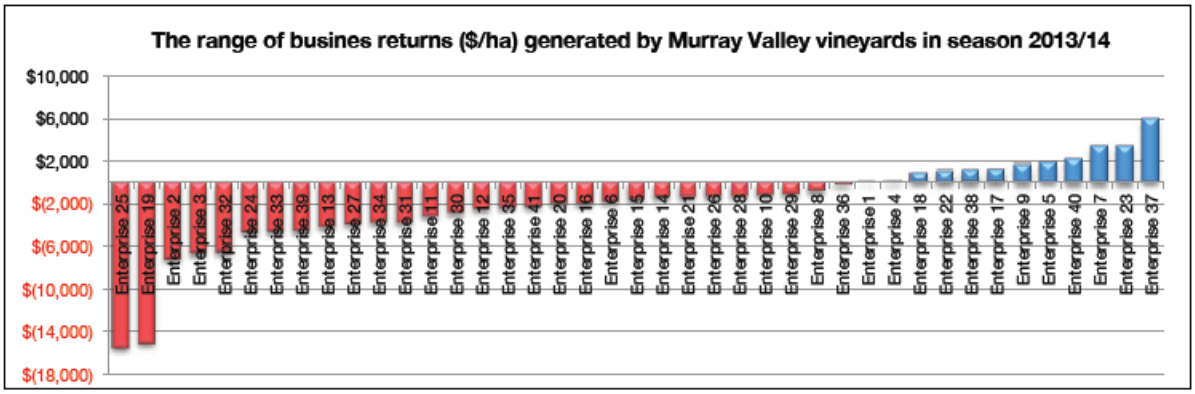
Finally, grape growing business returns are extremely variable, and often overall negative, which is displayed in Figure 1.10, based on 2013/14 Murray Valley grape growing business data (Retallack 2015)[9]. Average Murray Valley grape farm cash income in 2013/14 was slightly lower than the Murray-Darling Basin 10-year average of $69,000 between 2006/07 - 2015/16 (Ashton and Gomboso 2017).

This extends to the Riverland where 84% - 94% of growers were generating an operational loss between 2012-2015 (WFA 2015, p. 16). Interestingly, vineyard profitability seems not correlated with size as such, as both small and large vineyards can make positive business

[9] Note that the majority of grape growing businesses had negative business returns across different years and different studies (e.g. (Retallack 2010, 2012; WFA 2015; ACCC 2019))

returns. However, some evidence was found that the least profitable businesses tended to be small vineyards under 10 ha (Retallack 2015) .

Figure 1.10 Business returns $/ha in Murray Valley vineyards in 2013/14



Source: Retallack (2015, p. 21)

1.4 Summary

In summary, the state of the Australian wine industry and its grape growers is as follows:

- 63% of Australia's wine production in 2018/17 went into export
- 85% of Australian wine exports by volume retailed for below 10 $/L in 2012 and are therefore considered bulk wine
- International customers see bulk wine as a homogeneous product, leading to intense price competition amongst producers
- Given this price competition and an oversupply of wine in the global market, Australian wine makers are price takers.
- Due to market power, wine makers can hand price pressures down the supply chain to growers, making them price takers in turn
- This situation led to low grape prices and consolidation in the grape growing businesses, with a reduction in number of growers by 35%, a reduction in total vineyard area by 19% and an increase of average vineyard size by 25% between 2008-2015.

This report uses benchmarking to assess grape grower competitiveness and business viability:

- Benchmarking allows to assess the viability and competitiveness of grape growing businesses
- Benchmarking defined by its subject is often categorized as process, performance and strategic benchmarking.
- Benchmarking defined by its scope is categorised as internal, competitive, functional and generic benchmarking.
- Benchmarking categories are not mutually exclusive, with individual benchmarking tasks spanning multiple categories while using similar tools.
- Although benchmarking is widely used in practice, there are no standardised approaches or terminology to benchmarking.
- This can lead to confusion and ambiguity of benchmarking studies, and often confounds benchmarking with comparative farm business analysis.

- Benchmarking is by definition process focused, whereas comparative farm business analysis contends itself with comparing static snapshots of a business' position at one point in time
- In practice, the term benchmarking is used for both types of analysis. The benchmarking analyses in this report therefore also encompassing comparative farm business analysis.

Common farm business indicators include:

- Farm size, yield and turnover
- Fixed and variable costs
- Assets and liabilities
- Gross farm income, Total income and net income

Common farm business benchmarks include:

- Cost of production
- Total equity
- Earnings before income and tax (EBIT)
- Equity to asset ratio
- Free cash flow
- Labour productivity
- Return on assets (ROA)
- Debt to equity ratio
- Return on equity (ROE)
- Gross margin per hectare
- Net profit margin
- Operating margin

Benchmarking studies of grape production are scarce. They show that most grape farms have upgraded their irrigation systems to drip irrigation, with half of growers not participating in the water market. It is therefore not surprising that water costs (including trading costs) are only the fourth most important cost factor, with labour, contract and interest costs as the most important factors (ABARES (2019). Although cost of production seems to have been falling from 2009/10 – 2015/16, this has coincided with low grape prices over the same period (ABARES 2019). Many studies therefore found a substantial number of grape farms achieve operative losses from 2009/10 onwards (Retallack 2010, 2012; WFA 2015; ACCC 2019).

Existing grape benchmarking studies often limit themselves to yield and revenue analysis but fail to incorporate the cost of production and seasonal variability. While a good production snapshot, National Vintage and Grape crush surveys by Wine Australia do not collect any cost of production data and limit themselves to grape yield, planted grape area per region and grape price data. Indeed, the South Australian grape crush surveys (Wine Australia 1999 - 2020) contain yield and planted grape area by different farm sizes (<10 ha, 11-24 ha, 25-49ha, 50-99ha, and >100ha) as additional data, but this is unfortunately not replicated for other regions in the national survey.

While the ABS and ABARES collect and analyse grape growing data for the Murray-Darling Basin which includes costs to a varying extent, these studies are based on intermittent farmer

surveys, such as the 5-yearly ABS agricultural census; the last available data is from 2016 (ABS 2015; ABARES 2019)[10]. Therefore, they also only offer a snapshot of grape production.

Ultimately, there are no benchmarking studies available which assess cost of production and financial performance of the Riverland grape industry on a yearly continuous basis. Therefore, the literature on Riverland grape growing performance is at best outdated and at worst not reflective of current practices and realities. This report attempts to address this issue in the next chapter by undertaking benchmarking analysis of the most recent available secondary data sets for Riverland grape production.

[10] The ABS undertook another Agricultural census in 2020/21, but results are not yet publicly available at time of writing

2 Riverland grape growing farm financial characteristics and benchmarks

This section uses secondary data sets to benchmark the characteristics and structure of Riverland grape growing businesses. This is based on a variety of data sources, including the ABS DataLab (2020) microdata, the SA Auditor General (2020) and Wine Australia (1999 - 2020).

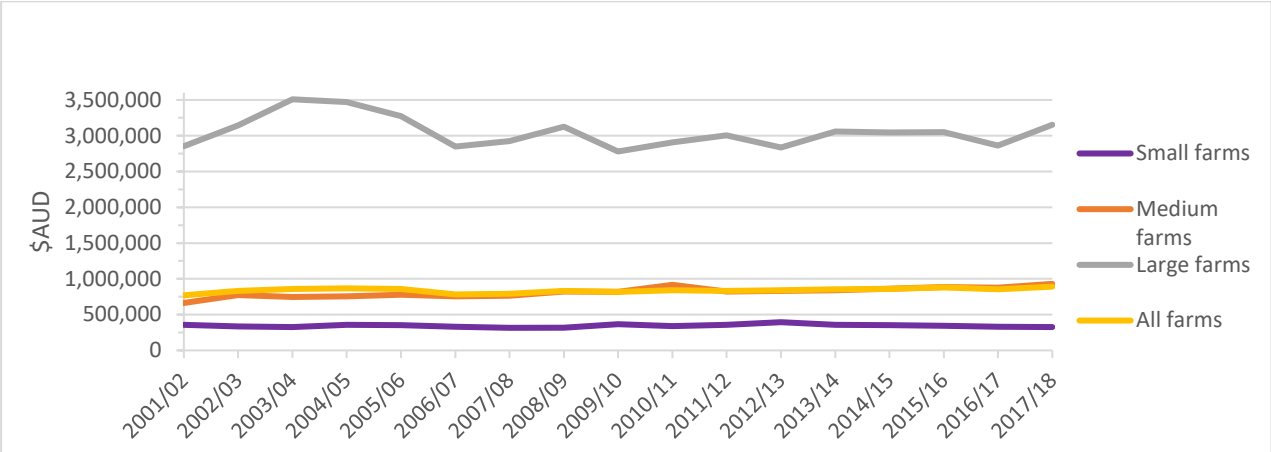
2.1 Grape farm assets and liabilities

An important factor of grape industry financial viability is the asset and liability position of businesses. In general, having more assets than liabilities enable a business to better deal with income shortfalls and therefore provides for better business financial viability and sustainability. Unfortunately, as seen from Chapter One, there is only limited data available on Riverland grape businesses' asset and liability positions.

We sought to supplement this detail using a new ABS database that has just become available for academic researchers to use in 2020. The ABS BLADE microdata incorporates a range of ABS data with ATO data on individual business, with annual data available from 2000-01 to 2017-18 as of 2022. Specifically, variables sourced from ATO come from The Business Activity Statement (BAS), Business Income Taxation (BIT) and the Pay As You Go (PAYG) installments system. In order to identify grape growing businesses, Australia and New Zealand Standard Industrial Classification (ANZSIC) was used (code 0131 for Grape Growing, (ABS 2014)). The caveat is that table grape growing may also be included as there is no further sub-classification for wine grape growing alone in ANZSIC. Each business in BLADE has their identifiable information removed such as ABN (Australian Business Number) and correspondence address. However, a generic identification number is given to each business so that the same business can be recognized across different years, which is a unique advantage of the BLADE microdata. Although businesses cannot be identified at the street level, their postcode of the correspondence address is available to identify their location at the postcode level. However, it needs to be noted that the correspondence postcodes may not necessarily represent the postcodes in which vineyards are located. Nevertheless, it is anticipated that the majority of vineyards in Riverland should have their correspondence postcodes within the Riverland region, and likewise, the number of vineyards that are outside of the Riverland region but have correspondence postcodes in Riverland is small.

According to Wine Australia's Riverland GI region and Australia Post's postcode map, the Riverland GI region encompasses the postcodes 5311, 5320, 5321, 5322, 5330, 5331, 5332, 5333, 5340, 5341, 5342, 5343, 5344, 5345, 5346, 5357, and 5417. The BLADE microdata can be accessed by ABS approved users via ABS DataLab (2020) (https://beta.datalab.abs.gov.au/). Farm assets include cash, machinery, water entitlements, farmland, buildings and bearing plants such as vines. Farm liabilities includes farm debt or bills yet to be paid. Unfortunately, ATO data only contains asset and liability data for taxation purposes, which includes deductions and exemptions, and therefore does not provide a complete picture, but nevertheless allows for a good approximation (see Figure 2.1).

Figure 2.1 Average total farm assets of small, medium and large[11] Riverland grape growers from 2001/02 till 2017/18 (in 2017/18 $AUD)

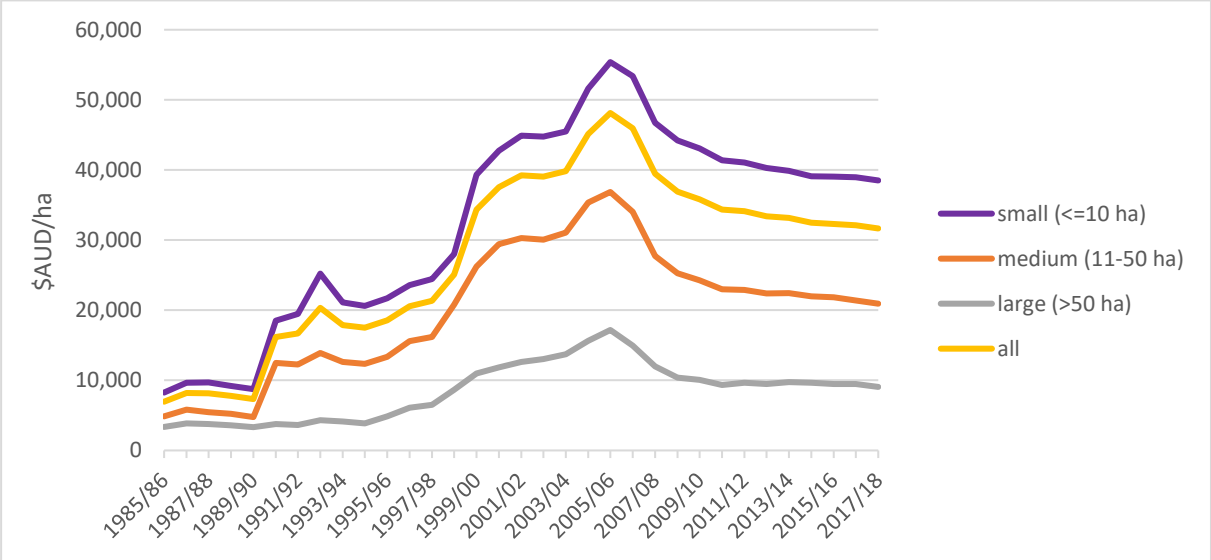


Source: created from ABS DataLab (2020)

Large farms' asset value oscillates around $3,000,000 over the time-period, whereas medium sized farms' assets increased from around $660,000 in 2001/02 to around $930,000 in 2017/18. Small farms' assets have remained largely stable around $330,000 to $350,000.

Farmland and associated improvements (e.g. buildings) are an important component of farms' asset base. This data is available as 'capital value' from the South Australian Auditor General's Office, albeit on the lot level. A lot refers to a parcel of land in the land titles register. These lots can vary in size and a farm enterprise may consist of multiple lots. We distinguish between small lots <=10 ha, medium lots 11-50ha, and large lots >50ha. Figure 2.2 displays the capital value[12] of Riverland lots, classified as grape growing, from 2001/02 till 2017/18.

Figure 2.2 Riverland lot average capital value per ha (in 2017/18 $AUD)



[11] Based on turnover reported by the ATO, we classify small farms have the lowest 55% of annual turnover, medium farms have the middle 35% and large farmers the top 10% of annual turnover.

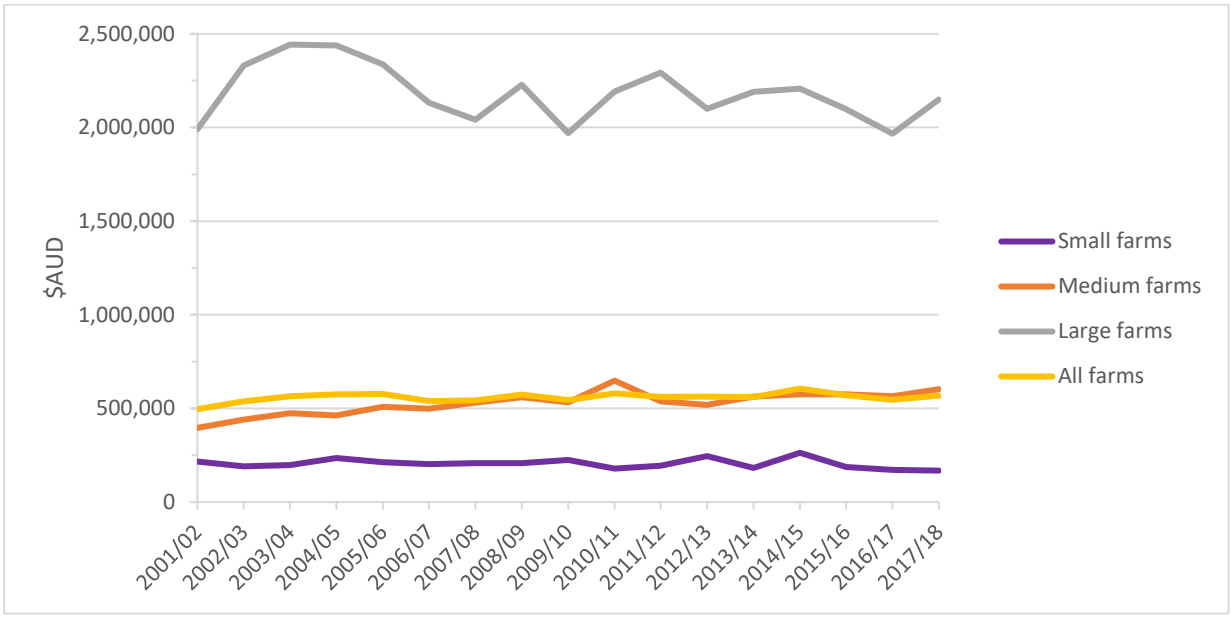
[12] Capital value is the value of a parcel of land including improvements such as buildings & structures, wells, dams & reservoirs, and planting of trees for commercial purposes (SA Auditor General 2019b).

Source: created from SA Auditor General (2020)

Large lots have an average capital value of around 10,000 $/ha, medium lots of around 20,000 $/ha and small lots of 40,000 $/ha in 2017/18. The capital value of all lots, irrespective of size, has decreased over time beginning in 2006/07. This likely corresponds to falling grape prices over this period, as the prices vineyards could achieve on the market would be depressed due to limited earning potential. The decline in land value may have been partly offset by the large increase of high security water entitlement asset values since 2006/07 (Seidl et al. 2020).

ATO data shows that Riverland grape farm liabilities in 2017/18 have been on average around $2,150,000 for large, $600,000 for medium and $170,000 for small farms. While large farm's liabilities have remained largely constant over time, they increased for medium farms and deceased for small farms (see Figure 2.3).

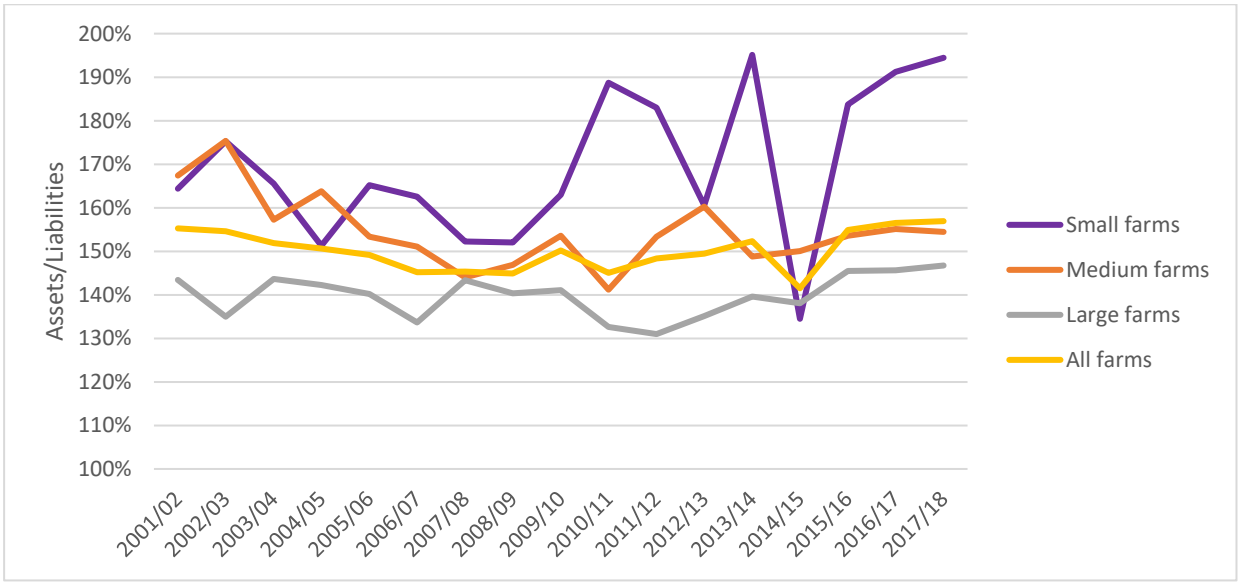
Figure 2.3 Riverland grape farms' total liabilities from 2001/02 to 2017/18 (in 2017/18 $AUD)



Source: created from ABS DataLab (2020)

At first glance, the asset position of Riverland grape growers seems viable, particularly with large farms having assets in excess of around $1,000,000 over their liabilities. Upon closer inspection however, smaller farms seem in the best position, with 94% more assets than liabilities in 2017/18 (see Figure 2.4).

Figure 2.4 Riverland grape farms assets/liabilities from 2001/02 to 2017/18

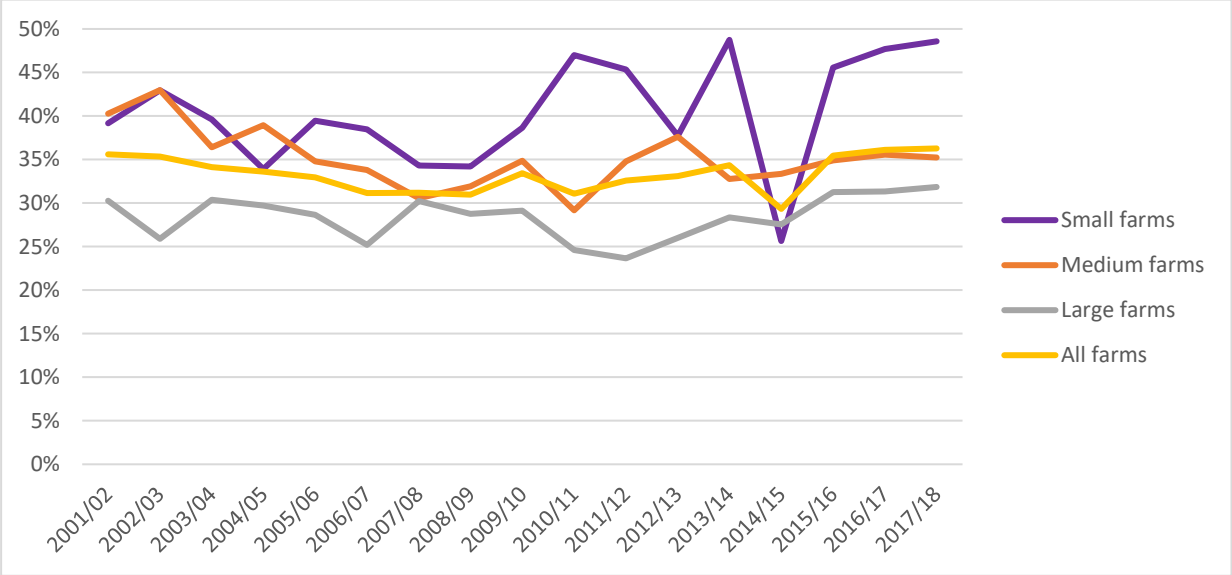


Source: created from ABS DataLab (2020)

Yet, the benchmark of equity to asset ratio (see Table 1-5) reveals that all Riverland grape growing farms have high degrees of financial leverage: an equity to asset ratio of below 70% indicates solvency issues, meaning 70% of farms on average are effectively owned by

someone else, and has the potential of lowering businesses' borrowing capacity (Kantrovich 2011).

Figure 2.5 Riverland grape farms equity to asset ratios from 2001/02 to 2017/18



Source: created from ABS DataLab (2020)

Figure 2.5 shows that Riverland grape farms of all sizes hold too few assets in comparison to their liabilities, albeit that small sized farms seem to again be in the best position. This limits businesses' ability to weather years with low income or financial deficits and presents risks for business viability and continuity.

2.2 Grape farm income and expenses

Another important indicator of business viability is farm turnover, income and expenses. The ATO defines turnover as "all ordinary income you earned in the ordinary course of running a business for the income year" (ATO 2020, p. 1). Income and expenses for ATO purposes are defined in ATO (2019a, 2019b, 2019c). Given the absence of dedicated farm financial studies for Riverland grape farms, ATO data provides a valuable proxy. But, similarly to the data limitations discussed in the previous section, ATO data does not completely match the economic concepts of income, variable and fixed costs. For example, income and expenses recorded in the ATO data includes permissible deductions for taxation purposes, such as donations.

Figure 2.6 clearly shows the reduction in grape turnover from reduced grape prices between 2004-2015, and the recovery since 2016. However, recovery seems to progress differently for large as opposed to small and medium grape growers. While large growers have experienced significantly increasing net income since the 2011/12, income for medium growers has been rising much slower, and has barely changed for small growers. Small growers' income recovered by only around $14,500 from a loss of $2,500 in 2011/12 to an income of $12,024 in 2017/18. Indeed, in the period from 2001/02 to 2017/18, small grape growers had a net loss in 29% of all years. It is worth mentioning that neither turnover nor income has reached the pre-grape price crash levels of 2002/03.

On the flip side, growing expenses have slightly reduced from 2001/02 to 2017/18 for grape growers of all sizes, with the biggest reduction for small grape growers of around 37% (for more details see section A.1.6 in the Appendix).

