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Microeconometric analysis of wine grape supply contracts in Australia*

Iain Fraser[†]

This paper examines wine grape supply contracts used in the main grape growing regions of Australia. An empirical analysis provides insight into specific aspects of contract design and implementation. Statistical analyses of sample data reveal differences between regions in contract specifications. Lower quality grape growing regions place a greater reliance on grape quality assessment to determine bonus/penalty payments compared to higher quality regions. Contracts in higher quality regions place greater emphasis on explicit winery involvement and direction in vineyard management. Results indicate that longer duration contracts are more inclusive in terms of the number of clauses included. Evidence of risk shifting (i.e., winery to grower) for high quality grapes is reported, where the price received by growers is determined by the bottle price of the wine produced.

Key words: contract design, supply contracts, wine grapes.

1. Introduction

There is a growing published economics literature, theoretical and empirical, examining various aspects of supply coordination in agriculture. In particular, there has been considerable interest in the role of contracts in USA and European agriculture (e.g., Sheldon 1996; Hueth *et al.* 1999; Hueth and Ligon 1999; Goodhue 2000; Bogetoft and Olesen 2002). However, the use of contracts is by no means a new phenomenon in coordinating agricultural supply. For example, lettuce has been grown almost entirely under contract since the 1930s in California (Jones 1951). The reason for this recent increase in research stems from developments in the published theoretical and econometrics literatures.

Despite the growth of research into contracts in the USA and Europe there is currently very little research in Australia that has considered the design and implementation of contracts in agriculture. Indeed, what little research there has been has

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† Iain Fraser (email: i.fraser@imperial.ac.uk), Applied Economics and Business Management Section, Department of Agricultural Science, Imperial College at Wye, Wye, Kent, UK.

frequently had a rural sociology perspective. For example, Burch *et al.* (1996) contains a number of interesting rural sociology case studies that examine contract farming in Australia. Other researchers who have examined supply coordination and the role of contracts include, Haughton and Browett (1995) and Pritchard (1999a,b). In the published economics literature in Australia, much of the analysis of supply coordination has been interested in issues of market power (e.g., Griffith 2000; Digal and Ahmadi-Esfahani 2002) as opposed to the design and implementation of contracts.

The lack of published literature is somewhat surprising given the fact that contracts are used to coordinate many aspects of primary production supply in Australia. Furthermore, as traditional forms of commodity marketing change, it is likely that contracting will become more important. This evolution of commodity marketing in Australian agriculture (i.e., the increased role of contracting) has been identified by the Department of Agriculture, Fisheries and Forestry, Australia (AFFA 2002). In a submission to the Review of the Trade Practices Act, AFFA noted that primary producers will, in the future, rely less on conventional price discovery mechanisms and more on exclusive supply agreements (i.e., contractual arrangements).¹

One particular rural industry that has recently attracted much attention with regard to the role and importance of contracts is wine grape supply. This heightened interest has arisen for several reasons. First, since the beginning of the 1990s there has been widespread adoption of long-term wine grape supply contracts (Scales *et al.* 1995; Taylor 2000). Also, 75 per cent of wine grapes used by Australian wineries are sourced from non-winery vineyards (AWBC 2001). As a result, independent grape growers are a crucial component of the Australian wine industry.² The adoption of contracts to coordinate the supply of grapes to make wine is a rational response to difficulties encountered in the use of spot markets. For example, wine grapes are a perishable product requiring a great deal of effort to coordinate supply between grower and winery at harvest time. A contract that guarantees grape supply in a timely manner introduces certainty into production, allows allocation of resources with greater confidence, and reduces the costs associated with locating grapes to be used in the production of wine. The need to secure grape supply from a particular grower may also be important in terms of maintaining wine quality and, in turn, building brand reputation.

Second, wine grapes are now in excess supply in Australia. This has occurred at the same time as wineries have increased their requirements for grape quality (Anderson 2001; Standford 2000). The continued drive to increase the volume of wine exports has produced a desire on the part of wine makers to improve the quality of their wine and, as a result, the quality of the grapes they use. This has led to pressure being applied

¹ The Department of Agriculture, Fisheries and Forestry, Australia (AFFA) submission and many others are available at the review website (AFFA 2002).