However, the importance of contractor costs has increased significantly over time, from 2% of total expenses in 2001/02 to 6% in 2017/18. Motor vehicle costs have remained largely unchanged at 2% of total expenses in 2001/02 and 2017/18, with a temporary increase to 3-4% between 2008/09-2013/14. The importance of a particular cost item is different across farm sizes. For example, motor vehicle, repair and maintenance, and depreciation costs are much smaller for large farms than for medium and small farms. This is likely due to economies of scale: large farms use a similar amount of machinery and production assets for a larger area, leading to a smaller share of total costs. In contrast contractor costs are similar across farm sizes in the range of 8% - 6% for medium and large farms respectively.

Water and energy costs have been identified as major cost factors for grape growers (Retallack 2010, 2012, 2015). However, these are not specifically reported in the ATO, Wine Australia, nor the SA auditor general data, and can therefore not be assessed based on available secondary data in this Chapter.

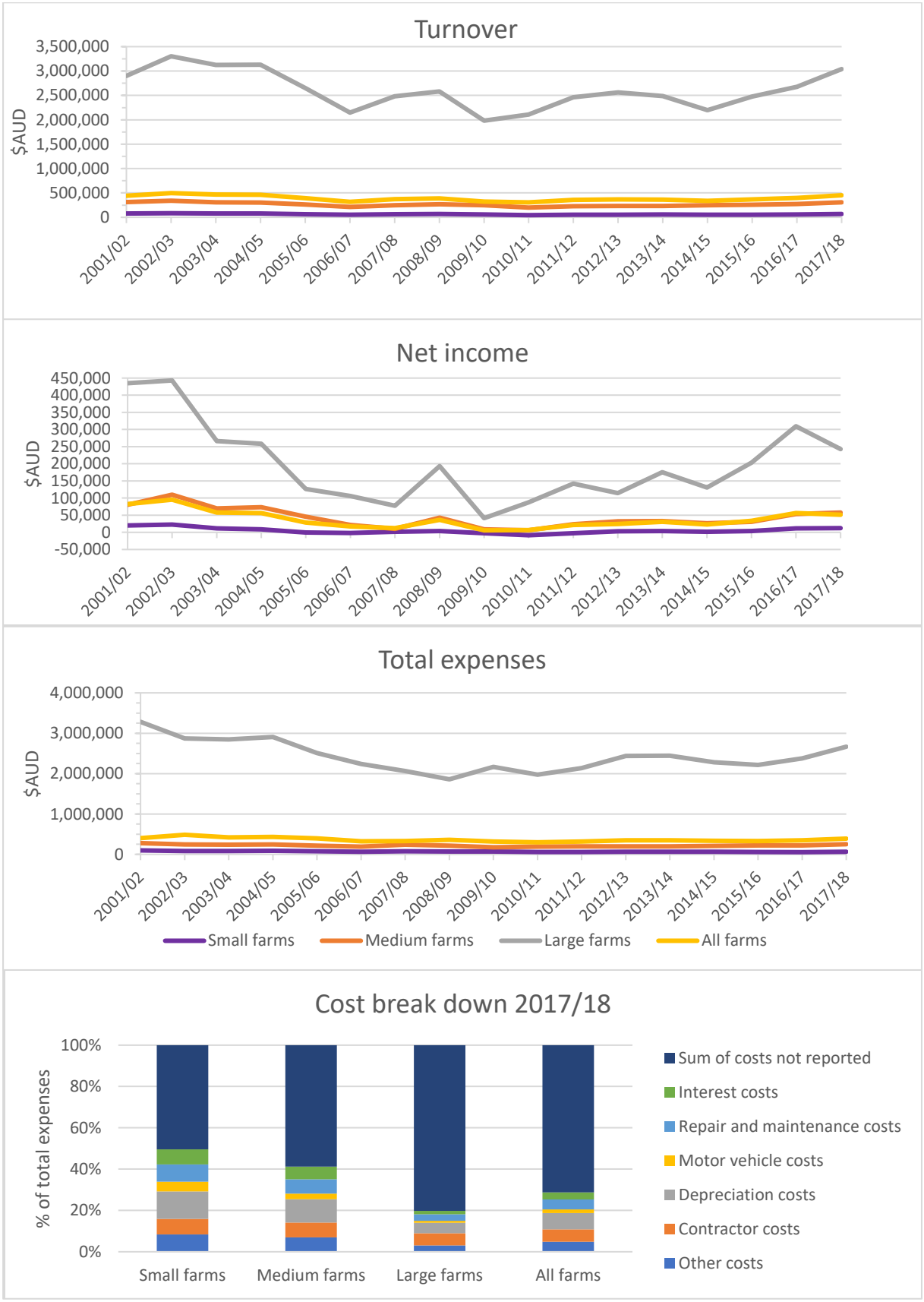
While analysis of ATO, Wine Australia and SA Auditor General Data provides for more insights than published grape benchmarking studies, it is subject to data limitations. ATO asset, liability, income and expense data only reflects income and expenses for tax purposes, which includes exemptions, deductions and rebates. Their values therefore differ, sometimes materially, from the economic concepts of fixed and variable costs as required for many benchmarking indicators.

SA Auditor General Data does not allow for an assessment of growers' land values, as data is reported at a lot level and one grower may own multiple lots.

Wine Australia data only contains average grape prices and production values for the Riverland region as a whole, not lending itself to benchmarking analysis on a farm enterprise level.

To overcome these data limitations, we decided to conduct 20 in-depth Riverland grape grower case studies to collect the necessary data for business analysis and benchmarking on an enterprise level

Figure 2.6 Average turnover, net income and total expenses of Riverland grape farms from 2001/02 to 2017/18 (in 2017/18 $AUD)



Source: created from ABS DataLab (2020)

2.3 Summary

- Average farm assets for medium-sized Riverland grape farms are fairly stable from $660,000 in 2001/02 to $930,000 in 2017/18.
- Capital values of SA grape properties fell consistently from 2005/06 to 2017/18. However, this does not include water entitlement value, which increased over same period.
- Riverland grape farms have low equity to asset ratio: ratio was 40%, 35% and 32% for small, medium, and large grape farms respectively. This suggests farms hold too few assets compared to liabilities. Ratios <70% indicate business solvency issues.
- Net income for small and medium farms low and almost unchanged between 2001/02 to 2017/18.
- Neither turnover nor income reached pre grape price crash levels of 2002/03 for all Riverland grape farm sizes.
- Growing expenses decreased slightly from 2001/02 to 2017/18, but importance of cost components changed.

3 Farm financial case studies

3.1 Data collection and methodology

Twenty-five grape growers were individually selected by Riverland Wine and CCW Co-operative from their respective member bases as ideal candidates for the research. These growers were then contacted by the research team to conduct semi-structured interviews of a median length of one hour. Interview questions aimed at collecting detailed information about yield and varieties, grape growing practices, water use and trading strategies, farm income and fixed and variable costs for financial year 2019/20, as well as previous financial years back to 2016/17 if available. Of the 25 growers, 24 were interviewed in person, and six preferred to provide their farm financial profit and loss statements to the researchers. One interview was undertaken remotely via telephone. Three of the 25 grape growers interviewed did not provide detailed financial records and only shared cost and revenue data in form of high-level ranges (e.g. $500,000 - $1,000,000). Interviews were undertaken between July 2020 and April 2021, recorded and transcribed using Otter.ai. We combined interview and farm financial records provided to create an in-depth assessment of growers' income and cost positions, as well as computing common farm business indicators.

For every individual grower, we calculated their fixed and variable costs, their income and gross margins derived from grape production, and the relative importance of particular costs compared to total variable costs. Grape gross margins were also calculated on a per hectare and per ML irrigation water used basis. We also assessed farm profit and operating margin as outlined in Table 1-5, approaching this through variable and fixed cost analysis. Given that grape production is perennial and associated with significant capital and expenses which cannot readily changed from one financial year to the next, growers' main management levers are around short-term production inputs. This naturally lends itself to the framework of fixed costs and variable costs, rather than other analysis frameworks such as cashflow. Wherever possible, historical information was collected for financial years 2016/17 – 2018/19, and updated information for financial year 2020/21.

We then combined these results to create benchmarks for average and median costs and gross margins for Riverland grape production. Given the variation in growers' record keeping and record details, a number of assumptions and simplifications had to be made (see Table A-1 in the appendix). The most notable of these assumptions are 1) conservative estimates; 2) cost attribution by area share for mixed businesses; and 3) mechanisms to avoid double counting in variable costs. Further detail is provided below re these assumptions.

1) If growers provided ranges for income, debt, land value, costs or number of trims and spray applications, we chose the mid-point of the range.
2) Growers growing crops other than grapes and or receiving income from other sources (i.e. contract harvesting work), often provided whole of business financial and water use figures. In consultation with growers, as a default approach we attributed costs to grape production by the percentage of total farm area planted to grapes.
3) We were also interested in how much growers spent on vineyard managerial tasks such as vine tipping and pruning, and grape harvest. Unfortunately, the costings for these tasks are often not, or only partially reflected in growers' end of year financials. If pruning/tipping or harvesting have not been undertaken by an external contractor (therefore having an individual cost attached), growers were invited to provide their

best cost estimates for these costs. Usually, growers provided a labour, fuel and machinery cost component. For simplicity, we worked with the data growers provided, be it fuel/ labour costs including pruning, tipping and harvesting, or dedicated costing for pruning, tipping, and harvesting. Any discussion on pruning, tipping and harvesting costs will be based on irrigators' comments, and may therefore reflect costs being already accounted for in broader cost categories.

3.2 Results

This section reports results of the 25 case study interviews for the financial year 2019/20, 2020/21, and similar results for the previous financial years from 2015/16 – 2018/19. However, many growers have been unable or unwilling to provide financial data from the year 2018/19 and previous years. Therefore, results for financial years prior to 2019/20 should be interpreted with caution. Finally, we also collected follow-up financial data for the financial year 2020/21 wherever possible, and 10 growers ended up also providing this data.

3.2.1 Results for Financial year 2020/21

This section presents the results from follow-up financial data collection from the 25 grape irrigator cade study interview participants for the financial year 2020/21. At time of writing, 10 participants have provided us their financial data for this year and their farm characteristics are displayed in Table 3-1.

Table 3-1 Biophysical and farm management characteristics of case study irrigators 2020/21 (n=10)

Variable	***Mean***	***Median***
Area of red grapes (in ha)	29.20	10.59
Area of white grapes (in ha)	23.45	5.77
Total grape area (in ha)	52.64	13.10
Total water use (in ML)	382.30	103.69
Red grape yield per hectare (tonnes/ha)	25.26	25.00
White yield per hectare (tonnes/ha)	30.64	31.67
Water use per hectare (ML/ha)	7.61	7.71

On average, case study irrigators have 29 hectares of red grapes and 23 hectares of white grapes, and their total average grape area is 53 ha, albeit some growers have no white grapes and every grower has some area of red grapes. Average water use per hectare was 7.61 ML, and average grape yield was 25.26 tonnes per hectare red, and 30.64 tonnes per hectare white grapes.

Table 3-2 displays overall farm financial characteristics and measures of overall farm returns, such as grape gross-margins, grape revenue, farm income, farm profits, grape variable and fixed costs in their total and per hectare form. This also includes operating margin. As most case study irrigators owned their own farms, any drawings or wages they pay themselves contribute to household income, as does the operational profit from the farm business. Therefore, we added any drawings back to profit to account for this situation. Operating margins were calculated as outlined in Table 1-5. Gross margin is farm revenue less variable

costs and a major indicator of business profitability. Most case study irrigators gain their income from grape production, although a few receive income from a diversified business model including other crops or contract work (e.g. contract harvesting). To associate costs of productions with the appropriate revenues, we report only the grape gross margin associated to grape production.

Table 3-2 Farm financial characteristics and measures of overall farm returns of case study irrigators 2020/21 (n=10)

Variable	***Mean***	***Median***
Grape revenue ($)	662,245	150,000
Farm income ($)	723,636	166,771
Total Grape Gross Margin ($)	390,273	71,440
Total farm profit (inclusive drawings, in $)	288,972	59,683
Total variable grape expenses ($)	282,972	97,808
Total fixed expenses ($)	249,096	30,021
Variable grape expenses per hectare ($/ha)	6,501	6,106
Variable grape expenses per ML ($/ML)	870	858
Fixed expenses per hectare ($/ha)	2,966	2,589
Grape revenue per ha ($/ha)	12,720	13,008
Grape revenue ($/tonne)	457	459
Grape Gross Margin per ha ($/ha)	6,219	6,016
Grape Gross Margin per ML ($/ML)	840	816
Total farm profit + Drawings per ha ($/ha)	4,803	4,889
Operating margin	29%	31%

Note: rounded to the nearest $

Case study irrigators achieved on average a grape gross margin of 6,219 $/ha. Grape revenue was on average 12,720 $/ha, roughly double of average variable expenses per ha. Grape revenue per tonne was on average $457. Given the importance of irrigation water costs, we also expressed grape gross margin in dollars per ML. Our case study irrigators achieved on average a grape gross margin of 840 $/ML. We calculate profit as farm income less fixed and variable costs. Profit (including drawings) was on average 4,803 $/ha. Operating margin shows the amount on money available to cover non-production costs. Hence the higher a company's operating margin, the more cost efficient the company's production. Case study irrigators have on average an operating margin of 29%, albeit there is a large variability between observations, with the operating margins in the range of 6% - 50%.

We also examined case study irrigators' detailed cost of production structure. Table 3-6 displays irrigators' fixed and variable grape costs on a per hectare basis. While undertaking the interviews, it became clear that most irrigators have a better understanding of their variable cost base, than their fixed costs. Therefore, we have higher confidence in variable cost figures. In particular, repairs and maintenance, and depreciation fixed costs were not comprehensively reflected in irrigators' financial data.

Table 3-3 Detailed farm costs of case study irrigators 2020/21 (n=10)

Variable	***Mean***	***Median***	***% of total****
Variable grape expenses per ha ($/ha)	6,501	6,106	100%
Chemicals ($/ha)	421	434	7%
Fertilisers ($/ha)	544	554	8%
Freight and Handling ($/ha)	602	614	10%
Contract & Labour ($/ha)	892	724	14%
Machinery + fuel ($/ha)	1,041	654	16%
Electricity ($/ha)	289	285	5%
Water costs ($/ha)	1,401	1,073	20%
Other variable grape expenses per ha ($/ha)*	1,311	1,312	20%
Fixed expenses per ha ($/ha)	2,966	2,589	100%
Permanent Labour (not including drawings) ($/ha)	409	0	9%
Permanent labour drawings ($/ha)	1,143	765	28%
Fixed water and electricity costs ($/ha)	137	48	8%
Repairs and maintenance ($/ha)	77	0	1%
Other admin and professional services ($/ha)	871	636	46%
Interest expenses ($/ha)	286	0	8%
Depreciation ($/ha)	43	0	1%

Note: rounded to the nearest $

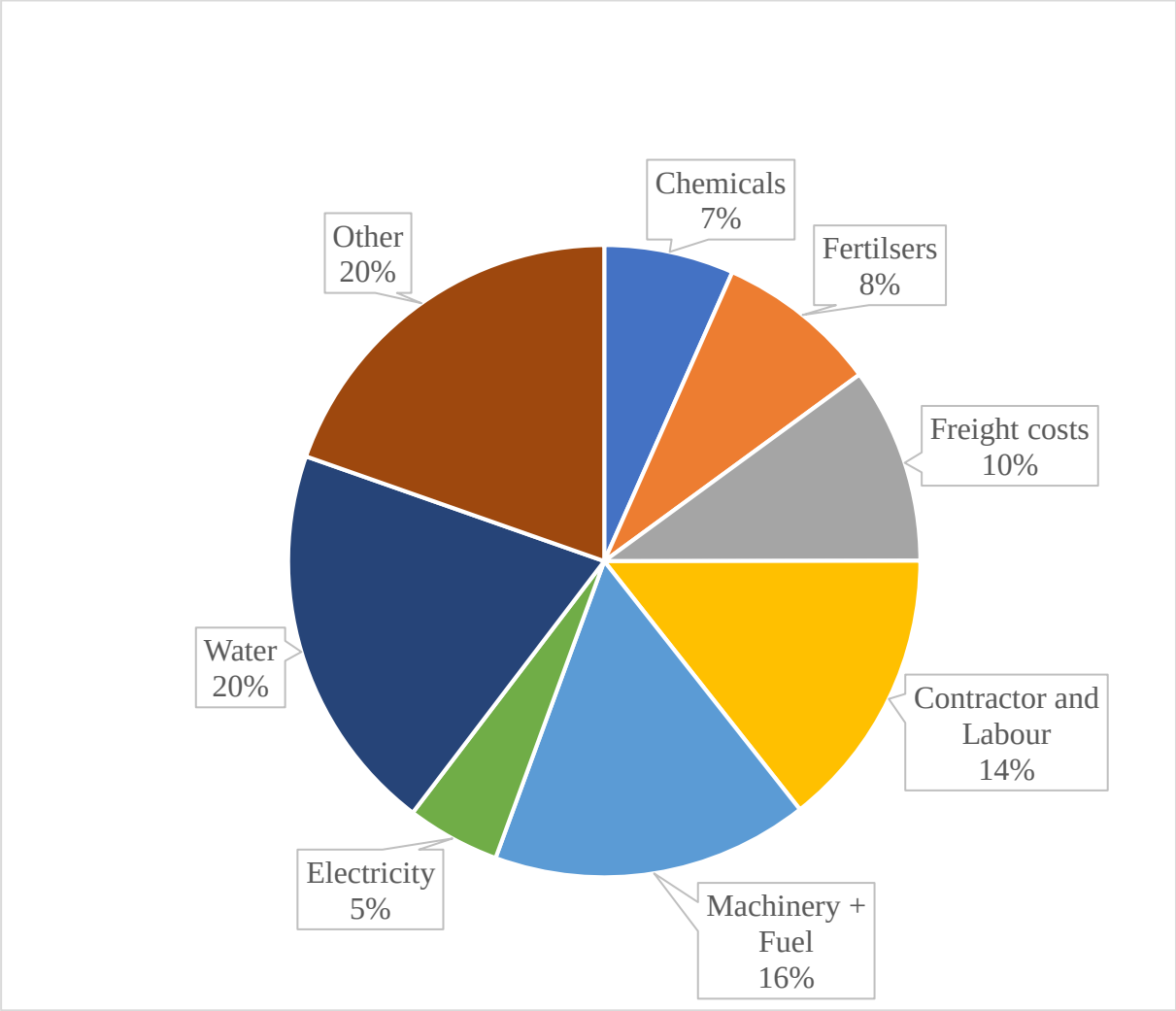
* Other variable grape costs include harvesting, pruning and tipping, and trellis repairs and maintenance

** This is the average of individual grape irrigator's cost percentage figures, and may therefore not align with the order of average and median costs/ha

Average total variable grape cost per hectare for case study irrigators were 6,501 $/ha and average total fixed costs per hectare were 2,966 $/ha. The largest fixed cost component on average at 1,143 $/ha were permanent labour drawings, which include wages irrigators pay themselves, or financial drawings they take from their business. Other admin and professional services were the second highest fixed costs per hectare at 871 $/ha. This includes insurance payments, office and admin, land lease costs, general fixed expenses, council and bank charges.

Figure 3.3 shows the average share different variable cost categories have of the total variable grape costs per hectare

Figure 3.1 Variable cost categories as average percentage of total variable grape costs per hectare for 2020/21 (n=10)



This confirms the importance of variable water costs as the highest variable expense category with 1,401 $/ha or 20% of total variable costs per ha, together with other variable expenses at 1,311 $/ha; a category made up of harvesting, pruning and tipping, and trellis repair and maintenance costs. This is followed by machinery and fuel costs with 1,041 $/ha at 16% of average variable costs per ha, and contractor and labour expenses with 892 $/ha and 14%. The fifth largest variable cost category is freight costs with 602 $/ha at 10%, followed by fertilisers and chemicals at 544 $/ha and 421 $/ha (8% and 7%) respectively, and electricity expenses with 289 $/ha at 5% of average variable costs per ha.

The next section illustrates the analysis of grape irrigators' farm financials for the financial year 2019/20, the main data collection period of this study.

3.2.2 Results for financial year 2019/20

This section presents the results from 25 grape irrigator case study interviews. Broader farm characteristics are based on all 25 irrigators (see Table 3-4), but given three incomplete data sets, the final detailed cost analysis from Table 3-5 onwards is based on 22 farm observations.

Table 3-4 Biophysical and farm management characteristics of case study irrigators 2019/20 (n=25)

Variable	***Mean***	***Median***
Area of red grapes (in ha)	30.65	17.85
Area of white grapes (in ha)	26.58	10.00
Total grape area (in ha)	57.23	23.00
Total water use (in ML)	475.61	200.00
Red grape yield per hectare (tonnes/ha)	21.81	21.41
White yield per hectare (tonnes/ha)	23.46	27.97
Water use per hectare (ML/ha)	7.61	7.62
Number of sprays (includes herbicides under vine)	10.62	10.00
Number of trims	2	2

On average, case study irrigators have 31 hectares of red grapes and 27 hectares of white grapes, and their total average grape area is 57 ha, albeit some growers have no white grapes and every grower has some area of red grapes. Average water use per hectare was 7.61 ML, and average grape yield was 21.8 tonnes per hectare red, and 23.4 tonnes per hectare white grapes.

Table 3-5 displays overall farm financial characteristics and measures of overall farm returns, such as grape gross-margins, grape revenue, farm income, farm profits, variable grape and fixed costs in their total and per hectare form. This also includes operating margin. As most case study irrigators owned their own farms, any drawings or wages they pay themselves contribute to household income, as does the operational profit from the farm business. Therefore, we added any drawings back to profit to account for this situation. Operating margins were calculated as outlined in Table 1-5. Gross margin is farm revenue less variable costs and a major indicator of business profitability. Most case study irrigators gain their income from grape production, although a few receive income from a diversified business model including other crops or contract work (e.g. contract harvesting). To associate costs of productions with the appropriate revenues, we report only the grape gross margin associated to grape production.

Table 3-5 Farm financial characteristics and measures of overall farm returns of case study irrigators 2019/20 (n=22)

Variable	***Mean***	***Median***
Grape revenue ($)	723,086	391,533
Farm income ($)	800,958	405,150
Total Grape Gross Margin ($)	325,114	143,021
Total farm profit (inclusive drawings, in $)	166,344	55,737
Total variable grape expenses ($)	399,558	120,944
Total fixed expenses ($)	263,015	67,844
Variable grape expenses per hectare ($/ha)	6,763	6,452
Variable grape expenses per ML ($/ML)	933	902
Fixed expenses per hectare ($/ha)	3,747	2,685
Grape revenue per ha ($/ha)	13,197	12,508
Grape revenue ($/tonne)	657	523
Grape Gross Margin per ha ($/ha)	6,269	5,837
Grape Gross Margin per ML ($/ML)	781	792
Total farm profit + Drawings per ha ($/ha)	3,883	3,790
Operating margin	12%	24%

Note: rounded to the nearest $

Case study irrigators achieve on average a grape gross margin of 6,269 $/ha. Grape revenue is on average 13,197 $/ha, roughly double of average variable expenses per ha. Grape revenue per tonne is on average $657, which is within the boundaries of historically observed grape prices (see Section 1.1.2). Given the importance of irrigation water costs, we also expressed grape gross margin in dollars per ML. Our case study irrigators achieved on average a grape gross margin of 781 $/ML. We calculate profit as farm income less fixed and variable costs. Profit (including drawings) is on average 3,883 $/ha, although there are case study participants (n=4) who have negative profits of which two also had a negative grape gross margin in 2019/20. Operating margin shows the amount on money available to cover non-production costs., hence the higher a company's operating margin, the more cost efficient the company's production. Case study irrigators have on average an operating margin of 12%[13], albeit there is a large variability between observations, with the operating margins in the range of less than -200% and more than 50%. Interestingly, operating margin seems not structurally associated with farm size, as there are small farms with high operating margins and large farms with negative operating margins.

We also examined case study irrigators' detailed cost of production structure. Table 3-6 displays irrigators' fixed and variable grape costs on a per hectare basis. The incomplete nature of three cost data sets meant that the detailed per hectare costs are based on the 22

[13] Our data set contains one outlier with a large negative operating margin. Excluding this outlier does not significantly change average per hectare costs or gross margins, so we opted to include the observation. However, excluding the outlier would increase the average operating margin to 22%, and the median operating margin to 23%.

remaining case study irrigators. While undertaking the interviews, it became clear that most irrigators have a better understanding of their variable cost base, than their fixed costs. Therefore, we have higher confidence in variable cost figures. In particular, repairs and maintenance, and depreciation fixed costs were not comprehensively reflected in irrigators' financial data.

Table 3-6 Detailed farm costs of case study irrigators 2019/20 (n=22)

Variable	***Mean***	***Median***	***% of total***
Variable grape expenses per ha ($/ha)	6,928	6,666	100%
Chemicals ($/ha)	448	413	7%
Fertilisers ($/ha)	696	656	11%
Freight and Handling ($/ha)	391	393	6%
Contract & Labour ($/ha)	1,063	786	17%
Machinery + fuel ($/ha)	739	582	12%
Electricity ($/ha)	341	310	5%
Water costs ($/ha)	2,221	1,355	28%
Other variable grape expenses per ha ($/ha)*	1,029	974	15%
Fixed expenses per ha ($/ha)	3,815	2,999	100%
Permanent Labour (not including drawings) ($/ha)	709	0	11%
Permanent labour drawings ($/ha)	1,736	508	21%
Fixed water and electricity costs ($/ha)	412	334	10%
Repairs and maintenance ($/ha)	656	0	4%
Other admin and professional services ($/ha)	1,955	830	41%
Interest expenses ($/ha)	319	31	9%
Depreciation ($/ha)	404	0	4%

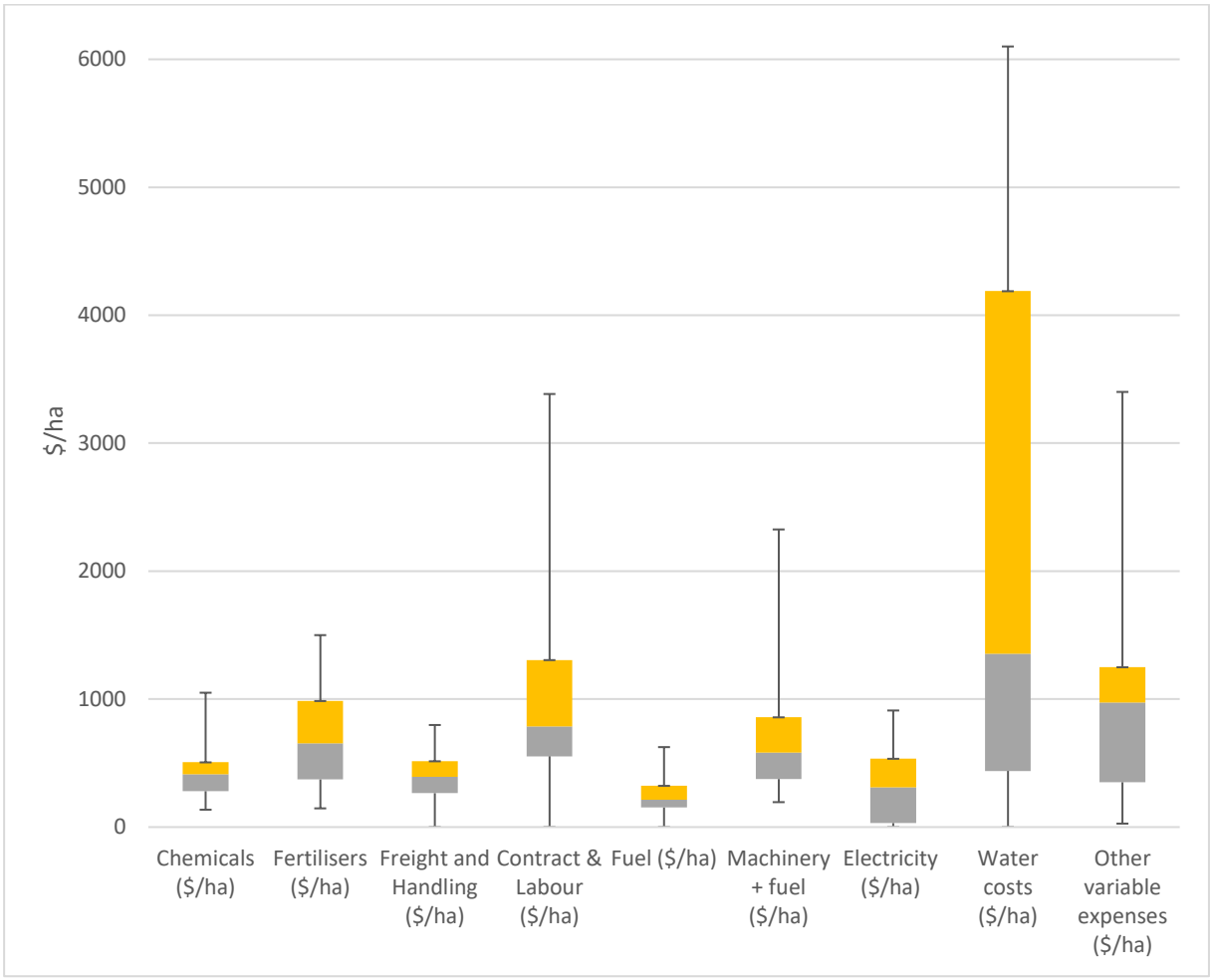
Note: rounded to the nearest $

* Other variable grape costs include harvesting, pruning and tipping, and trellis repairs and maintenance

Average total variable grape cost per hectare for case study irrigators are 6,928 $/ha and average total fixed costs per hectare are 3,815 $/ha. The largest fixed cost component on average at 1,955 $/ha are other admin and professional services, which include insurance payments, office and admin, land lease costs, general fixed expenses, council and bank charges. Permanent labour drawings are the second highest fixed costs per hectare at 1,736 $/ha. This includes wages irrigators pay themselves, or financial drawings they take from their business.

However, the different variable costs can vary significantly between different growers. To illustrate this, the boxplots in Figure 3.2 illustrate both the variable costs, as well as their associated variability across case study participants.

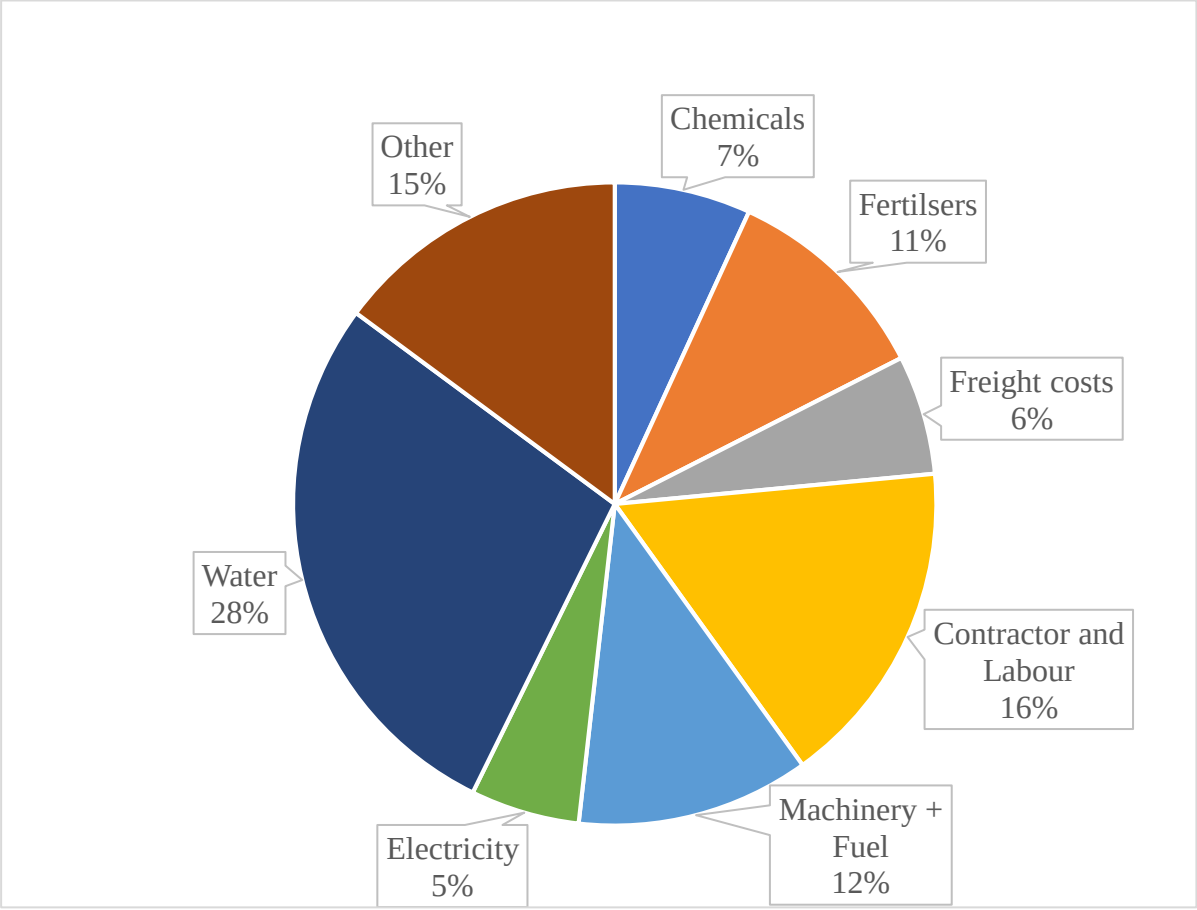
Figure 3.2 Boxplot of case study variable costs per ha for 2019/20 (n=22)



This reveals that chemical, freight and handling, fuel and electricity costs per hectare show comparatively little variability across case study participants. In contrast, contract & labour, and water costs in particularly are very different across case study growers, mirroring the different water ownership and trading strategies employed by irrigators (Seidl et al. 2020), as well as the structure of their labour force.

Furthermore, different variable cost categories are of different importance to growers, as illustrated by their relative contribution towards a grower's cost base. Figure 3.3 shows the share different variable cost categories have of the total variable grape costs per hectare.

Figure 3.3 Variable cost categories as average percentage of total variable grape costs per hectare for 2019/20 (n=22)

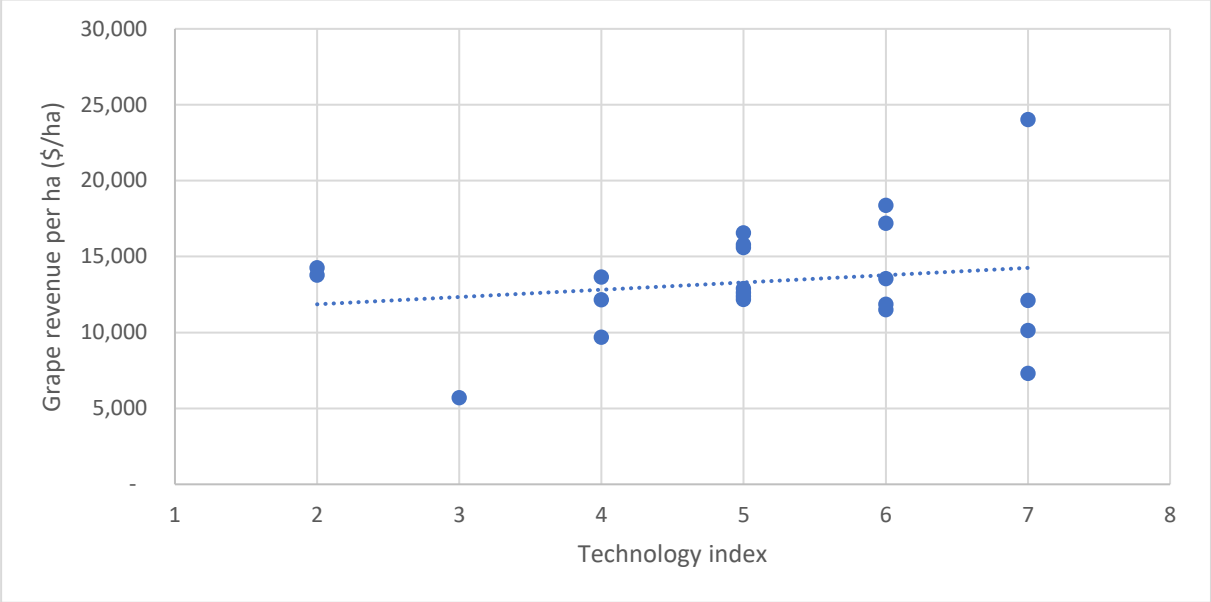


Note: Percentages are the average of individual irrigators' cost percentages

As shown above on average water costs are the largest component of total variable grape costs per hectare with 28% and 2,221 $/ha, followed by contract and labour costs with 16% and 1063 $/ha. Machinery and fuel make up 12% of variable cost per ha for on average 739 $/ha, fertiliser costs are 11% and 696 $/ha, chemical costs are 7% and 448 $/ha, freight costs amount to 6% and 391 $/ha, electricity costs are 5% and 341 $/ha, and other variable grape costs make up 15% of total variable costs per hectare, and 1,029 $/ha.

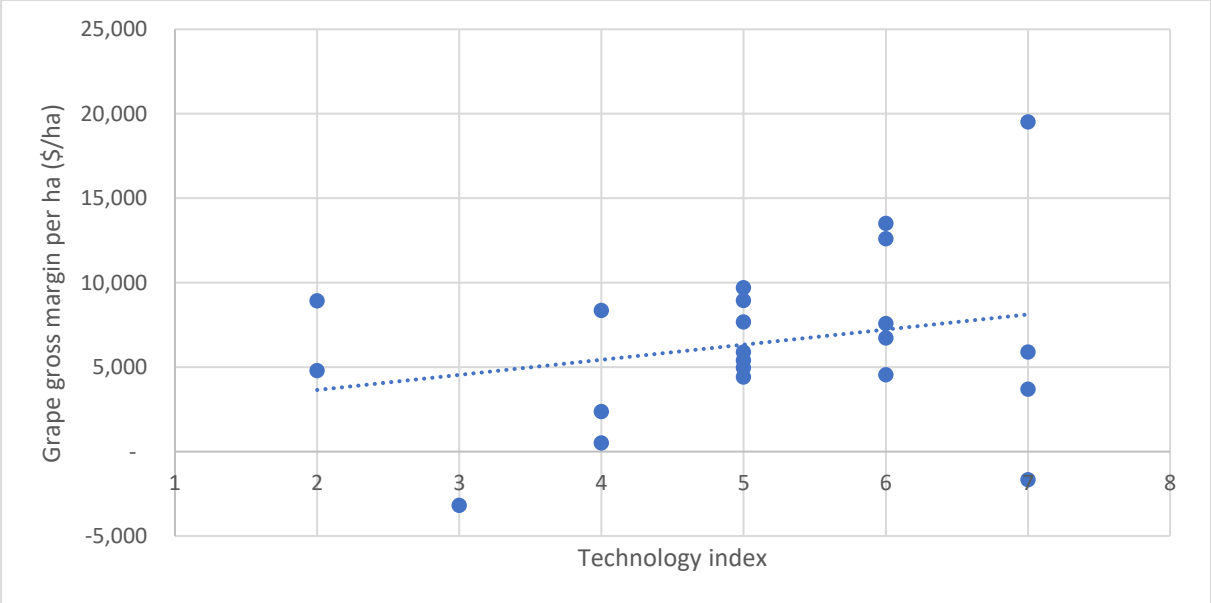
Finally, we also explored whether grape gross margin per hectare and grape revenue per hectare are associated with the level of new technologies irrigators use. To measure case study irrigators' technology use, we constructed a simple technology index consisting of binary questions about irrigators' use of drones, soil moisture monitoring, water sensors, weather data, soil and plant nutrition tests, accounting software and their agreement with the statement "Knowing about new technologies is important to me" with agreement coded as 1, and neutral or disagreement coded as 0. The index is an unweighted sum of these seven questions, resulting in a value range of 0 to 7. Figure 3.4 and Figure 3.5 display case study irrigators' technology index and their grape revenue or grape gross margin per hectare respectively.

Figure 3.4 Case study irrigators' technology index and grape revenue per ha for 2019/20



The correlation coefficient between grape revenue per hectare and irrigators' technology index is 0.195 for 2019/20, indicating that case study irrigators who use more (sophisticated) technology tend to achieve higher grape revenues. This has to be viewed with caution, as correlation does not imply causality, meaning the use of more (sophisticated) technology does not necessarily lead to higher grape revenues.

Figure 3.5 Case study irrigators' technology index and grape gross margin per ha 2019/20



There is a correlation coefficient of 0.265 between case study irrigators' grape gross margin per hectare and their technology index. In other words, case study irrigators who use more (sophisticated) technology tend to achieve higher grape gross margins per hectare. As mentioned above, correlation does not equal causality and these results therefore don't imply that using more (sophisticated) technology necessarily leads to higher grape gross margins.

3.2.3 Results for financial years 2016/17 to 2018/19

Case study participants were also invited to provide their historical farm financial records for the years 2016/17- 2018/19 to enable gross-margin and farm financial analysis over time. Unfortunately, this received a muted response, with at the time of writing nine participants providing their records for 2018/19, eight for 2017/18, and seven for 2016/17[14]. As these numbers do not allow for a yearly analysis (to calculate robust averages a minimum number of ten observations is required), we pooled the three years together to analyse a 3-year average, which is based on 24 observations in total across the 7-9 irrigators that provided data. Given we are using observations from the same seven case study participants over multiple years, we report median functional forms rather than averages, to add more robustness to farm financial benchmarks and characteristics.

Table 3-7 shows average historical biophysical and farm management characteristics for the years 2016/17 – 2018/19.

Table 3-7 Biophysical and farm management characteristics of case study irrigators from 2016/17 - 2018/19 (n=24)

Variable	***Mean***	***Median***
Area of red grapes (in ha)	33.71	17.23
Area of white grapes (in ha)	33.87	16.85
Total grape area (in ha)	67.58	31.80
Total water use (in ML)	475.32	257.73
Red grape yield per hectare (tonnes/ha)	21.87	21.74
White yield per hectare (tonnes/ha)	27.30	26.92
Water use per hectare (ML/ha)	7.52	7.86

The historical median size of red and white grape plantings was 17.23 ha and 16.85 ha respectively. Historical median water use per hectare was 7.86 ML/ha, and median grape yield was 21.74 tonnes/ha and 26.92 tonnes/ha for red and white grapes respectively.

Table 3-8 displays overall farm financial characteristics and measures of overall farm returns, such as grape gross-margins, grape revenue, farm income, farm profits, variable grape and fixed costs in their total and per hectare form for the period of 2016/17 – 2018/19. This also includes farm profit and operating margin. These are calculated the same way as outlined for the financial year 2019/20 in Section 3.2.2.

[14] Seven growers provided historical data for all years, and eight growers for 2018/19 and 2017/18/

Table 3-8 Farm financial characteristics and measures of overall farm returns of case study irrigators from 2016/17 - 2018/19 (n=24)

Variable	***Mean***	***Median***
Grape revenue ($)	593,798	383,258
Farm income ($)	758,468	420,250
Total Grape Gross Margin ($)	255,828	152,729
Total farm profit (inclusive drawings, in $)	19,872	19,345
Total variable grape expenses ($)	348,586	151,772
Total fixed expenses ($)	425,861	150,421
Variable grape expenses per hectare ($/ha)	5,456	4,891
Variable grape expenses per ML ($/ML)	800	737
Fixed expenses per hectare ($/ha)	5,708	4,842
Grape revenue per ha ($/ha)	9,949	9,158
Grape revenue ($/tonne)	411	390
Grape Gross Margin per ha ($/ha)	4,493	3,618
Grape Gross Margin per ML ($/ML)	616	495
Total farm profit + Drawings per ha ($/ha)	900	749
Operating margin	-7%	-6%

Note: rounded to the nearest $

Historical median grape gross margin per ha was 3,618 $/ha and 495 $/ML. Median grape revenue was 390 $/tonne or 9,158 $/ha, with variable grape expenses per hectare roughly 53% of revenue, at 4,891 $/ha. Median fixed expenses per hectare amounted to 4,842 $/ha. Median profit per hectare over the period from 2016/17 – 2018/19 was 749 $/ha, with a median operating margin of -6%. The operating margin is negative based on the fact that positive values are maximum 56%, and minimum -78%, with the majority (n= 14) of observations <0%.

Detailed farm costs over the period of 2016/17 – 2018/19 are displayed in Table 3-9, including key variable and fixed costs.

Table 3-9 Detailed farm costs of case study irrigators from 2016/17 - 2018/19 (n=24)

Variable	*Mean*	*Median*	*% of total*
Variable grape expenses per ha ($/ha)	5,456	4,891	100%
Chemicals ($/ha)	463	417	9%
Fertilisers ($/ha)	414	411	7%
Freight and Handling ($/ha)	436	427	9%
Contract and Labour ($/ha)	727	588	13%
Machinery + fuel ($/ha)	822	602	16%
Electricity ($/ha)	352	336	7%
Water costs ($/ha)	1,058	450	17%
Other variable grape expenses per ha ($/ha)*	1,184	1,148	23%
Fixed expenses per ha ($/ha)	5,708	4,842	100%
Permanent labour (not including drawings) ($/ha)	522	0	9%
Permanent labour drawings ($/ha)	1,859	1,994	27%
Fixed water and electricity costs ($/ha)	457	182	8%
Repairs and maintenance ($/ha)	452	193	7%
Other admin and professional services ($/ha)	1,420	1,288	26%
Interest expenses ($/ha)	563	433	14%
Depreciation ($/ha)	664	0	9%

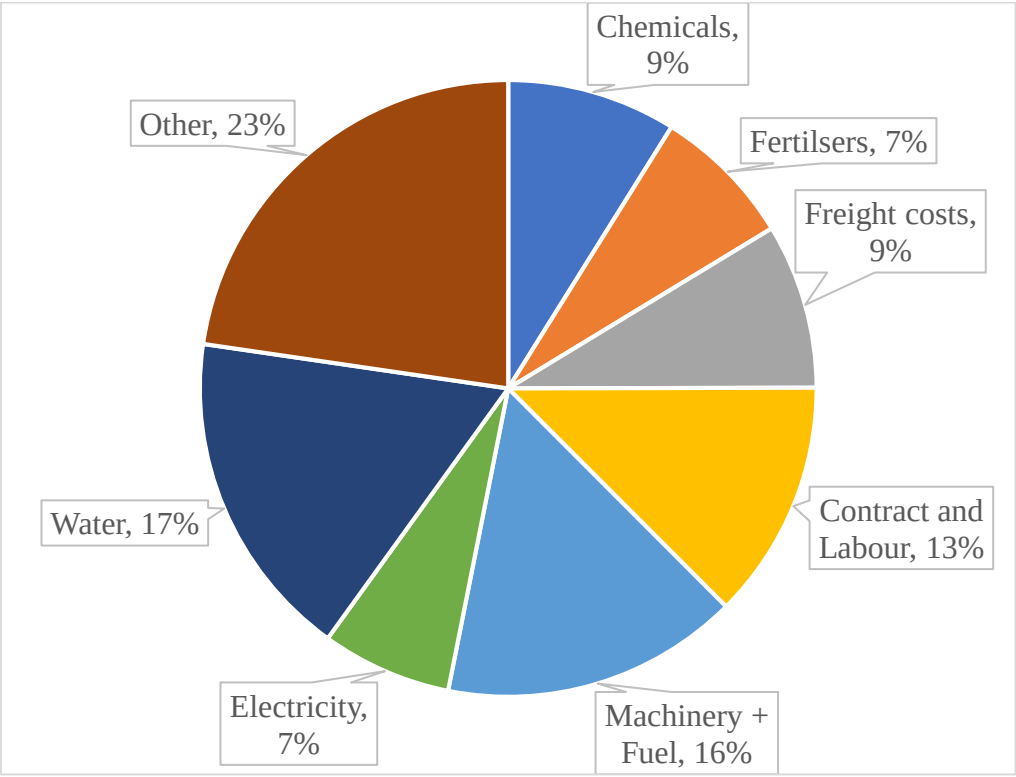
Note: rounded to the nearest $

* Other variable grape costs include harvesting, pruning and tipping, and trellis repairs and maintenance

The largest single variable grape cost position for the period 2016/17 – 2018/19 was water costs per hectare at a median of 450 $/ha and 17% of average total variable costs. Median other variable grape expenses also made up 23% of total variable grape costs at a median of 1,148 $/ha. These other costs are a compound of harvesting, pruning and tipping and trellis repair and maintenance costs. Machinery and fuel expenses are the second biggest cost position at a median of 602 $/ha. This is followed by contract and labour expenses for 13% of average total variable expenses and a median of 588 $/ha.

Figure 3.6 is a graphical representation of different variable costs and their proportional contribution to overall variable grape costs.

Figure 3.6 Variable cost categories as average percentage of total variable grape costs per hectare from 2016/17 - 2018/19 (n=24)



This is consistent with cost fractions for 2020/21 and 2019/20, displayed in Figure 3.1 and Figure 3.3 respectively, in so far that water is the largest single cost component for variable grape costs, and that machinery and fuel, and contract and labour costs are significantly contributing to overall variable grape costs, more so than chemicals, fertilizer or electricity.

3.3 Summary

Case study irrigators' benchmarks in 2020/21:

- Mean total grape area was 52.64 ha, with on average 29.20 ha of red grapes and 23.45 ha of white grapes.
- Average total water use per ha was 7.61 ML/ha.
- Average red grape yield per ha was 25.26 tonnes/ha, and average white grape yield per ha was 30.64 tonnes/ha.
- Average total variable grape expenses per ha were 6,501 $/ha and 870 $/ML.
- Average fractions of individual variable costs on total variable grape costs per ha: water costs 20%, machinery and fuel costs 16%, contract and labour costs 14%, freight costs 10%, fertiliser cost 8%, chemical costs 7%, electricity costs 5% and other variable costs 20%.
- Average grape revenue per hectare was 12,720 $/ha and 457 $/tonne.
- Average grape gross margin per hectare was 6,219 $/ha and 840 $/ML.
- Average profit (including drawings) per hectare was 4,803 $/ha.
- Average operating margin was 29%.

Case study irrigators' benchmarks in 2019/20:

- Mean total grape area was 57.23 ha, with on average 30.65 ha of red grapes and 26.58 ha of white grapes.
- Average total water use per ha was 7.61 ML/ha.
- Average red grape yield per ha was 21.81 tonnes/ha, and average white grape yield per ha was 23.46 tonnes/ha.
- Average total variable grape expenses per ha were 6,928 $/ha and 933 $/ML.
- Average fractions of individual variable costs on total variable grape costs per ha: water costs 28%, contract and labour costs 16%, machinery and fuel costs 12%, fertiliser cost 11%, chemical costs 7%, freight costs 6%, electricity costs 5% and other variable costs 15%.
- Average grape revenue per hectare was 13,197 $/ha and 657 $/tonne.
- Average grape gross margin per hectare was 6,269 $/ha and 781 $/ML.
- Average profit (including drawings) per hectare was 3,883 $/ha.
- Average operating margin was 12%.
- Variable costs can differ greatly between individual case study irrigators, with water costs, contract and labour costs and other variable costs the most variable across participants

Case study irrigators' benchmarks for the period of 2016/17 - 2018/19:

- Median total grape area was 31.80 ha, with median 17.23 ha of red grapes and 16.85 ha of white grapes.
- Median total water use per ha was 7.86 ML/ha.
- Median red grape yield per ha was 21.74 tonnes/ha, and median white grape yield per ha was 26.92 tonnes/ha.
- Median total variable grape expenses per ha were 4,891 $/ha and 737 $/ML.
- Average fractions of individual variable costs on total variable grape costs per ha: water costs 17%, machinery and fuel costs 16%, contract and labour costs 13%, chemical costs 9%, freight costs 9%, fertiliser cost 7%, electricity costs 7% and other variable costs 23%.
- Median grape revenue per hectare was 9,158 $/ha and 390 $/tonne.
- Median grape gross margin per hectare was 3,618 $/ha and 495 $/ML.
- Median profit (including drawings) per hectare was749 $/ha.
- Median operating margin was -7%.

4 Irrigator survey analysis

To triangulate our case study findings with more quantitative data, we used regression analysis of two representative telephone surveys of MDB irrigators to explore the main drivers of farm net income and income per hectare for South Australian and MDB horticultural and grape industries.

4.1 Data and methods

We used data from two representative telephone surveys of 1,946 southern MDB irrigators from 2010/11 (946) and 2015/16 (1,000) across three states (New South Wales, South Australia, Victoria), which contain a range of socioeconomic questions, including farm income, farm size, and water trading behavior. See Wheeler et al. (2014) and Seidl et al. (2021) for a more detailed description of each dataset. Removing all non-horticultural observations (i.e. dairy, broadacre, and livestock irrigators), we ended up with a final cross-sectional dataset of 593 southern MDB horticultural irrigators of which 258 were SA Riverland grape farms.

Following the approach by Wheeler et al. (2014), we used ordinary least squares (OLS) to model farm income and income per hectare, our dependent variables, as:

$$Y_i = \alpha + x_i\beta + \varepsilon_i$$

Where x_i is the vector of independent variables, β is the vector of estimated parameters, α is the constant, and ε_i is the error term. The independent variables were selected based on a literature review of comparable studies and include off-farm income, farm size, water entitlement ownership, whole of farm planning, irrigation water application rate, organic production, number of employees, age, male gender, education, recent production changes, diversified horticultural production, end of season allocation levels, water trading behavior, debt to equity ratio, and state and year dummies. For a table of descriptive statistics, see Table A-2 in Appendix 2.

To check for robustness, we also modelled farm size and application rate in logarithmic functional forms to test log-linear models (see Wooldridge (2019) for relevant discussion of log-linear regressions), and included historic climate variables (mean temperature and mean rainfall over the last 30 years). However, these approaches did not materially improve model robustness and a regular OLS regression was chosen as the appropriate functional form. Net farm income is a semi-continuous variable based on a categorical income survey question. Given the resulting limited variation in net income levels, we did not regress it in a logarithmic form, as this would further compress the spread of variable values.

We started with a full model of net farm income or net farm income per hectare, and subsequently removed insignificant independent variables (based on $p>0.1$) until we arrived at a reduced final model only containing significant independent variables.

This chapter reports the result of seven horticultural net farm income models:

1) the base model for South Australian horticultural net farm income (model 1);
2) the base model for MDB grape irrigator net farm income (model 2);
3) the reduced model for MDB grape irrigator net farm income (model 3);
4) the reduced model for grape irrigator net farm income outside of SA (model 4);
5) the base model of South Australian grape irrigator net farm income (model 5);
6) the reduced model of South Australian grape irrigator net farm income (model 6);
7) and the reduced model of South Australian grape net farm income per hectare (model 7).

4.2 Regression results

Independent variables	*(Model 1) Base model of net income of SA hort. farms*	*(Model 2) Base model of net income of MDB grape farms*	*(Model 3) Reduced model of net income of MDB grape farms*	*(Model 4) Reduced model of net income of grape farms outside SA*	*(Model 5) Base model of net income of SA grape farms*	*(Model 6) Reduced model of net income of SA grape farms*	*(Model 7) Reduced model of net income per ha of SA grape farms*[15]
Off-farm income (in %)	-0.163**	-0.051			-0.049		0.015*
Farm size (in ha)	0.030***	0.041***	0.049***	-0.037***	0.049***	0.047***	-0.001**
Low reliability entitlement ownership (in ML)	0.026***	0.056***	0.051***	0.078***	-0.018		-0.013***
High reliability entitlement ownership (in ML)	0.017***	0.019			0.053**	0.053***	-0.006***
Whole of farm plan (1=yes)	0.838	0.741			-1.971		
Application rate (in ML/ha)	-0.054***	-0.117***	-0.108***		0.037		0.029***
Certified organic (1=yes)	-10.857	11.236			17.243		
Number of full-time employees	1.348**	-0.005			-0.529		
Changed production in last five years (1=strongly decrease; 5= strongly increase)	7.074***	3.248			2.523		
Male (1=yes)	3.475	4.137		15.889*	-3.954		
Age	-0.546**	-0.504**	-0.413*		-0.349		
Education more than year 12 (1=yes)	4.914	-0.620			-0.204		
Debt-equity ratio	-7.040	-5.255*			-10.981**	-7.609*	-1.109**
Grapes main crop (1=yes)	-7.400						
End of season allocation (in %)	0.440**	0.104			0.362	0.537***	
Diversified production (1=yes)	10.745*	1.582			1.257		
Sold allocation previous season (1=yes)	-1.079	6.999			9.302		
Purchased allocation previous season (1=yes)	0.434	-6.348			-0.228		
2015 dummy (1=yes)	Omitted	10.167	19.224***	14.426*	Omitted		
South Australia dummy (1=yes)		6.085					
Constant	16.877	32.543	49.320***	17.751**	18.766	-14.491	3.865***
Observations	346	352	358	104	250	257	252
AIC	3666.78	3689.92	3735.29	1093.89	2604.35	2653.36	1461.72
BIC	3739.86	3767.2	3758.58	1107.11	2667.74	2671.11	1486.43
Adjusted R-squared	0.325	0.136	0.138	0.189	0.161	0.185	0.118

*** p<0.01, ** p<0.05, * p<0.1

[15] All models were also tested for application rate squared, and for irrigators' technology attitude. These were not statistically significant, did not change our model results and were therefore not included. Irrigators' technology attitude is a dummy variable, based on the question "Knowing about new technologies that become available is important to me" which used a scale of 1 = strongly disagree to 5= strongly agree. The dummy variable used 1= agreement (4 & 5 of original question) and 0= other (1; 2 &3 of original question).

In the base model for South Australian horticultural net farm income (model 1), net farm income is statistically significantly negatively impacted at the 1% level by off-farm income, application rate of irrigation water, and farmer age at the 5% level. Statistically significant positive impacts at the 1% level include farm size, water entitlement ownership (high and low reliability), production increase over the last five years, at the 5% level number of full-time employees and end of season water allocation factor, and diversified horticultural crops at the 10% level.

In the base model for Murray-Darling Basin grape irrigator net farm income (model 2), net farm income is statistically significantly positively influenced at the 1% level by farm size, and low reliability water entitlement ownership. Statistically significant negative influences at the 1% level include application rate of irrigation water, farmer age at the 5% level, and debt to equity ratio at the 10% level.

For the reduced Murray-Darling Basin grape irrigator net farm income model (model 3), income is statistically significantly positively influenced at the 1% by farm size, low reliability entitlement ownership, and the year 2015 dummy. Statistically significant negative influences at the 1% level are application rate of irrigation water, and farmer's age at the 10% level.

The reduced net farm income model of grape farms outside of South Australia (model 4) is statistically significantly positively influenced at the 1% level by low reliability entitlement ownership, and male gender and the year 2015 dummy at the 10% level. Farm size is of statistically significant negative influence at the 1% level in this model.

The base model of South Australian grape irrigator net farm income (model 5) is statistically significantly positively influenced at the 1% level by farm size, and at the 5% level by high reliability entitlement ownership. Debt equity ratio is a statistically significant negative influence at the 5% level.

The reduced model of South Australian grape irrigator net farm income (model 6) is statistically significantly positively influenced at the 1% level by farm size, high reliability entitlement ownership and end of season allocation rates. Debt equity ratio is a statistically significant negative influence at the 10% level.

The reduced model of South Australian grape irrigator net farm income per hectare (model 7) is statistically significantly positively influenced at the 1% level by application rate of irrigation water, and by off-farm income at the 10% level. Statistically significant negative influences at the 1% level include low and high reliability entitlement ownership, and debt to equity ratio and farm size at the 5% level.

4.3 Discussion and Summary

In summary:

- Farm size is a highly statistically significant positive influence for SA and MDB net farm income models, but a statistically significant negative influence for net farm income per ha for SA grape farms, and grape irrigator net farm income outside SA models.
- Water entitlement ownership (high and low reliability) is a highly statistically significant positive influence for all models but for SA grape irrigator net farm income per hectare.

- Application rate is a highly statistically significant negative influence for SA horticultural and MDB grape irrigator net farm income models, and a highly statistically significant positive influence for SA grape irrigator net farm income per ha models.
- Farmer age is a statistically significant negative influence in SA horticultural irrigator, and the MDB grape irrigator net farm income models.
- Debt to equity ratio is a statistically weakly significant negative influence for the MDB grape income base model, the SA grape income (base and reduced) and income per hectare models.
- End of season closing allocation is a highly statistically significant positive influence for the SA horticultural and SA grape irrigator net farm income models.
- The dummy for year 2015 is a highly statistically significant positive influence for the reduced MDB grape irrigator net farm income model.

Based on our regressions, farm size and water entitlement ownership are the most important influence on horticultural and grape irrigator net farm income. While larger farms and farms with more water entitlement ownership have higher net farm income in SA and for MDB grape farms, farm size has a negative impact on net farm income for grape farms outside SA, and negatively impacts net farm income per hectare on SA grape farms. This points towards that large, likely more automated farms, particularly in SA, have larger net farm income than small family farms, albeit that net farm income per hectare decreases with farm size. The negative influence of farm size on net farm income per hectare might indicate that there is a size ceiling for grape farms, above which further size increases will have a negative marginal income effect.

The positive influence of water entitlement ownership on net farm income is expected, as larger water ownership reduces the amount of water allocation purchases necessary to maintain production. Additionally, larger ownership can also lead to water allocation sales income, therefore increasing net farm income as well.

The negative influence of application rate on net farm income can be explained by the savings of water costs associated with efficient irrigation. The negative influence of a high debt to equity ratio on net farm income is not surprising, given that businesses with high dept levels tend to be less financially viable, and often have to spend considerable resources on debt servicing.

In summary, farm size, water ownership and use, and farm debt levels are the biggest influence on horticultural and grape irrigator net farm income. This is in line with a number of farm income and profitability studies in the peer-reviewed literature (Gloy et al. 2002; Rae and Zhang 2009; Wheeler et al. 2014).

5 Financial analysis

5.1 Financial benefit cost analysis

A financial Benefit Cost Analysis (BCA) was conducted to estimate the net benefit of adopting Vitivisor. The main difference between a social BCA and a financial BCA is that a financial analysis compares benefits and costs to an enterprise whilst a BCA compares benefits and costs to the whole economy, including financial, social and environmental costs and benefits.

BCA is a widely used tool for evaluating alternative courses of action, or options, by comparing the values of net benefits that each option produce. An important feature of BCA is that costs and benefits are, to the extent possible, monetised to enable direct comparison across the full suite of options under evaluation.

Another important feature of BCA is discounting, or adjusting future benefits and costs to their equivalent present-day values to standardise various costs and benefits with different time profiles. Specifically, the process of discounting considers the fact that present costs and benefits are worth more than future costs and benefits even when the nominal value is the same. By providing present value equivalents of all future streams of costs and benefits, discounting to enable direct comparison among options with different time profiles of costs and benefits.

In addition, BCA involves calculation of a benefit-cost ratio (BCR) for estimating the expected return on investment from a particular activity, or intervention. For example, a benefit cost ratio of 1.37 would indicate a net return on investment of $0.37 for every dollar of investment in an intervention. The financial BCA conducted to estimate the net benefit of adopting Vitivisor involved an adaptation of the following steps for carrying out a BCA based on Commonwealth Government Guidelines:[16]

1. Describe the 'base case' scenario and an alternative, or counterfactual scenario for which costs and benefits will be estimated.
2. Establish the overall time frame of analysis and the expected timelines over which each of the expected potential economic costs and benefits will be incurred or realised.
3. Identify the full suite of potential costs and benefits of switching from the base case scenario to the counterfactual scenario
4. Identify the costs and benefits that will be quantified and describe how they will be quantified and any potential uncertainties.
5. Monetise, or quantify the costs and benefits.
6. Calculate net present values (NPV) for each cost and benefit.
7. Conduct sensitivity analysis to address the identified uncertainties.
8. List unquantified costs and benefits and discuss implications of not including unquantified costs and benefits.

The costs and benefits of adopting the Vitivisor dashboard technology were measured using a 'with' and without' adoption framework, that is, quantification of the incremental changes associated with adoption compared to the 'without adoption', or base case scenario.

[16] Department of Finance and Administration 2006, *Handbook of Cost-Benefit Analysis*, Financial Management Reference Material No. 6, Commonwealth of Australia, Canberra.

Specifically, the 'base case' scenario was defined as the business as usual, or the 'without adoption' scenario and was used as the benchmark against which the 'with adoption' scenario was compared.

The financial analysis was conducted over a five-year period based on the life expectancy of fixed capital technological investments required under the 'with adoption' scenario, with no salvage value for capital investments. Costs and benefits were specified in real terms (i.e. constant 2022 dollars). Future values were converted to present values by applying a discount rate of 7% consistent with Commonwealth Government CBA Guidelines.

Three evaluation criteria were employed for this analysis, including:

1. Net present value (NPV) – discounted benefits of adoption less discounted costs of adoption. Under this decision rule, adoption of Vitivisor technology was considered to be potentially viable if the NPV was greater than zero. The NPV for the 'with adoption' scenario was calculated as an incremental NPV, using the standard formulation:

$$NPV = (PV(\text{adoption benefits} - \text{'base case' benefits})) - (PV(\text{adoption costs} - \text{'base case' costs}))$$

2. Benefit-cost ratio (BCR) – the ratio of the present value of benefits to the present value of costs. Under this decision rule, adoption of Vitivisor was considered to be potentially viable if the BCR was greater than one. The ratio was expressed as:

$$BCR = (PV(\text{net returns with adoption} - \text{net returns under the 'base case' scenario})) / (PV(\text{adoption costs} - \text{'base case' costs}))$$

3. The threshold of economic viability for Vitivisor, or the maximum cost of adoption of Vitivisor dashboard technology that would justify the investment based on the expected incremental net return from the investment for an average farm enterprise

5.2 Data and Assumptions

The following assumptions were used to estimate costs and potential benefits of adoption based on ABS/AWRI data, interview findings from farm case studies conducted in 2019-20 and consultations with the project focus group:

1. Benefits and costs were assumed to accrue over a five-year lifespan of Vitivisor dashboard technology. Note, many elements of the software may last longer than this, but we assumed a conservative 5 years.
2. The base case was the continuation of the standard financial results, without adopting Vitivisor dashboard.
3. Average per-hectare benefits and costs were calculated using data on average costs incurred by the average viticultural farm. Specifically, the case study data of the Riverland farms was used, which was checked with ABS/AWRI data, to calculate average farm costs, including the average area of a Riverland viticultural farm (57.2 hectares); volume water applied (7.6 ML/ha); yield received (22.6 tonnes/hectare); and grape prices received ($657/tonne average for all varieties).
4. Members of the Vitivisor team provided estimates of the potential costs of the Dashboard and software. Other information on other software packages were also collected. Total fixed capital costs of Vitivisor adoption incurred in the first year of investment, including the initial cost of dashboard software packages, online and satellite data, IOT network and sensors, tractor mounted cameras were estimated at

$6,000 on average. A maximum fixed capital cost of adoption of up to $10,500 could be incurred depending on the types and the total number of sensors adopted, including soil moisture sensor with IoT node ($2,500), micro weather station with IoT node ($4,000), flow meter with IoT node ($1,500) and ground-based vision system (RGB images with RTK-GPS geo-tagged and time stamped) ($2,500).

5. The initial time cost of developing vineyard manager's skills, incurred in the first year of investment, were assumed at $500 based on the assumption that an experienced vineyard manager, earning $50 per hour on average, would take 10 hours to learn how to operate the Vitivisor dashboard technology.
6. The total annual wage cost of operating the dashboard technology was estimated as $10,400 based on the assumption that it would take a total of four hours to make ongoing decisions each week using the Vitivisor dashboard, or 208 hours a year at $50 per hour wage rate.
7. The total ongoing annual maintenance costs of maintaining dashboard software technology, including labour and battery replacements was estimated as $6,000. This would vary depending on the types and the total number of sensors adopted, including soil moisture sensor with IoT node ($1,400 labour cost and $100 battery replacement cost), micro weather station with IoT node ($1,400 labour cost and $100 battery replacement cost)), flow meter with IoT node ($1,400 labour cost and $100 battery replacement cost) and ground-based vision system (RGB images with RTK-GPS geo-tagged and time stamped) (($1,400 labour cost and $100 battery replacement cost). Annual maintenance labour costs would be higher if maintenance was done by a contractor.
8. Savings of 10% on electricity, fuel and, labour costs were assumed as a result of better-informed and timely decision-making. Some case studies identified improvements of up to 50% (e.g. in electricity), however, we used a conservative estimate of 10% in this analysis.
9. It was assumed that savings in chemical costs would be offset by additional costs of harvesting and freight associated with increased yields.
10. Average yield improvements were assumed at 3 tonnes/ha as a result of improved optimization of inputs (e.g. water application and reduced yield loss in vines from timely detection of water leaks).
11. The additional costs of increasing watering by 1 ML/year to achieve optimal yields was assumed as $298/ML/ha.

Potential benefits of adoption not quantified in this analysis, include reduced operator labour time on farms, increases in farm revenue from improvements in price received due to improvements in grape quality, decreases in water variable costs; increased soil carbon levels, improvements in vine nutrition, soil quality and water quality. In addition, no social benefits of industry knowing predicted yield, or optimizing harvest times etc, were quantified.
Table 5-1 provides parameters, parameter values and data sources used to quantify cost and benefit values under the base case and 'with adoption' scenarios. Costs and benefits of the base case and the 'with adoption' scenarios were calculated per hectare and for an average farm enterprise.

Table 5-1 Parameters, parameter values and data sources used to quantify costs and benefits of adoption of Vitivisor Dashboard Technology

Parameter	Value
Period of analysis (years)	5
Discount rate	7%
Total grape area (ha)	57.2
Fixed expenses per hectare ($/ha)	3,815
Variable Expenses (Average Farm Operating Costs)	
Chemicals ($/ha)	448
Fertilisers ($/ha)	696
Freight and Handling ($/ha)	391
Contract operations ($/ha)	683
Casual Labour ($/ha)	380
Contract & Labour ($/ha)	1,063
Fuel ($/ha)	255
Machinery + fuel ($/ha)	739
Electricity ($/ha)	341
Water costs ($/ha)	2,221
Water costs ($/ML)	298
Other variable expenses (Pruning, harvesting, trellis R & M, Levies, other) ($/ha)	1,029
Total variable expenses ($/ha)	6,928
Average farm returns	
Grape revenue per ha ($/ha)	13,197
Grape revenue ($/tonne)	657
Grape Gross Margin per ha ($/ha)	6,269
Profit per ha ($/ha)	3,120
Cost of adoption of Vitivisor Dashboard Technology	
Skills: Initial cost to develop Vineyard Manager's skills	
Hours required to develop Vineyard Manager's skills (hours)	10
Vineyard Manager's wage rate ($/hour)	50
Annual cost of operating the dashboard technology	
Hours required to operate dashboard in a week (hours)	4
Dashboard Technology Software	
Initial cost of dashboard software packages	*(6,000)*
Soil moisture sensor with IoT node ($)	2,500
Micro weather station with IoT node ($)	4,000
Flow meter with IoT node ($)	1,500
Ground-based vision system ($)	2,500
Ongoing annual maintenance cost	
Soil moisture sensor with IoT node ($/year)	1,500
Micro weather station with IoT node ($/year)	1,500
Flow meter with IoT node ($/year)	1,500
Ground-based vision system ($/year)	1,500
Cost of increasing watering by 1ML/ha ($/ML/ha)	298
Benefits of adoption of Vitivisor Dashboard Technology	
Yield gains from increasing watering by 1 ML/ha (t/ha)	3
Additional revenue from increasing watering by 1ML/ha ($/ha)	1,970
Electricity cost saving ($/ha)	34
Fuel cost saving ($/ha)	25
Labour cost saving ($/ha)	38

5.3 Results

Results were expressed in terms of the incremental benefits and costs of adoption relative to farm returns and costs realized under the 'base case' scenario per hectare (Table 5-2) and per average farm (Table 5-3). The net present value of benefits (NPV) and the benefit cost ratio (BCR) of adoption were also calculated. The present value incremental benefit of adoption can also be interpreted as the threshold of economic viability for Vitivisor, or the maximum cost of adoption that would justify investing in the Vitivisor dashboard technology.

Table 5-2 Annual and net present value costs and returns per hectare with and without adoption of Vitivisor Dashboard Technology

	PV	2022/23	2023/24	2024/25	2025/26	2026/27
Base case (without adoption) scenario						
Fixed expenses ($/ha)	**16,739**	3,815	3,815	3,815	3,815	3,815
Total variable expenses ($/ha)	**30,395**	6,928	6,928	6,928	6,928	6,928
Revenue ($/ha)	**57,898**	13,197	13,197	13,197	13,197	13,197
Gross margin ($/ha)	**27,503**	6,269	6,269	6,269	6,269	6,269
Profit ($/ha)	**13,688**	3,120	3,120	3,120	3,120	3,120
With adoption scenario						
Fixed expenses ($/ha)	**16,852**	3,929	3,815	3,815	3,815	3,815
Total variable expenses ($/ha)	**32,533**	7,415	7,415	7,415	7,415	7,415
Revenue ($/ha)	**66,543**	15,168	15,168	15,168	15,168	15,168
Gross margin ($/ha)	**34,010**	7,752	7,752	7,752	7,752	7,752
Profit ($/ha)	**17,158**	3,823	3,937	3,937	3,937	3,937
Incremental benefits ($/ha)	**3,470**	**703**	**817**	**817**	**817**	**817**
Incremental costs ($/ha)	**2,251**	**601**	**487**	**487**	**487**	**487**
Net benefits (NPV) ($/ha)	**1,219**	**102**	**330**	**330**	**330**	**330**
Benefit cost ratio (BCR)	**1.5**					

The expected NPV of adoption was estimated as $1,219 per hectare, or $69,749 per average farm enterprise. The BCR was calculated as 1.5, indicating an expected net return on investment of $1.50 for every dollar of investment. The maximum present value cost of adoption that would justify investing in the Vitivisor dashboard technology for the average farm enterprise was estimated as $198,592, or $45,448 per year on average over the five-year period of analysis.

5.4 Sensitivity analysis

The results of the financial BCA were re-estimated using different values for key uncertain parameters to test the sensitivity of BCA results to assumptions on values of the uncertain parameters.

The sensitivity analysis tested the sensitivity of BCA results to the following uncertain parameters:

- Cost of increasing watering by 1ML/ha ($/ML/ha)
- Yield gains from increasing watering by 1 ML/ha (t/ha)
- Electricity cost saving ($/ha)
- Fuel cost saving ($/ha)
- Labour cost saving ($/ha

Table 5-3 Annual and net present value costs and returns per average farm with and without adoption of Vitivisor Dashboard Technology

	PV	2022/23	2023/24	2024/25	2025/26	2026/27
Base case (without adoption) scenario						
Fixed expenses ($)	**957,963**	218,353	218,353	218,353	218,353	218,353
Total variable expenses ($)	**1,739,521**	396,498	396,498	396,498	396,498	396,498
Revenue ($)	**3,313,526**	755,269	755,269	755,269	755,269	755,269
Gross margin ($)	**1,574,005**	358,771	358,771	358,771	358,771	358,771
Profit ($)	**783,348**	178,553	178,553	178,553	178,553	178,553
With adoption scenario						
Fixed expenses ($)	**964,463**	224,853	218,353	218,353	218,353	218,353
Total variable expenses ($)	**1,861,864**	424,384	424,384	424,384	424,384	424,384
Revenue ($)	**3,808,266**	868,038	868,038	868,038	868,038	868,038
Gross margin ($)	**1,946,402**	443,654	443,654	443,654	443,654	443,654
Profit ($)	**981,940**	218,800	225,300	225,300	225,300	225,300
Incremental benefits ($)	**198,592**	**40,248**	**46,748**	**46,748**	**46,748**	**46,748**
Incremental costs ($)	**128,843**	**34,386**	**27,886**	**27,886**	**27,886**	**27,886**
Net benefits (NPV) ($)	**69,749**	**5,861**	**18,861**	**18,861**	**18,861**	**18,861**
Benefit cost ratio (BCR)	**1.5**					

Specifically, two scenarios were analysed:

1. An optimistic scenario where:
    a. the cost of increasing watering by 1ML/ha was estimated at $239/ML/ha instead of $298/ML/ha, or 20% less than expected;
    b. yield gains from increasing watering by 1 ML/ha were estimated as 4.0 tonnes/ha instead of 3.0 tonnes/ha, or 20% higher than expected; and
    c. electricity, fuel and labour cost savings were estimated at 12% instead of 10%, or 20% higher than expected.
2. A pessimistic scenario where:
    a. the cost of increasing watering by 1ML/ha was estimated at $358/ML/ha instead of $298/ML/ha, or 20% higher than expected;
    b. yield gains from increasing watering by 1 ML/ha were estimated as 2.0 tonnes/ha instead of 3.0 tonnes/ha, or 20% less than expected; and
    c. electricity, fuel and labour cost savings were estimated at 8% instead of 10%, or 20% less than expected.

Expected values provided in Table 5-1 were used for all the other parameters.

Overall, BCA results are sensitive to pessimistic assumptions, or use of pessimistic values in place of expected values for uncertain parameters indicating that the net benefit of adopting Vitivisor dashboard technology for a farm enterprise depends on expected values of the cost of increasing watering by 1ML/ha, expected yield gains from improvements in input use efficiency and expected electricity, fuel and labour cost savings.

Table 5-4 and Table 5-5 present incremental benefits and incremental costs of adoption under the optimistic and pessimistic scenarios.

Overall, BCA results are sensitive to pessimistic assumptions, or use of pessimistic values in place of expected values for uncertain parameters indicating that the net benefit of adopting Vitivisor dashboard technology for a farm enterprise depends on expected values of the cost of increasing watering by 1ML/ha, expected yield gains from improvements in input use efficiency and expected electricity, fuel and labour cost savings.

Table 5-4 Annual and net present value costs and returns per hectare with and without adoption of Vitivisor Dashboard Technology with optimistic assumptions

	PV	2022/23	2023/24	2024/25	2025/26	2026/27
Base case (without adoption) scenario						
Fixed expenses ($/ha)	**16,739**	3,815	3,815	3,815	3,815	3,815
Total variable expenses ($/ha)	**30,395**	6,928	6,928	6,928	6,928	6,928
Revenue ($/ha)	**57,898**	13,197	13,197	13,197	13,197	13,197
Gross margin ($/ha)	**27,503**	6,269	6,269	6,269	6,269	6,269
Profit ($/ha)	**13,688**	3,120	3,120	3,120	3,120	3,120
With adoption scenario						
Fixed expenses ($/ha)	**16,852**	3,929	3,815	3,815	3,815	3,815
Total variable expenses ($/ha)	**32,186**	7,336	7,336	7,336	7,336	7,336
Revenue ($/ha)	**68,272**	15,562	15,562	15,562	15,562	15,562
Gross margin ($/ha)	**36,087**	8,225	8,225	8,225	8,225	8,225
Profit ($/ha)	**19,234**	4,296	4,410	4,410	4,410	4,410
Incremental benefits ($/ha)	**5,546**	**1,177**	**1,290**	**1,290**	**1,290**	**1,290**
Incremental costs ($/ha)	**1,904**	**522**	**408**	**408**	**408**	**408**
Net benefits (NPV) ($/ha)	**3,643**	**655**	**882**	**882**	**882**	**882**
Benefit cost ratio (BCR)	**2.9**					

5.5 Threshold analysis

The threshold initial cost of Vitivisor dashboard software packages beyond which the expected incremental net return from the investment would be negative was calculated for the average farm enterprise as $67,198 over the five-year lifespan. In other words, the cost of the package should not be higher than $67,198 under the normal assumptions for an average farm to realise positive net returns from investing in the Vitivisor dashboard technology.

5.6 BCA Limitations

Table 5-3present conservative estimates for the following reasons:

- Reduced operator labour time on farms were not included;
- We have allowed for decision-making costs of using the Dashboard – but – this may reduce decision-making times overall for some farmers;
- Significantly greater savings in electricity, fuel and labour costs could be achieved than the 10% value used in this analysis;
- Some farms could realise significantly higher benefits from the investment than the average farm estimates used in this analysis;

- The salvage value from the technology investment was not included and the lifespan of the technology may be longer than five years;
- Improvements in health and safety operating issues, identified as potential benefit of adoption, and reduced chemical application, were not included;
- Improvements in grape, soil, water costs, vine quality were not included; and
- Community benefits of the technology (eg such as reduced chemical use; predicting yield for the season, improved logistics etc) were not quantified.

Table 5-5 Annual and net present value costs and returns per hectare with and without adoption of Vitivisor Dashboard Technology with pessimistic assumptions

	PV	2022/23	2023/24	2024/25	2025/26	2026/27
Base case (without adoption) scenario						
Fixed expenses ($/ha)	**16,739**	3,815	3,815	3,815	3,815	3,815
Total variable expenses ($/ha)	**30,395**	6,928	6,928	6,928	6,928	6,928
Revenue ($/ha)	**57,898**	13,197	13,197	13,197	13,197	13,197
Gross margin ($/ha)	**27,503**	6,269	6,269	6,269	6,269	6,269
Profit ($/ha)	**13,688**	3,120	3,120	3,120	3,120	3,120
With adoption scenario						
Fixed expenses ($/ha)	**16,852**	3,929	3,815	3,815	3,815	3,815
Total variable expenses ($/ha)	**32,880**	7,495	7,495	7,495	7,495	7,495
Revenue ($/ha)	**64,814**	14,773	14,773	14,773	14,773	14,773
Gross margin ($/ha)	**31,934**	7,279	7,279	7,279	7,279	7,279
Profit ($/ha)	**15,081**	3,350	3,463	3,463	3,463	3,463
Incremental benefits ($/ha)	**1,394**	**230**	**344**	**344**	**344**	**344**
Incremental costs ($/ha)	**2,599**	**680**	**566**	**566**	**566**	**566**
Net benefits (NPV) ($/ha)	**-1,205**	**-450**	**- 223**	**-223**	**-223**	**-223**
Benefit cost ratio (BCR)	**0.5**					

Indeed, for farms that had high water bills, they benefit of Vitivisor would increase manifold in helping to manage and track water better. Future economic research is highly warranted to address the outlined limitations and to address the lack of information on representative gross margins, farm business returns and profitability.

Overall, adoption of Vitivisor dashboard technology can be expected to be preferable to the base case scenario because even though BCA results are sensitive to pessimistic BCA assumptions, inclusion of the omitted benefits here-outlined would likely increase the value of estimated benefits significantly. The expected increase in benefit value estimates would likely be robust to changes in parameter values under the pessimistic scenario.

Finally, the works provided in this report showcase that future economic and financial research may be warranted to address limitations and to advance necessary understanding of actual benefits of adoption of decision-making tools across grower groups. The findings demonstrate that the Riverland region's growers need improved farm outcomes including profitability, and that the adoption of Vitivisor dashboard technology can be expected to be beneficial for growers for improved on farm decision-making.

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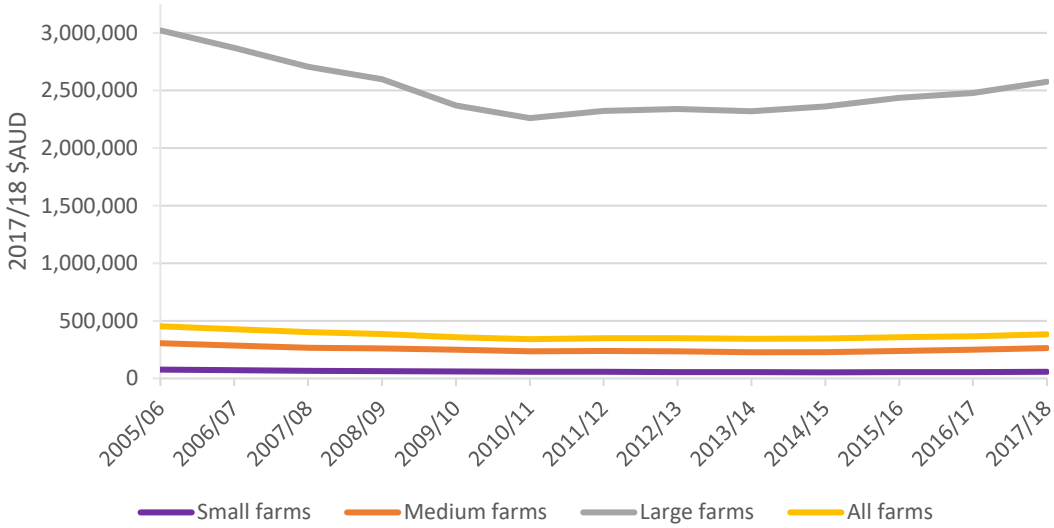
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A Appendices

A.1 Appendix 1

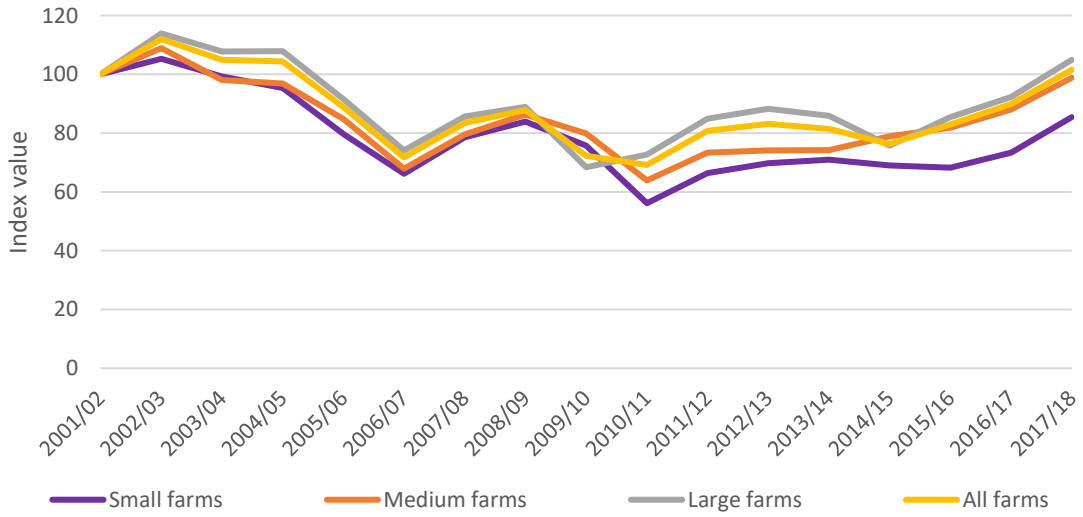
A.1.1 Average Turnover

Figure A.1 Average turnover 5-year moving average of Riverland grape farms from 2005/06- 2017/18 in 2017/18 $AUD



Source: created from ABS DataLab (2020)

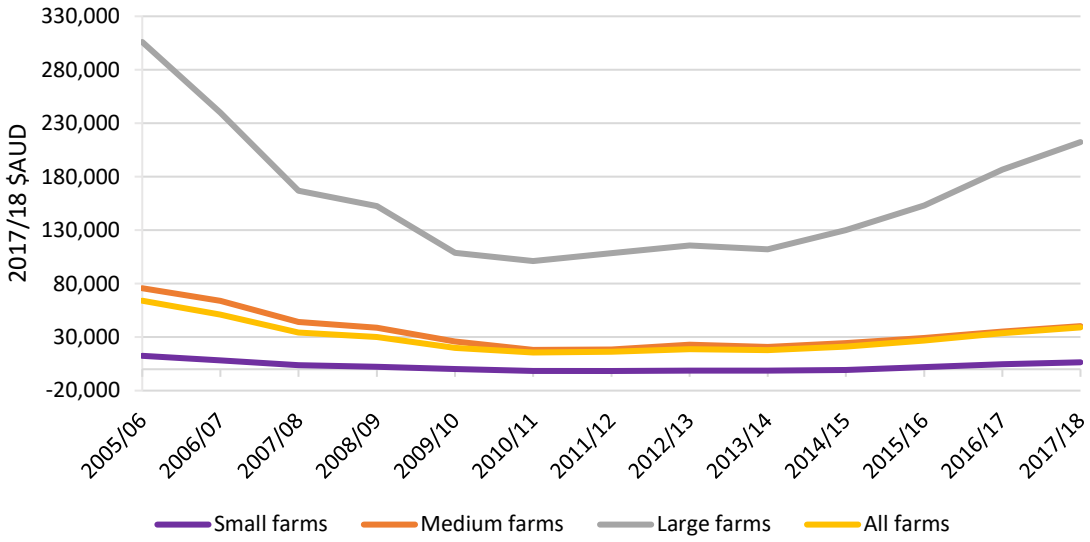
Figure A.2 Average turnover of Riverland grape farms from 2001/02- 2017/18, indexed to 2001/02 levels



Note: all turnover $ values used for indexing are in 2017/18 $AUD
Source: created from ABS DataLab (2020)

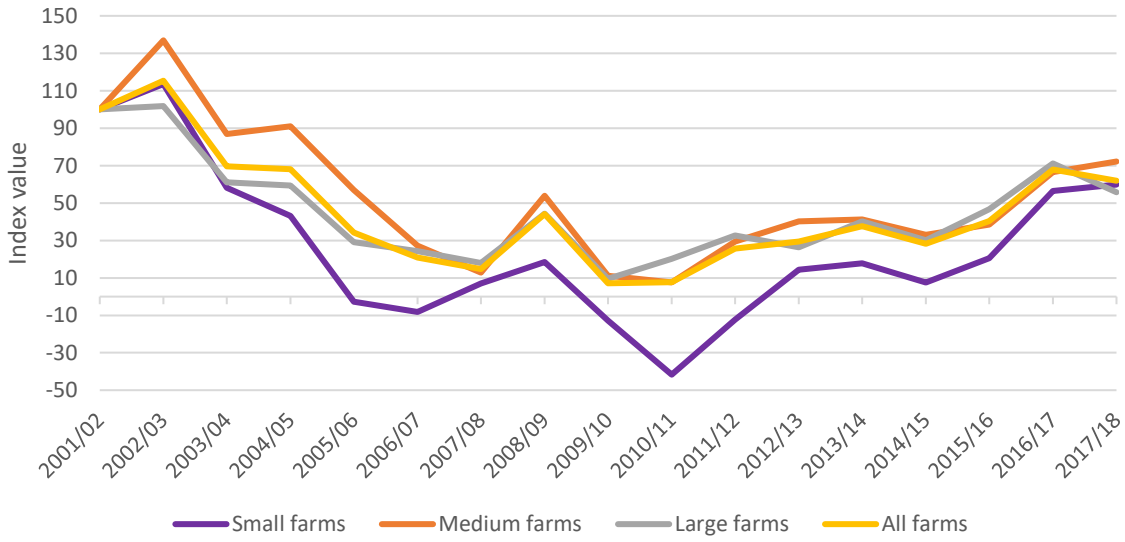
A.1.2 Average net income

Figure A.3 Average net income 5-year moving average of Riverland grape farms from 2005/06- 2017/18 in 2017/18 $AUD



Note: Net income is reported directly in ATO data.
Source: created from ABS DataLab (2020)

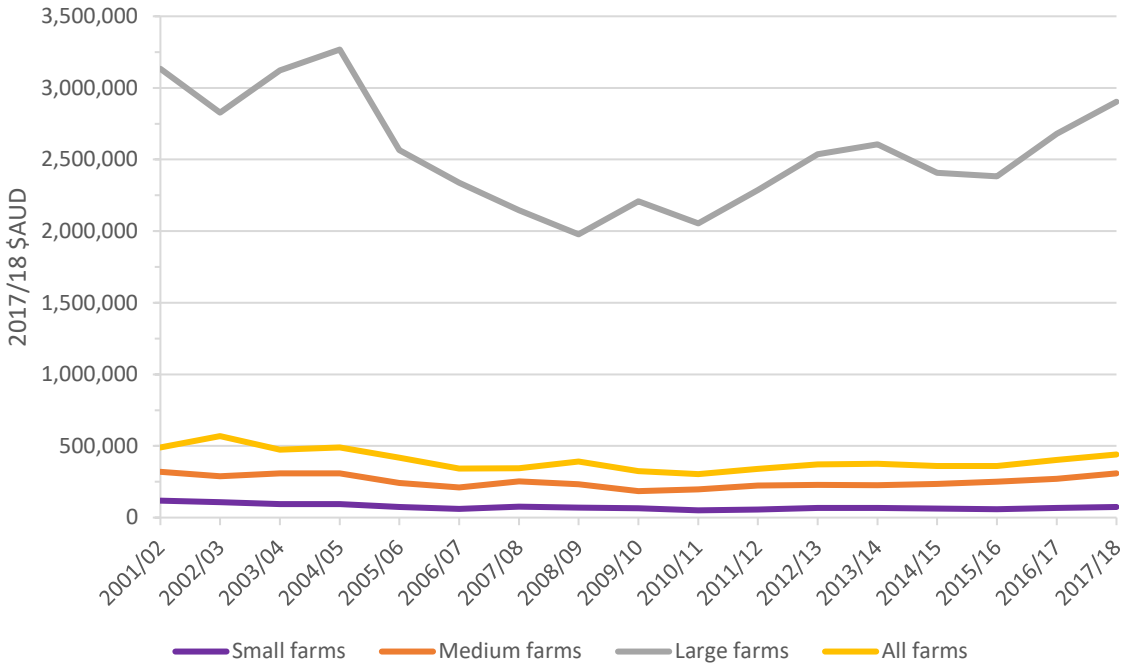
Figure A.4 Average net income of Riverland grape farms from 2001/02- 2017/18, indexed to 2001/02 levels



Note: all net income $ values used for indexing are in 2017/18 $AUD. Net income is reported directly in ATO data
Source: created from ABS DataLab (2020)

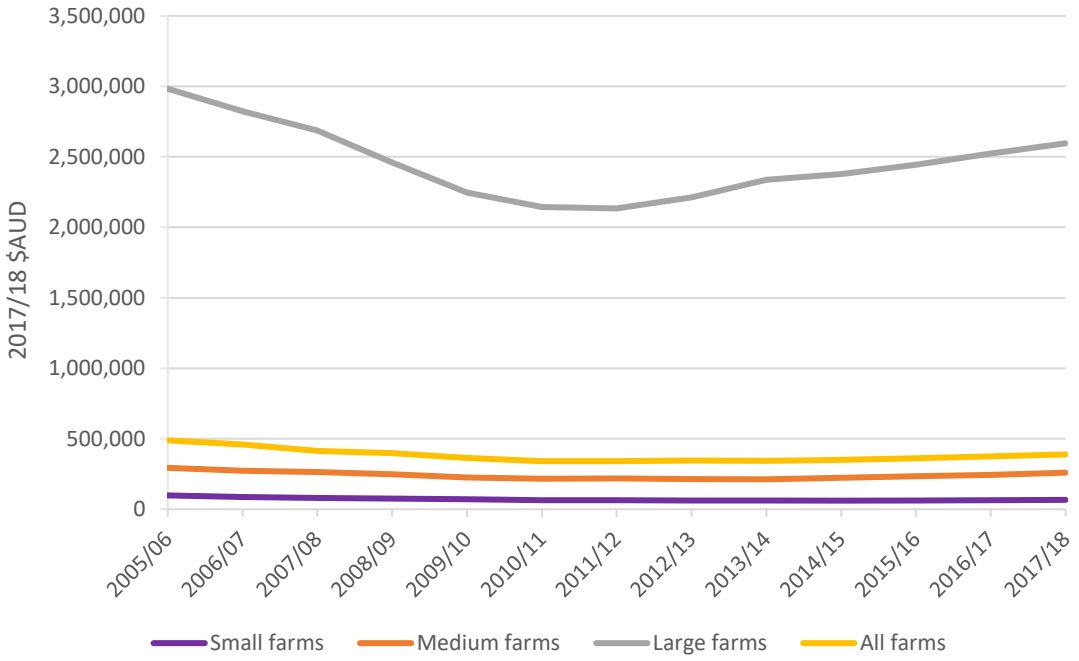
A.1.3 Average total business income

Figure A.5 Average total business income of Riverland grape farms from 2001/02-2017/18 in 2017/18 $AUD



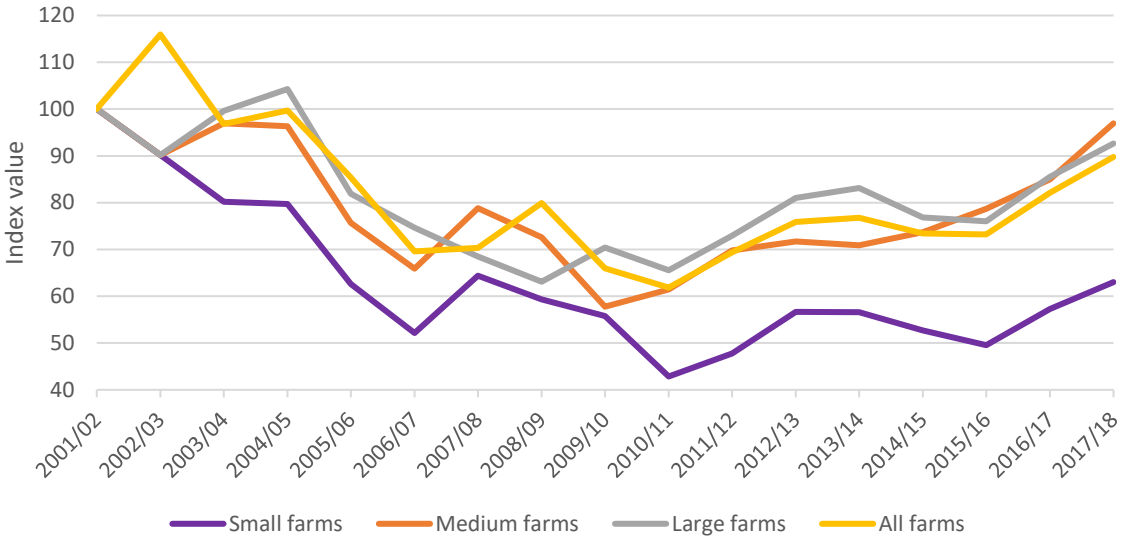
Note: Net income is reported directly in ATO data.
Source: created from ABS DataLab (2020)

Figure A.6 Average total business income 5-year moving average of Riverland grape farms from 2005/06- 2017/18 in 2017/18 $AUD



Note: Total business income is reported directly in ATO data.
Source: created from ABS DataLab (2020)

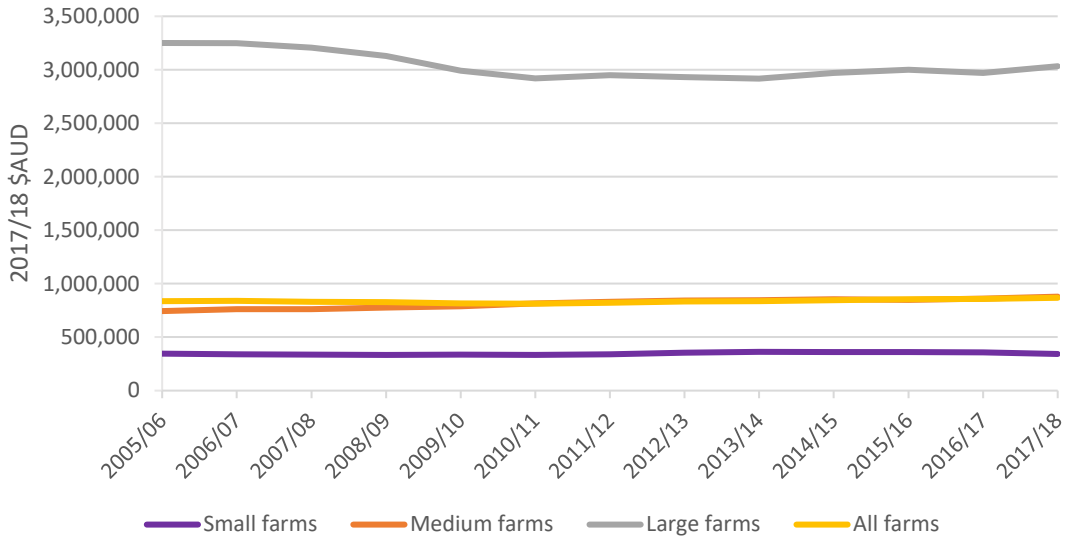
Figure A.7 Average total business income of Riverland grape farms from 2001/02-2017/18, indexed to 2001/02 levels



Note: Total business income is reported directly in ATO data
Source: created from ABS DataLab (2020)

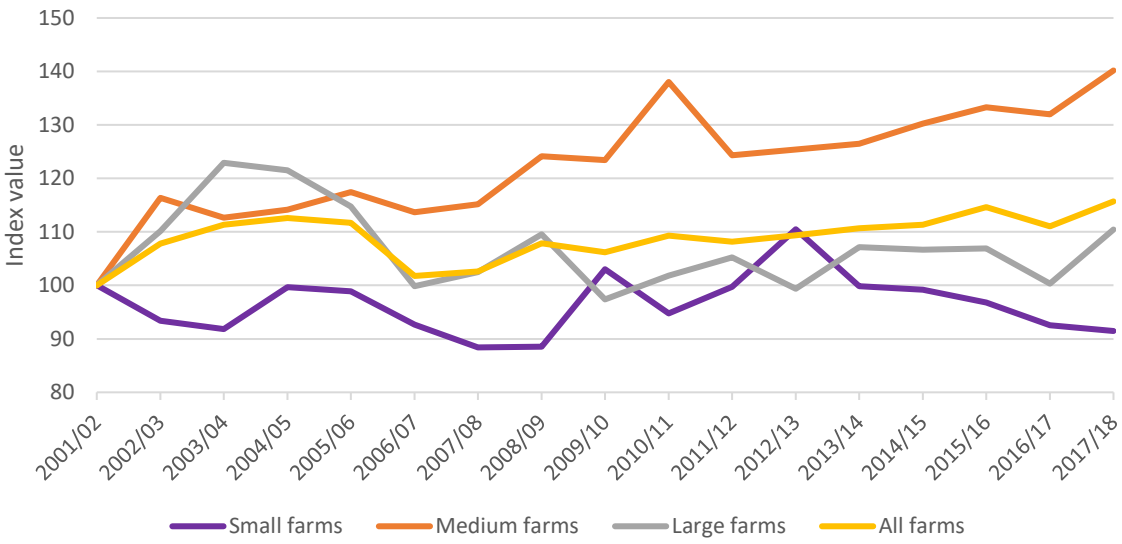
A.1.4 Average total assets

Figure A.8 Average total assets 5-year moving average of Riverland grape farms from 2005/06- 2017/18 in 2017/18 $AUD



Source: created from ABS DataLab (2020)

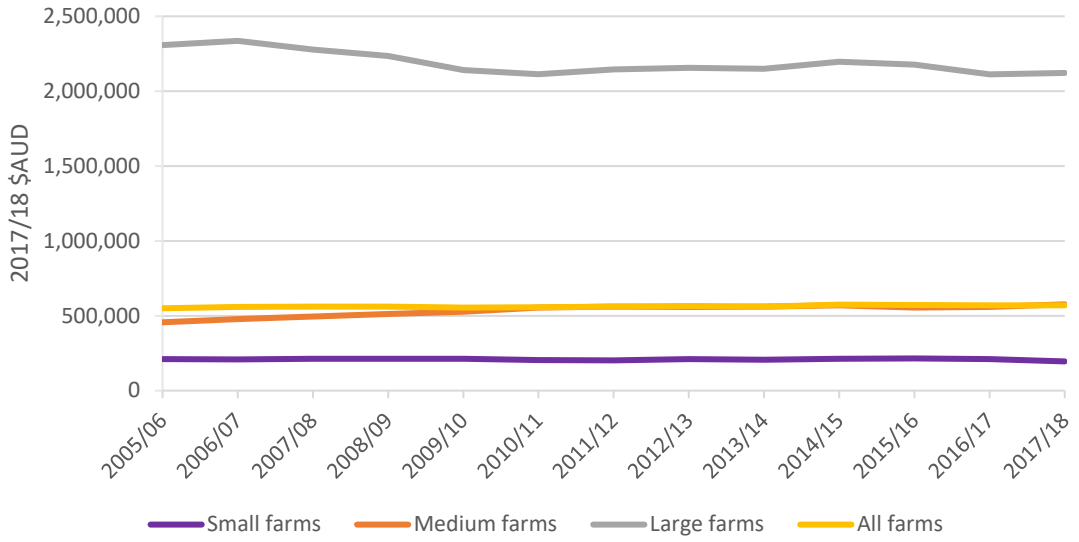
Figure A.9 Average total assets of Riverland grape farms from 2001/02- 2017/18, indexed to 2001/02 levels in 2017/18 $AUD



Note: Total assets are reported directly in ATO data.
Source: created from ABS DataLab (2020)

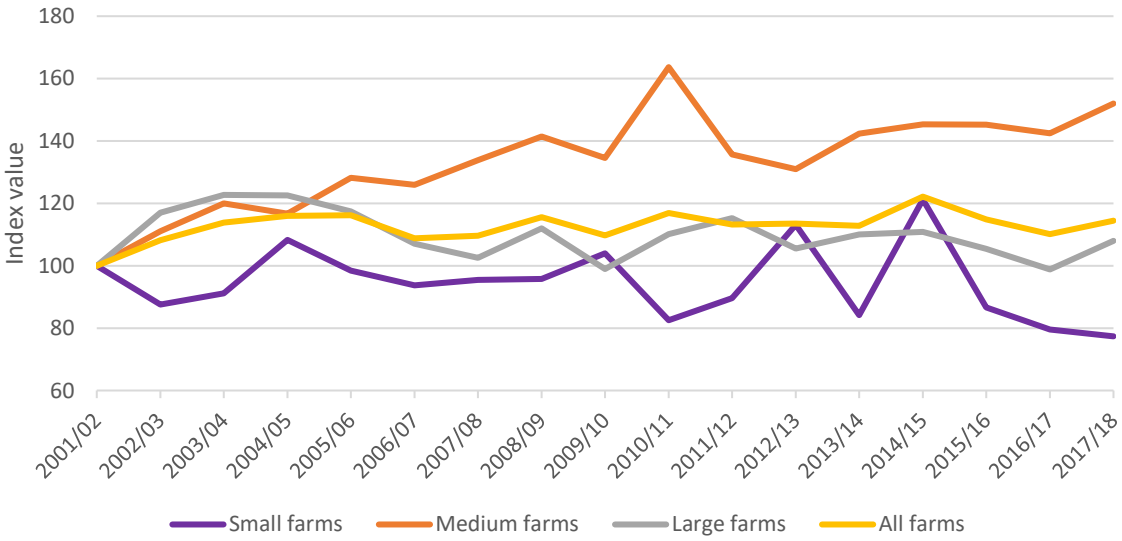
A.1.5 Average total liabilities

Figure A.10 Average total liabilities 5-year moving average of Riverland grape farms from 2005/06- 2017/18 in 2017/18 $AUD



Source: created from ABS DataLab (2020)

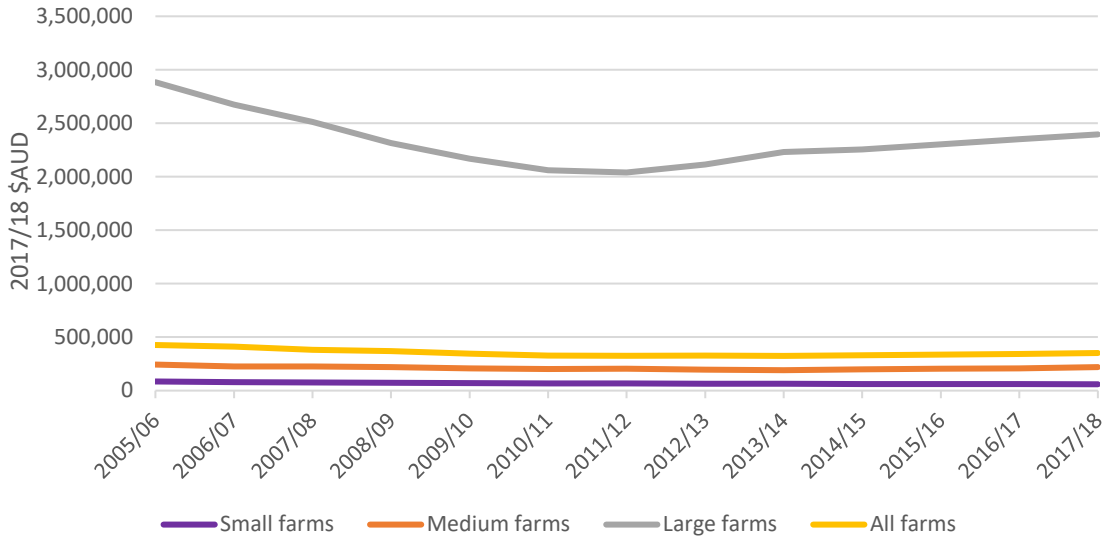
Figure A.11 Average total liabilities of Riverland grape farms from 2001/02- 2017/18, indexed to 2001/02 levels in 2017/18 $AUD



Note: Total liabilities are reported directly in ATO data.
Source: created from ABS DataLab (2020)

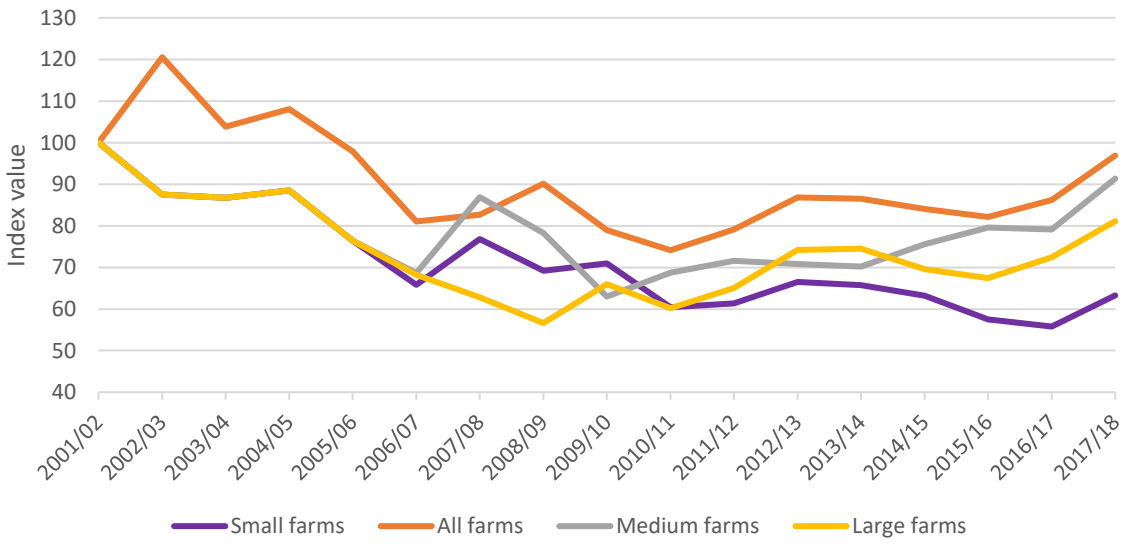
A.1.6 Average total expenses

Figure A.12 Average total expenses 5-year moving average of Riverland grape farms from 2005/06- 2017/18 in 2017/18 $AUD



Note: Total expenses are reported directly in ATO data
Source: created from ABS DataLab (2020)

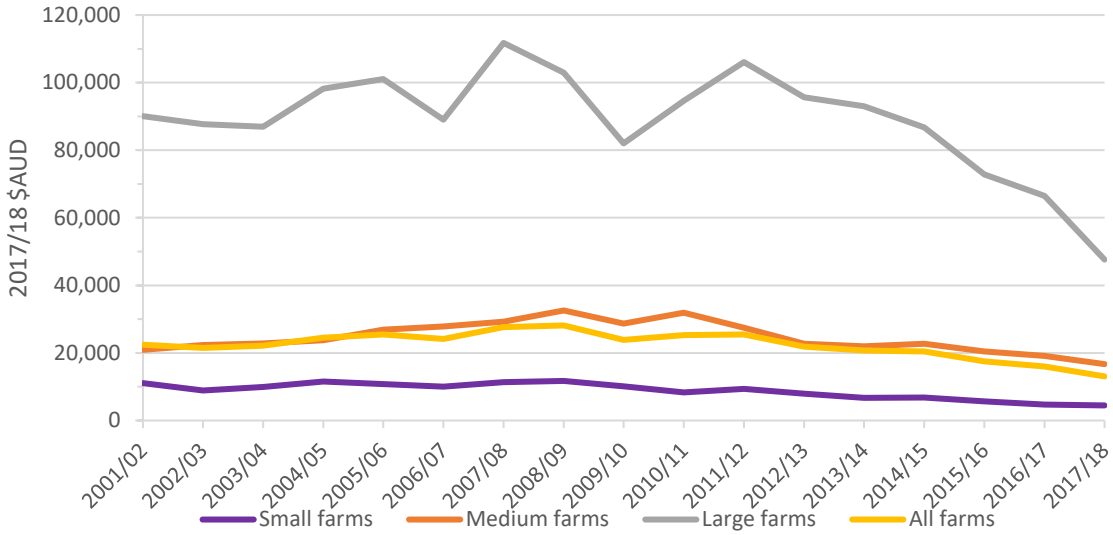
Figure A.13 Average total expenses of Riverland grape farms from 2001/02- 2017/18, indexed to 2001/02 levels



Note: Total expenses are reported directly in ATO data
Source: created from ABS DataLab (2020)

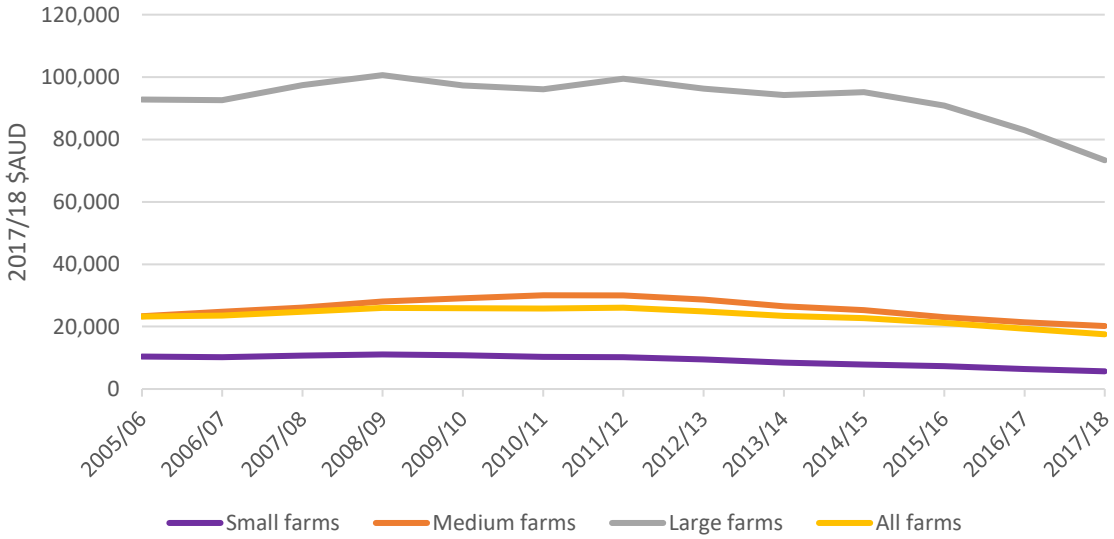
A.1.7 Average interest expenses

Figure A.14 Average interest expenses of Riverland grape farms from 2001/02- 2017/18 in 2017/18 $AUD



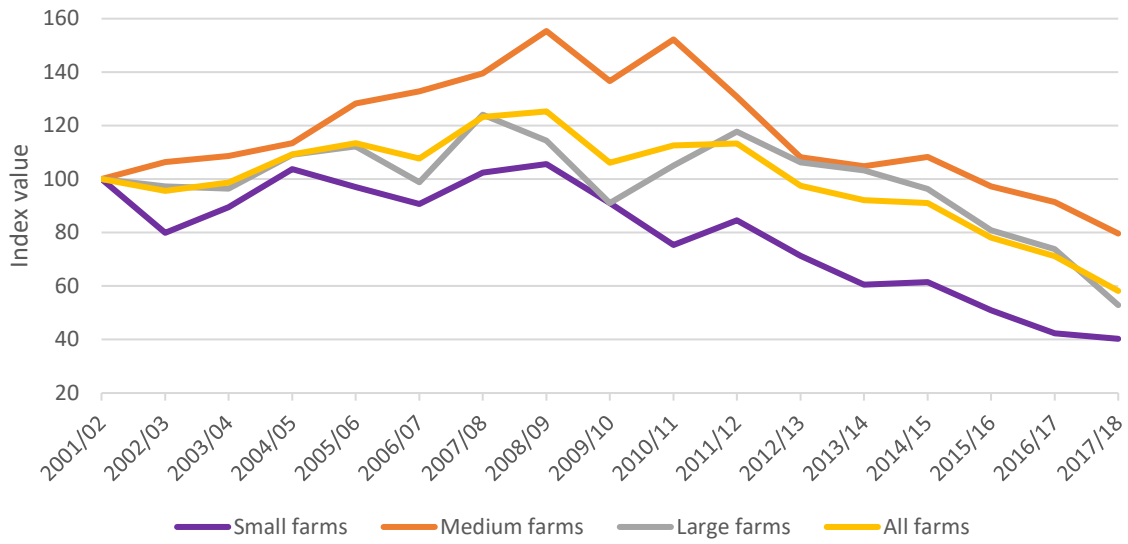
Note: Interest expenses are reported directly in ATO data
Source: created from ABS DataLab (2020)

Figure A.15 Average interest expenses 5-year moving average of Riverland grape farms from 2005/06- 2017/18 in 2017/18 $AUD



Note: Interest expenses are reported directly in ATO data
Source: created from ABS DataLab (2020)

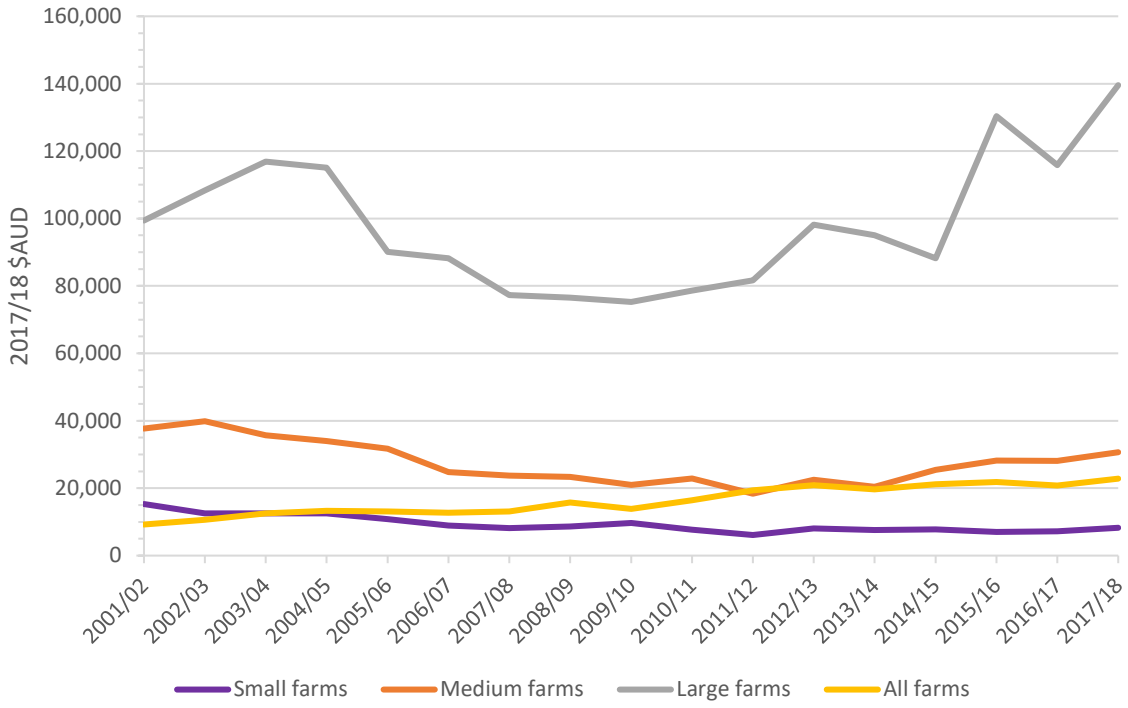
Figure A.16 Average interest expenses of Riverland grape farms from 2001/02- 2017/18, indexed to 2001/02 levels



Note: Interest expenses are reported directly in ATO data
Source: created from ABS DataLab (2020)

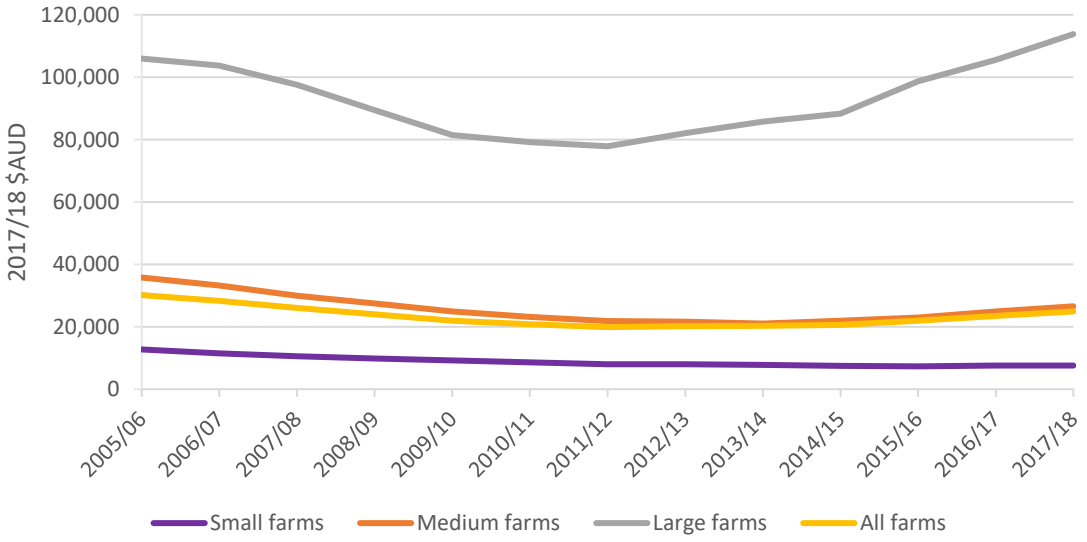
A.1.8 Average depreciation costs

Figure A.17 Average depreciation costs of Riverland grape farms from 2001/02- 2017/18 in 2017/18 $AUD



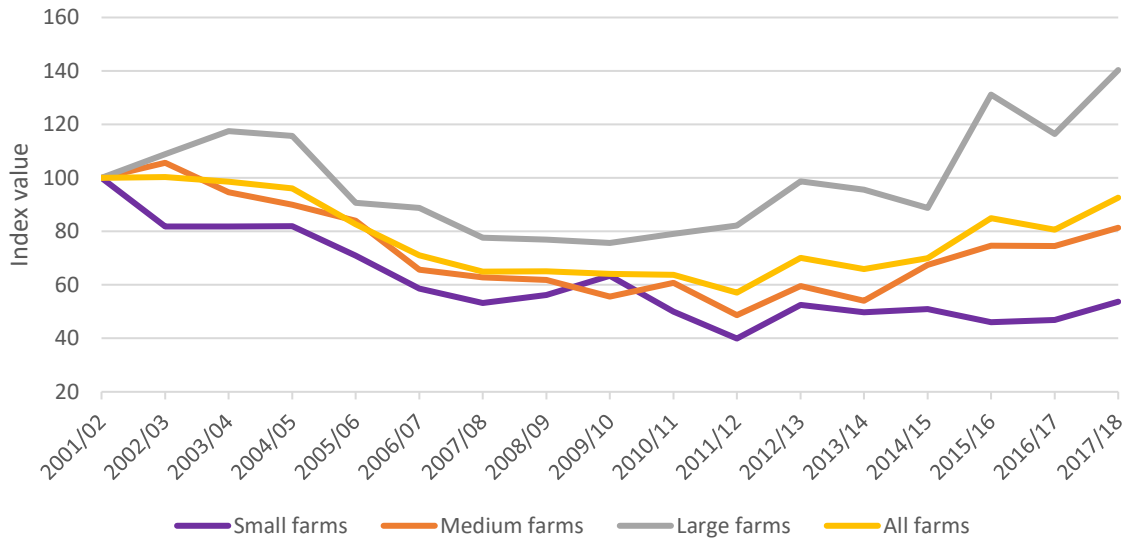
Note: Depreciation costs are reported directly in ATO data
Source: created from ABS DataLab (2020)

Figure A.18 Average depreciation costs 5-year moving average of Riverland grape farms from 2005/06- 2017/18 in 2017/18 $AUD



Note: Depreciation costs are reported directly in ATO data
Source: created from ABS DataLab (2020)

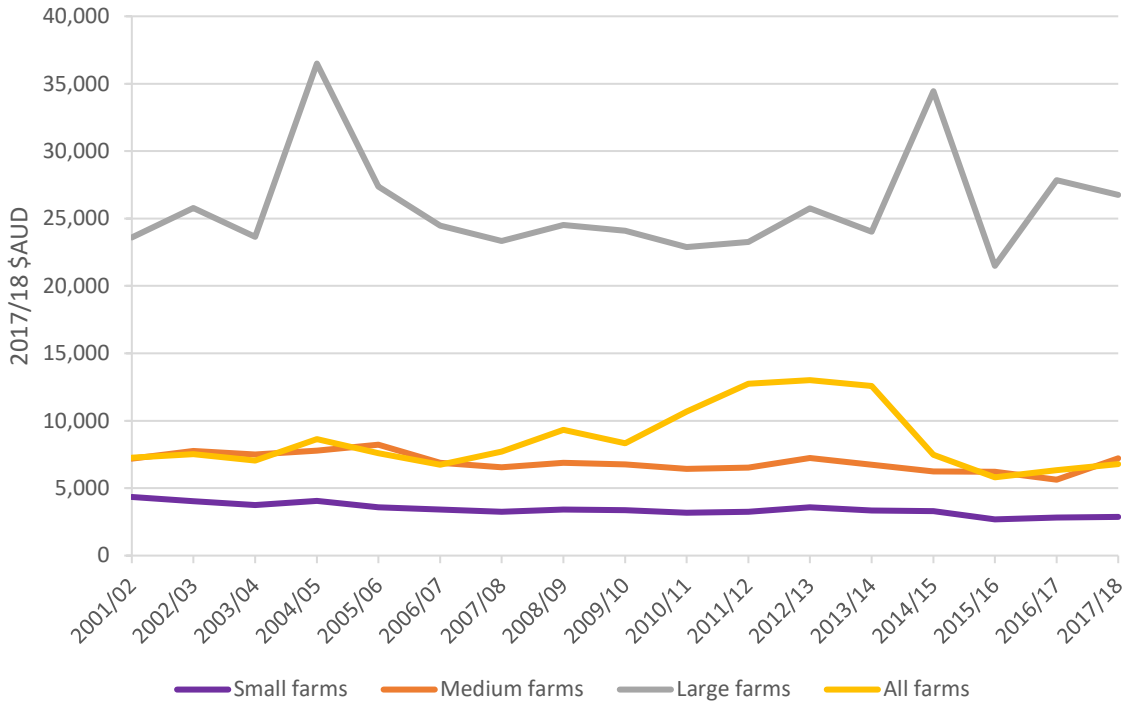
Figure A.19 Average depreciation expenses of Riverland grape farms from 2001/02-2017/18, indexed to 2001/02 levels in 2017/18 $AUD



Note: Depreciation costs are reported directly in ATO data
Source: created from ABS DataLab (2020)

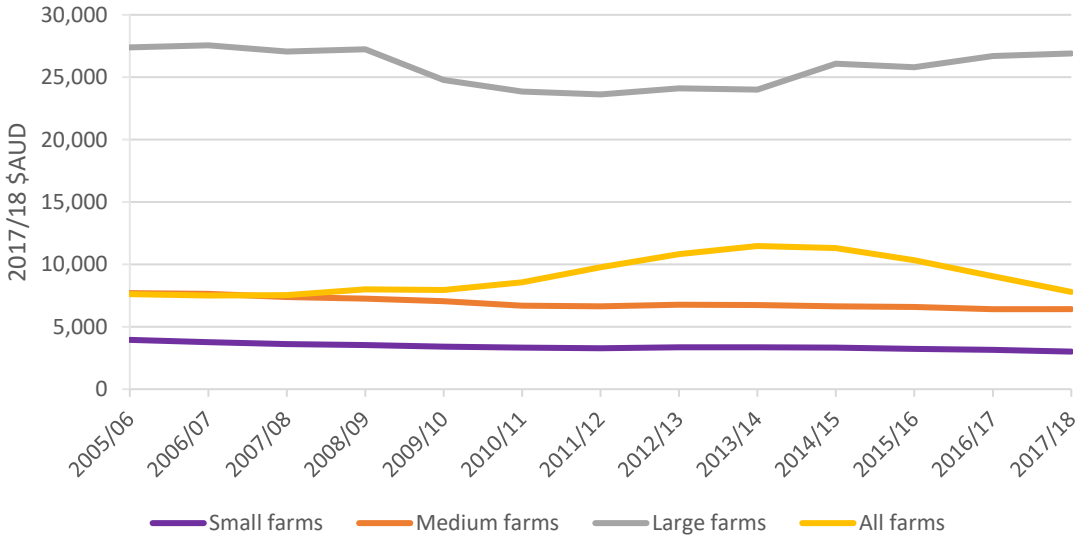
A.1.9 Average motor vehicle costs

Figure A.20 Average motor vehicle costs of Riverland grape farms from 2001/02-2017/18 in 2017/18 $AUD



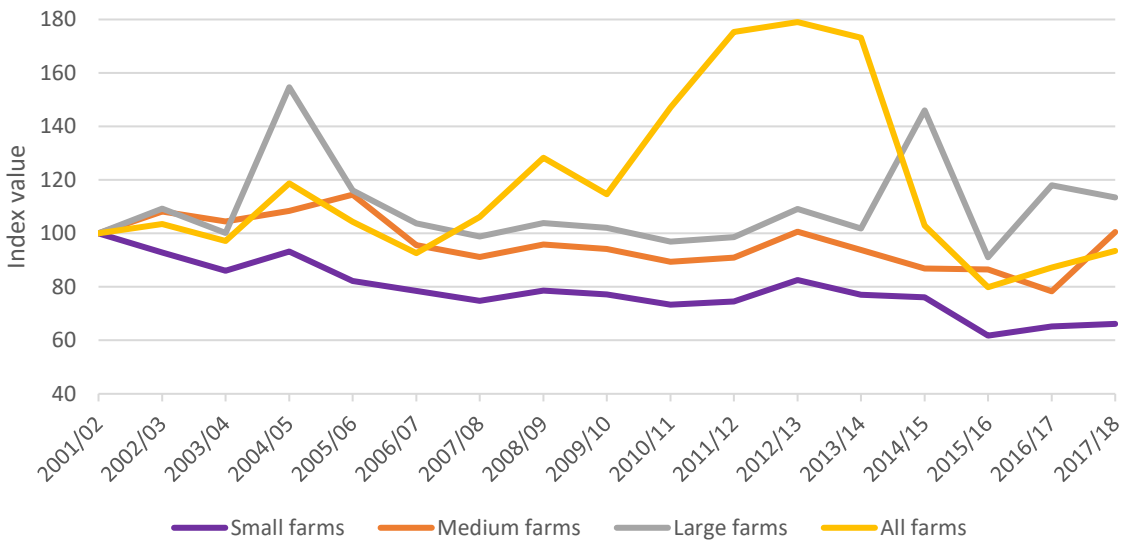
Note: Motor vehicle costs are reported directly in ATO data
Source: created from ABS DataLab (2020)

Figure A.21 Average motor vehicle costs 5-year moving average of Riverland grape farms from 2005/06- 2017/18 in 2017/18 $AUD



Note: Motor vehicle costs are reported directly in ATO data
Source: created from ABS DataLab (2020)

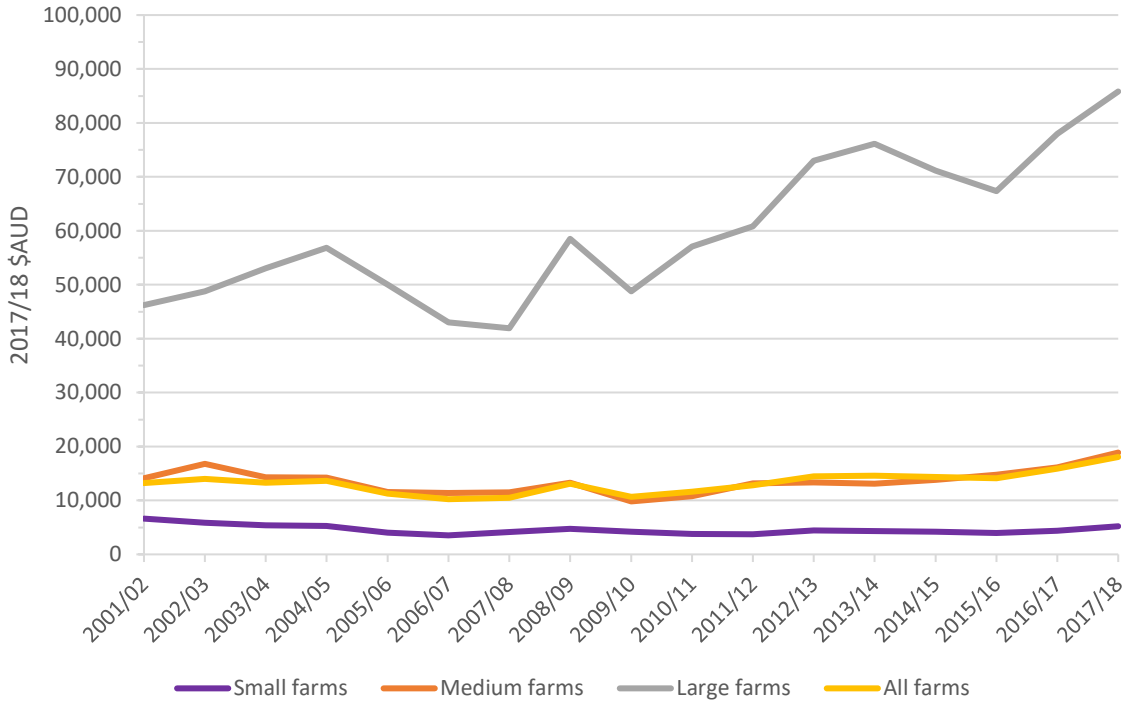
Figure A.22 Average motor vehicle costs of Riverland grape farms from 2001/02-2017/18, indexed to 2001/02 levels



Note: Motor vehicle costs are reported directly in ATO data
Source: created from ABS DataLab (2020)

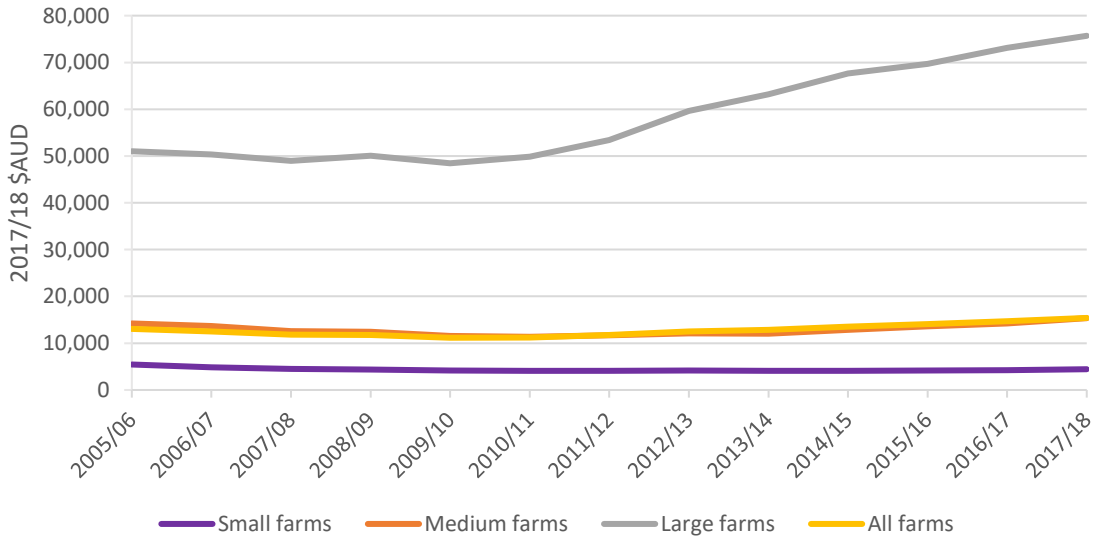
A.1.10 Average Repair and maintenance

Figure A.23 Average repair and maintenance costs of Riverland grape farms from 2001/02- 2017/18 in 2017/18 $AUD



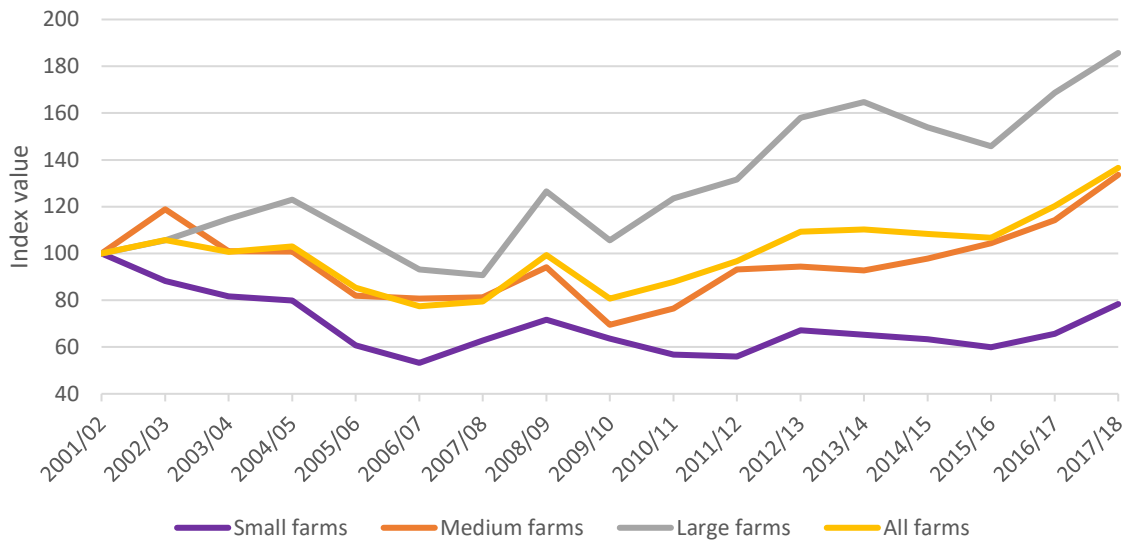
Note: Repair and maintenance costs are reported directly in ATO data
Source: created from ABS DataLab (2020)

Figure A.24 Average repair and maintenance costs 5-year moving average of Riverland grape farms from 2005/06- 2017/18 in 2017/18 $AUD



Note: Repair and maintenance costs are reported directly in ATO data
Source: created from ABS DataLab (2020)

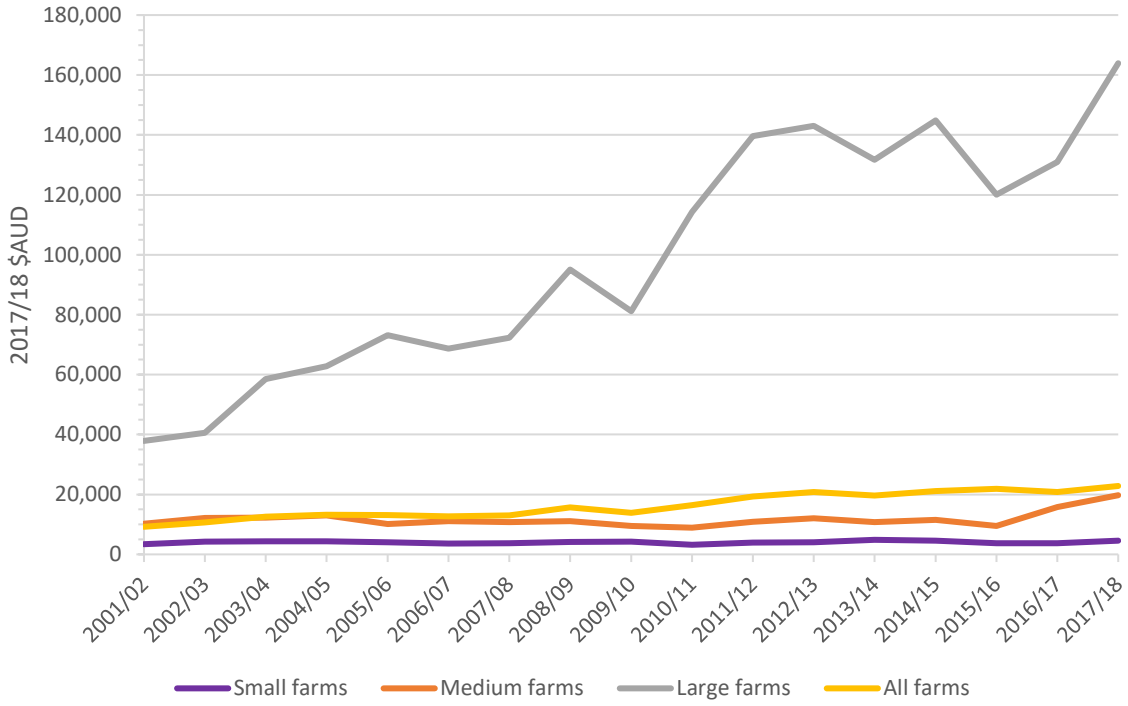
Figure A.25 Average repair and maintenance costs of Riverland grape farms from 2001/02- 2017/18, indexed to 2001/02 levels



Note: Repair and maintenance costs are reported directly in ATO data
Source: created from ABS DataLab (2020)

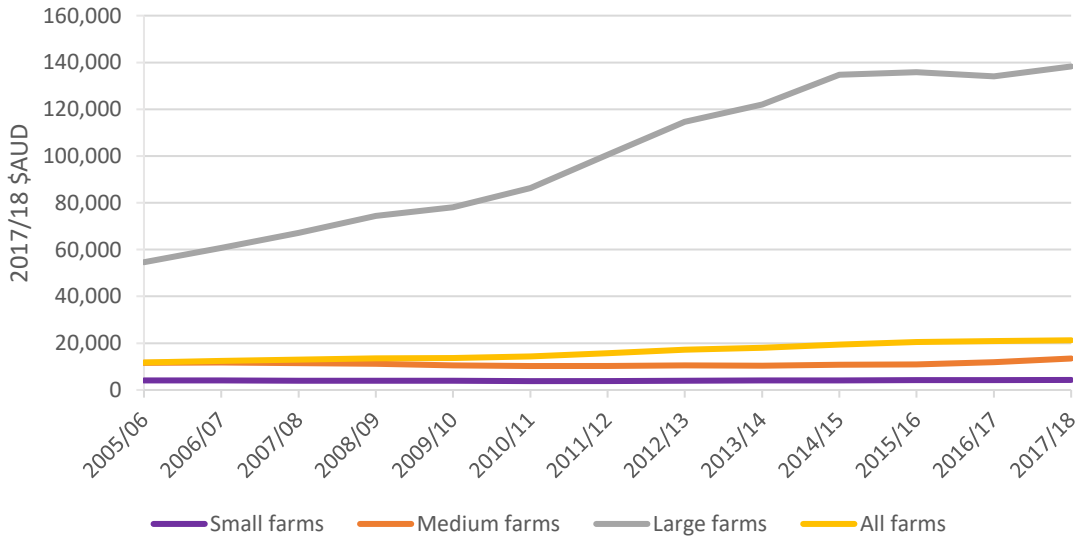
A.1.11 Average contractor costs

Figure A.26 Average contractor costs of Riverland grape farms from 2001/02- 2017/18 in 2017/18 $AUD



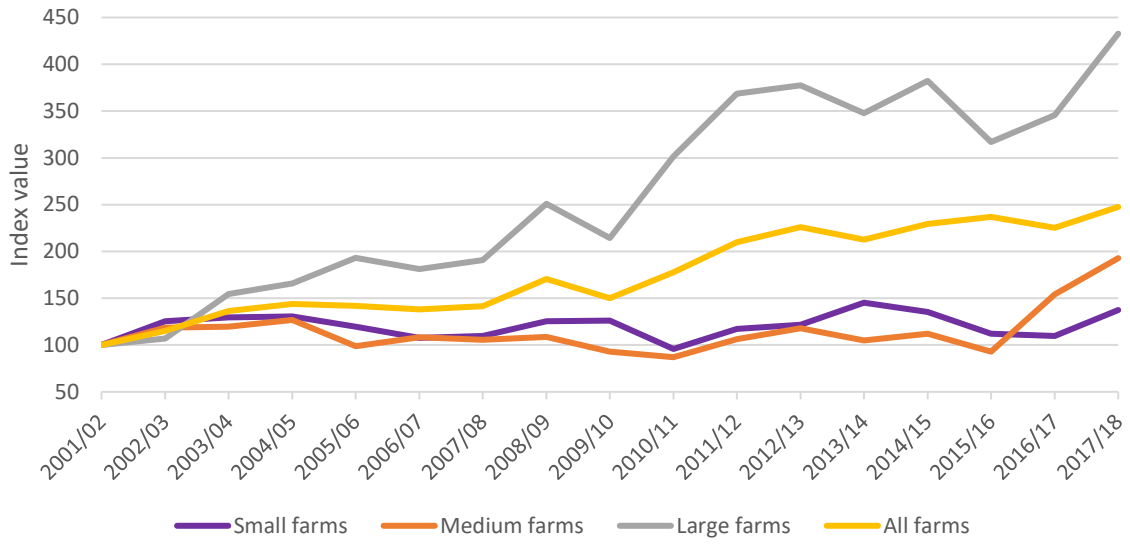
Note: Contractor costs are reported directly in ATO data
Source: created from ABS DataLab (2020)

Figure A.27 Average contractor costs 5-year moving average of Riverland grape farms from 2005/06- 2017/18 in 2017/18 $AUD



Note: Contractor costs are reported directly in ATO data
Source: created from ABS DataLab (2020)

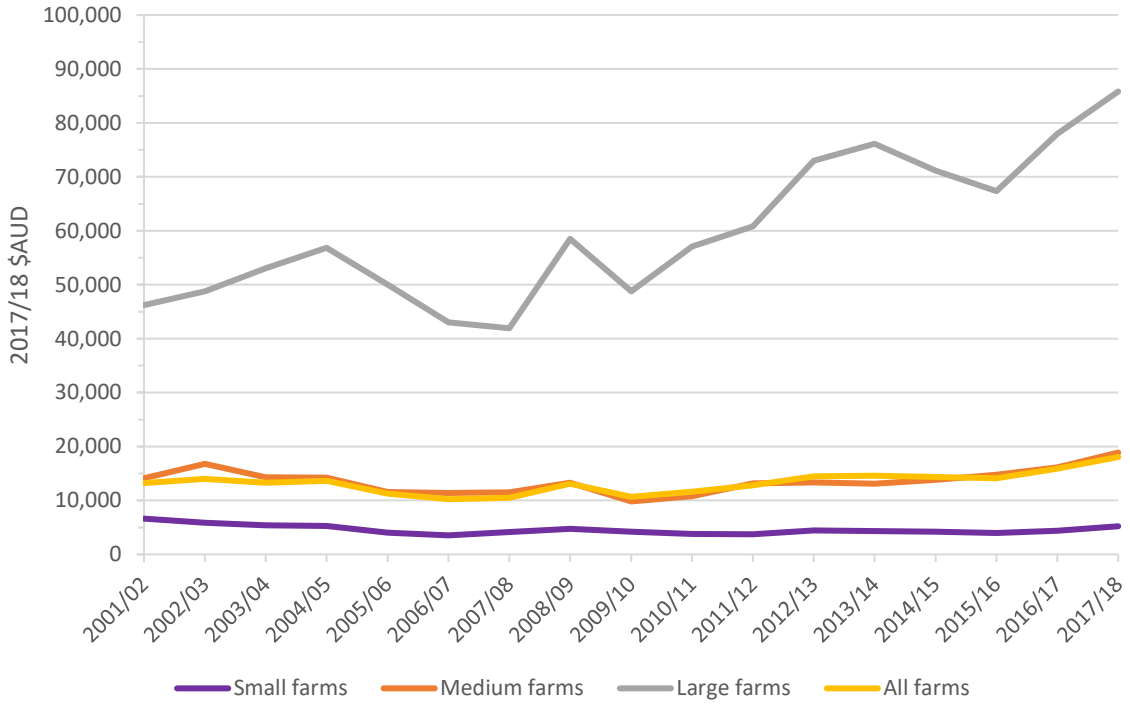
Figure A.28 Average contractor costs of Riverland grape farms from 2001/02- 2017/18, indexed to 2001/02 levels



Note: Contractor costs are reported directly in ATO data
Source: created from ABS DataLab (2020)

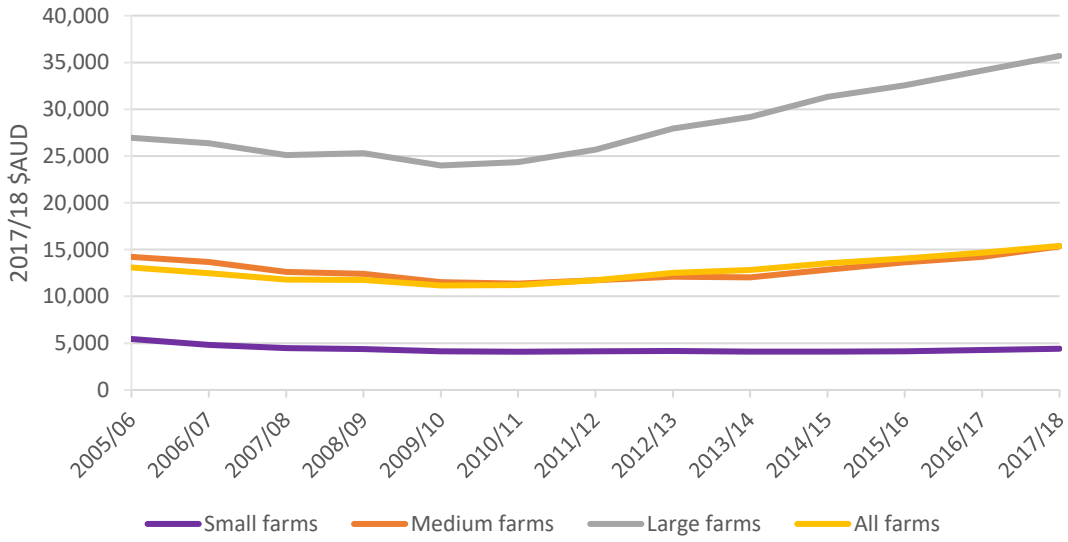
A.1.12 Average other costs

Figure A.29 Average other costs of Riverland grape farms from 2001/02- 2017/18 in 2017/18 $AUD



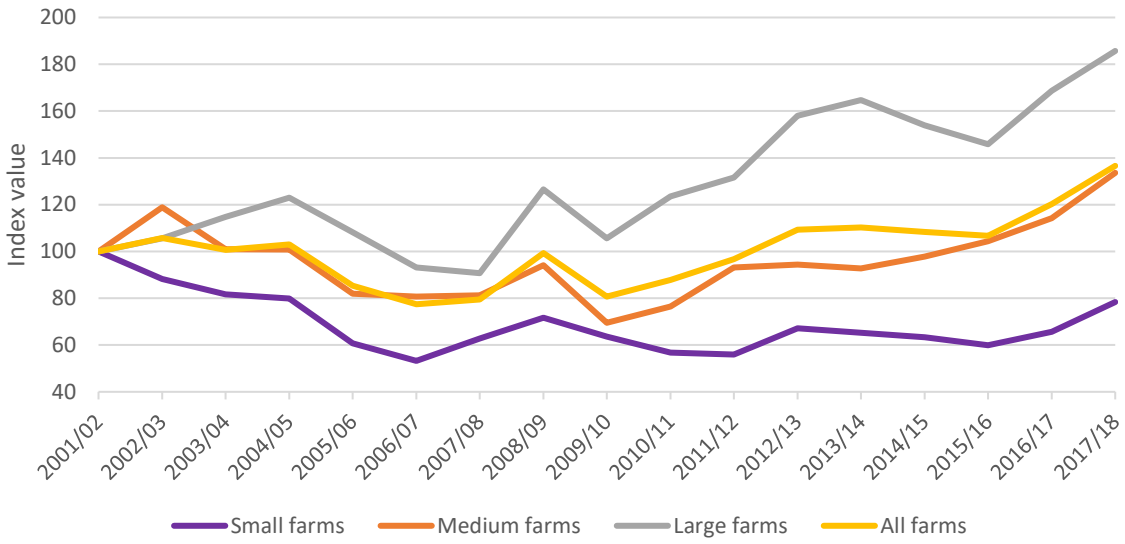
Note: Other costs are reported directly in ATO data
Source: created from ABS DataLab (2020)

Figure A.30 Average other costs 5-year moving average of Riverland grape farms from 2005/06- 2017/18 in 2017/18 $AUD



Note: Other costs are reported directly in ATO data
Source: created from ABS DataLab (2020)

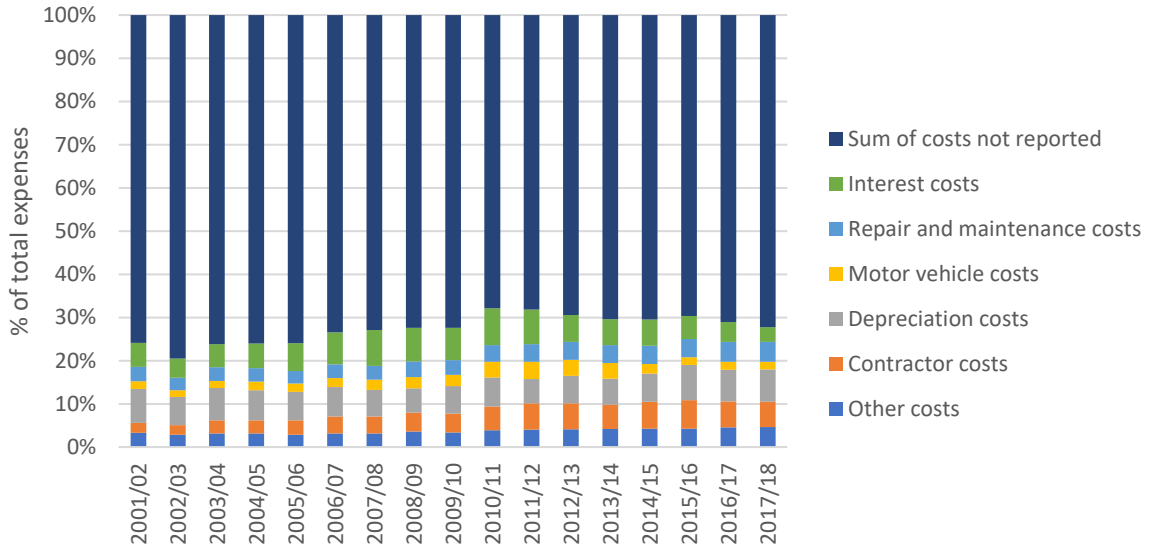
Figure A.31 Average other costs of Riverland grape farms from 2001/02- 2017/18, indexed to 2001/02 levels



Note: Other costs are reported directly in ATO data
Source: created from ABS DataLab (2020)

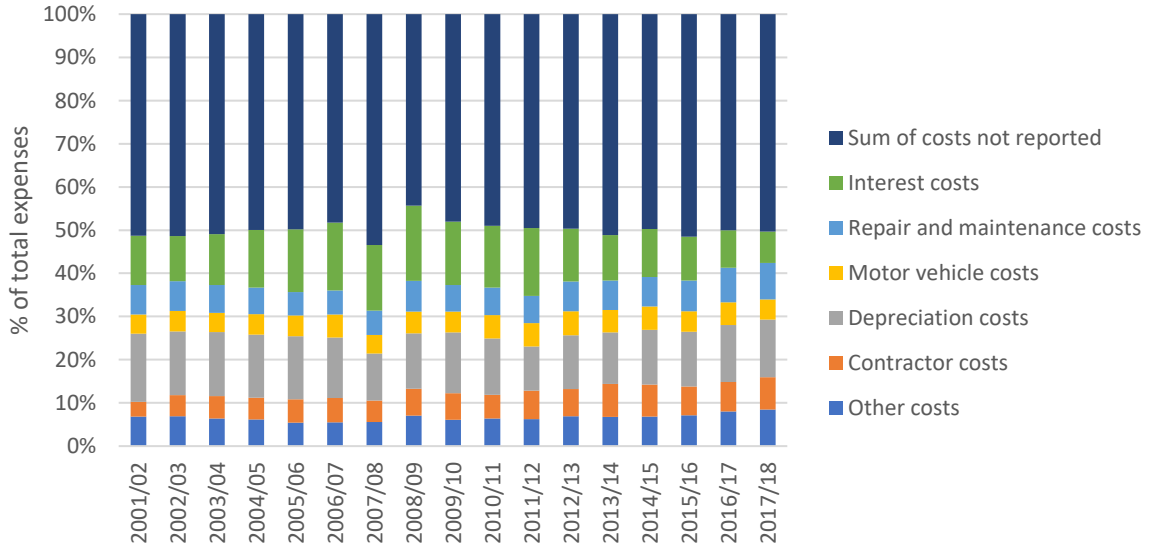
A.1.13 Cost break down

Figure A.32 Cost break down relative to total expenses of Riverland grape farms from 2001/02- 2017/18



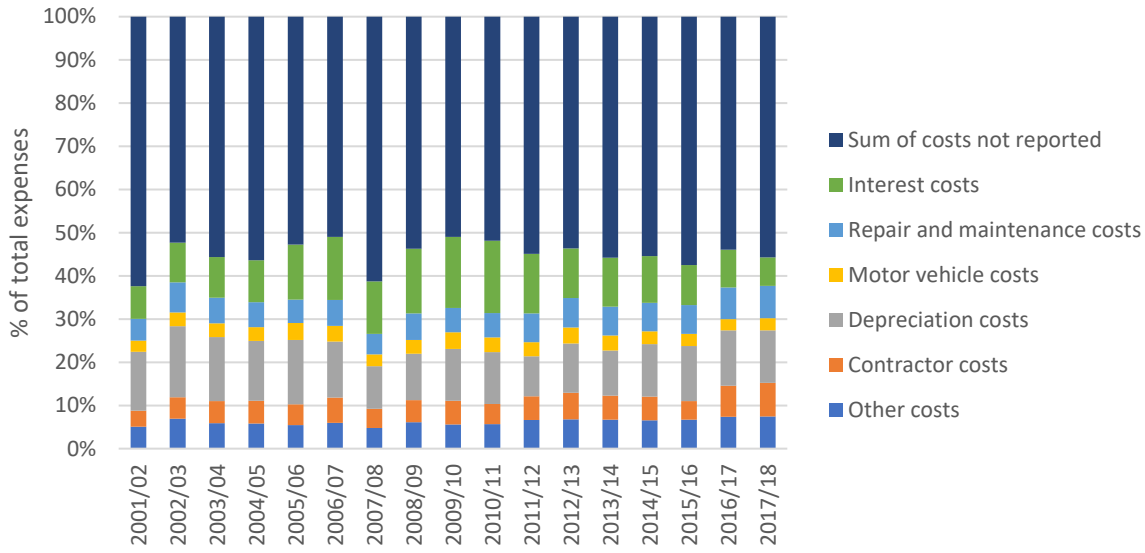
Note: Sum of costs not reported is a balancing item to align individual cost types with total expenses reported in the data.
Source: created from ABS DataLab (2020)

Figure A.33 Cost break down relative to total expenses of small Riverland grape farms from 2001/02- 2017/18



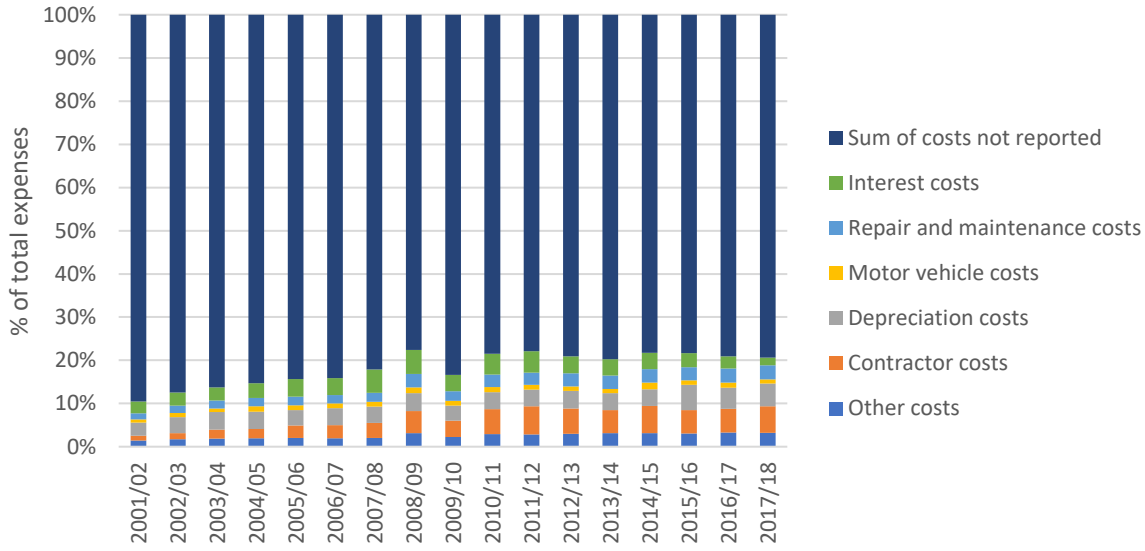
Note: Sum of costs not reported is a balancing item to align individual cost types with total expenses reported in the data.
Source: created from ABS DataLab (2020)

Figure A.34 Cost break down relative to total expenses of medium Riverland grape farms from 2001/02- 2017/18



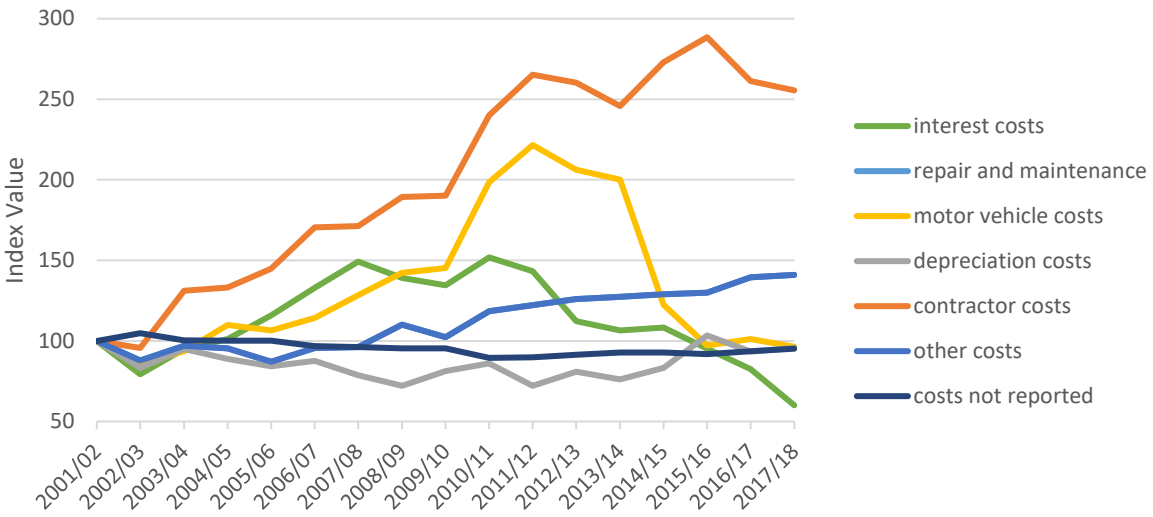
Note: Sum of costs not reported is a balancing item to align individual cost types with total expenses reported in the data.
Source: created from ABS DataLab (2020)

Figure A.35 Cost break down relative to total expenses of large Riverland grape farms from 2001/02- 2017/18



Note: Sum of costs not reported is a balancing item to align individual cost types with total expenses reported in the data.
Source: created from ABS DataLab (2020)

Figure A.36 Cost break down relative to total expenses of Riverland grape farms from 2001/02- 2017/18, indexed to 2001/02 levels



Note: costs not reported is a balancing item to align individual cost types with total expenses reported in the data.
Source: created from ABS DataLab (2020)

A.2 Appendix 2

Table A-1 Assumptions and data transformations for financial farm case studies

Assumption/data transformation	***Explanation***
Number of trims, sprays and herbicide applications	We used the mid-point of the range, if growers nominated ranges for these variables.
Income and land value ranges	We used the mid-point of the range, if growers nominated ranges for these variables.
Debt and cost ranges	We used the mid-point of the range, if growers nominated ranges for these items.
Whole of farm costings and water use.	Some growers run a mixed enterprise and grow crops other than wine grapes. They often found it difficult to separate out costings and water use for grape production only. In these cases, we attributed whole of business costings and water use to grape production by multiplying variables with the percentage of productive farm area planted to grapes. This was also confirmed with the respective growers as appropriate.
Farm financial documents	Some growers preferred to supply their financial statements and other documents rather than filling out the survey (profit and loss statements, water bills, etc). We allocated costs numbers to the survey cost categories based on grower feedback and researcher experience. For example, end of financial year documents may report "Wages & salaries", which the researchers split into permanent and casual labour.
Labour cost attribution	Some growers report salary and wage expenses without attributing them to casual and permanent work force. In confirmation with growers, we attribute wages corresponding to the fraction of casual and permanent employees or how the grower advises the split. Superannuation expenses are attributed at 9% of salary expenses
Pruning, tipping and harvesting costs	Growers were asked to nominate their pruning and tipping costs, as well as their harvesting costs. There were rarely specified cost items for these activities, in particular pruning and tipping expenses. In case pruning, tipping and harvesting were undertaken by contractors, "contract expenses" include costs for pruning, tipping and harvesting. If growers did not have specified cost positions, they were asked to estimate these costs. Growers tended to estimate a labour, fuel, and sometimes machinery component. For simplicity, we used the costs growers nominated for gross-margin and cost analysis, irrespective of the complications that broader cost categories, such as fuel, may include pruning, tipping and harvesting costs components for some growers, and not for others.
Cost percentages of total variable costs and costs per hectare/ML	We assess how many percent of all variable costs growers spend on different cost categories. To calculate these, we assess broad cost categories. Some growers may nominate dedicated pruning, tipping and harvesting costs, others may contract prune or harvest, others may have these costs as part of labour, fuel, and machinery costs. To avoid double counting, the costs of harvest, pruning and tipping are summarized in a broad category, such as "other variable costs". Therefore, there is an element of "fuzziness" around mainly fuel, labour, harvest, and pruning and tipping costs. Given this fuzziness is neutral on the assessment of gross-margins and variable costs in total, we

	deem it as inconsequential for our analysis.
Water drainage and delivery costs for private diverters	A number of growers are not member of an irrigation trust but pump from the river directly (private diverters). They do so either using electricity or diesel. Diesel and electricity costs associated with irrigation are listed under “fuel” or “electricity”. In these cases, water drainage and delivery costs are listed as $0 to avoid double counting of costs.
Water and solar income and cost	Some growers have installed solar capacity to run their irrigation. Some have water allocation trading income. Unless growers nominated electricity and or water trading costs specifically, and in case they have electricity and or water trading income, we treat these incomes as net and therefore list electricity and or water trading costs as $0.

A.3 Appendix 3

Table A-2 Table of descriptive stats

Variables	*Observations*	*Min*	*Max*	*Median*	*Standard deviation*
Farm income	546	0	250	25	58.90
Income per ha	541	0	247	1	11.99
Off-farm income (in %)	588	0	100	30	36.20
2015 dummy (1=yes)	593	0	1	1	0.50
Farm size (in ha)	593	0	6250	19	394.66
Low reliability entitlement ownership (in ML)	593	0	11700	0	722.61
High reliability entitlement ownership (in ML)	593	0	9604	126	660.02
Whole of farm plan (1=yes)	592	0	1	1	0.49
Application rate (in ML/ha)	586	0	5634	6	232.53
Certified organic (1=yes)	593	0	1	0	0.24
Number of full-time employees	592	0	60	1	4.17
Changed production in last five years (1=strongly decrease; 5= strongly increase)	593	1	5	3	1.25
Male (1=yes)	593	0	1	1	0.33
Age	590	24	84	57	10.67
Education more than year 12 (1=yes)	592	0	1	0	0.48
Debt-equity ratio	574	0	7	0	0.53
Grapes main crop (1=yes)	593	0	1	1	0.48
End of season allocation (in %)	593	62	100	97	17.68
Diversified production (1=yes)	593	0	1	0	0.42
Sold allocation previous season (1=yes)	593	0	1	0	0.46
Purchased allocation previous season (1=yes)	593	0	1	0	0.42
South Australia dummy (1=yes)	593	0	1	1	0.47

A.4 Appendix 4: Riverland Pilot Case Study Information

Given the short timelines and small budget, we chose a case study approach to confirm some current cash and operating costs incurred by three different sized farms in the Riverland: a small farm (<10ha); medium farm (11-80 ha) and a large farm (80+ha). Accounting returns ($/ha) over the past two years (2016-17 and 2018-19) were collected and averaged, and information from owners/managers on the potential for returns from different decision-making software was collected. In particular, information on costs of chemicals; fuel oil gas grease; electricity; harvesting/freight; labour hire costs; levies; machinery, plant and equipment repairs; nutrition/fertiliser; water and drainage costs; and water lease.

It is important to note that we are not suggesting that these farms are necessarily representative examples of viticultural production for the entire Riverland, and further research in this space will be needed in phase two of the project. However, they do represent a snapshot of the current situation, and along with the previous information collected, provide some idea of the current returns and costs; and where there may be benefits from the decision-making software.

A.4.1 Small Viticultural Farm Example <10ha

Our ***Small farm*** has a mix of red and white varieties and was first established in the Riverland in the early 1970s. The Small farm has made considerable investments in hard and soft technologies, including irrigation infrastructure, root stocks, new grape varieties and innovative management techniques (e.g. soil structure management and testing and fertilizer use), to address issues resulting from salinity, stony ground, soil impaction and increasing temperatures (climate change).

The ***Small farm*** can see benefits of new decision-making software for their farm in two key input areas: water and electricity use. There are a number of things that cameras and decision making software can improve related to under and overwatering issues: such as highlighting leaks, blowouts, lack of watering, fungus due to overwatering etc. Previous upgrading of water infrastructure (i.e. pump and filtration system) saved 25% in power costs, and allowed all watering to be completed at night. Given that electricity costs increased over 100% from 2017 to 2018, this was a significant saving. Additional savings on water allowed for an increase in the proceeds from leasing spare water from the farm (which represented 8.5% of gross net farm income in 2018). The percentage of various expenses in the small farm's total operating costs (an average of figures from 2016-17 and 2017-18 accounting returns) are shown in the table below. It highlights that labour, harvesting/freight, machinery repairs are the biggest expenses incurred.

Operating Expenses	*% of Total Operating costs*
chemicals	9
fuel oil gas grease	9
electricity	4
harvesting/freight	21
labour hire costs	35
levies	1
machinery, plant and equipment repairs	10
nutrition/fertiliser	4
water and drainage costs	7
water lease	0

A.4.2 Medium Viticultural Farm Example 11-80ha

Our Medium farm has 11 different grape varieties and also sells rootstock vine cuttings. Vines were first planted on the farm in the 1960s, and invested heavily in machinery (grape harvester) in the 1980s that, along with increased grape prices, helped clear the farm of debt and payout inheritance. Other investment in the 2000s included sheds, solar panels and irrigation drip infrastructure. Recent focus has been on improving soil health with compost and various fertiliser inputs, canopy management, becoming quality assured, buying the neighbour's property, adopting a variety of decision-making software and using the water market to buy and sell water allocations and entitlements for profit. Quality assurance has seen no reduction in quality, with increases in consistency and reliability.

It is estimated that the current decision-making software has saved considerable amounts of electricity, water and labour time. In particular, detecting water leaks much faster has improved yields (estimated at 2-4% reduced yield loss across property, for a gross revenue increase of between $10,000-$20,000), as well as the automatic detector for frost switching on watering and reducing potential damage. In addition, it was estimated that there was four hours of operator labour saving time a week, adding up to a month's time of labour over a year. Additional benefits are seen as possible in terms of predicting yield and downy mildew.

The percentage of various expenses in the medium farm's total operating costs (an average of figures from 2016-17 and 2017-18 accounting returns) are shown in the table below. It highlights that machinery repairs, harvesting/freight, water and drainage costs and electricity are the biggest expenses incurred.

Operating Expenses	*% of Total Operating costs*
chemicals	7
fuel oil gas grease	7
electricity	11
harvesting/freight	20
labour hire costs	7
levies	0
machinery, plant and equipment repairs	28
nutrition/fertiliser	4
water and drainage costs	15
water lease	0

A.4.3 Large Viticultural Farm Example 80+ha

Our Large farm in the Riverland has been established for decades, and has a number of red and white varieties. Considerable investment in viticultural technology has been incurred. The large farm does not see that investment in the decision-making software will lead to a decrease in costs at all, especially labour, as in their view those costs as fixed and non-changeable. They see two possible potential uses of the technology, namely 1) to allow more optimisation of inputs (especially fertiliser and water) to produce more consistency in yields from low vigour versus high vigour plants; and 2) allow better planning of truck deliveries from vineyard to winery to stop overloading issues (which have flow on implications for wine quality). The Large farm believes that a 10% increase in yield from improved optimisation is possible, which represents a potential increase (given current year yields and average prices received) of over $220,000 in gross revenue.

The percentage of current various expenses in the large farm's total operating costs are shown in the table below. It highlights that labour, water lease, machinery repairs, fuel/oil/gas & electricity are the biggest expenses incurred

Operating Expenses	***% of Total Operating costs***
chemicals	5
fuel oil gas grease	10
electricity	10
harvesting/freight	5
labour hire costs	30
levies	0
machinery, plant and equipment repairs	13
nutrition/fertiliser	6
water and drainage costs	1
water lease	20

Figure A.37 illustrates that overall labour, machinery repairs, harvesting/freight are the biggest expenses incurred by farms.

Figure A.37 Percentage of Operating Costs incurred by the Three Case Study Farms – $/ha averaged over 2016-17 and 2017-18