² Although independent grape growers in Australia are important, there is significant regional variation. This highlights an important aspect of industrial organisation within this industry that warrants further research. What is it that determines the make-buy decisions on the part of a winery? Scales *et al.* (1995) argue that this choice is based on the quality of grapes demanded by wineries. High quality grapes are more likely to be sourced from within the winery. However, this remains an open question. As Swann (2002) notes, in the USA many larger companies are moving towards a larger dependence of grapes grown in their own vineyards and only having contracts for premium grapes.

to growers to improve grape quality or face the possibility of having grapes rejected or contracts terminated by wineries.

The purpose of the present paper is to examine contract structure and content in the wine grape supply industry. We analyse data from a survey of independent grape growers in the main grape growing regions of Australia. In particular, we examine the various means by which a winery might try and influence the behaviour of a grower. The present paper adds to a growing list of studies of contracts in agriculture.³ Many of these studies have focused on the poultry and hog sectors (e.g., Kleibenstein and Lawrence 1995; Knoeber and Thurman 1995; Gillespie and Eidman 1998; Hennessey and Lawrence 1999; Silke 2001; Tsoulouhas and Vukina 1999, 2001). There are also a growing number of studies that examine contract use in fruit and vegetable production. For example, Hueth and Ligon (1999) develop a model of contracting that takes account of informational asymmetries. This model is then applied to actual contracts used to coordinate the supply of tomatoes in California. Hueth and Ligon find that the theoretical solution to the contracting problem is very similar to the real world solution for the commodity they examine.

The most relevant research for the present paper is Goodhue *et al.* (2004) who examine wine grape supply contracts in California. They examine three aspects of the contractual relationship between grower and winery: the pattern of contract use; specific production practice provisions; and bonus/penalty price incentives. We examine these aspects of the grower–winery relationship, as well as: other contract clauses; price determination; visits to the vineyard by winery representatives; and the implicit involvement of the winery in various grape-growing activities.⁴

The aim of the current analysis is to identify differences in contract design that result from grower-specific characteristics and regional differences. However, we are not able to explicitly test propositions of contract theory or the optimality of the contracts currently in use. For example, there are several reasons why colour testing of grapes might be included in a contract. As Goodhue (1999) explains, moral hazard and profit maximisation arguments can be used to justify why certain contracts might explicitly control the choice of various inputs used by a grower. We would then expect compensation to growers to vary more than under profit maximisation. Unfortunately, to assess what is meant by ‘more’ requires a richer data set than that used in the present paper. However, it is clear from the published wine industry technical literature and comments from survey participants that informational asymmetries exist and that they do have a bearing on contract design. For this reason, we interpret many of our empirical findings as support for theoretical propositions in the published contract literature.

The structure of the present paper is as follows. In Section 2 we begin by describing the role of contracts to coordinate supply in agriculture. We then consider what might

³ There also exists a general literature that empirically examines contracting. See for example Masten (1996).

⁴ Swann (2002) indicates that there are very strong similarities between contracting practices in California and Australia that makes the comparison of results with Goodhue *et al.* (2004) interesting and meaningful.

be included in a contract following economic theory. Based on this we identify a number of relationships to be estimated. In Section 3 we describe the data and methods of estimation employed. In Section 4 we present our results. Finally, we provide a summary and offer conclusions in Section 5.

2. Contracts and commodity supply

2.1 Contract design

Contract design is a multi-criterion decision problem. Bogetoft and Olesen (2002) identify three main objectives. First, a contract aims to coordinate the business relationship. In the case of wine grapes coordination is the primary reason for adopting a contract as grapes are perishable and there is a need to synchronise harvesting with processing. Second, a contract can be used to motivate behaviour and performance. Third, a contract can often minimise the transaction costs associated with doing business.

In practice, contracts vary significantly, in terms of style, content and purpose, to cope with the complexity of the real world. For example, a contract can be informal (i.e., oral/handshake) or formal (i.e., written). With informal contracts the agreed norms of coordination can take the form of implicit conventions established by repeated interaction. Even formal contracts are incomplete. Many facets of the business relationship may be left unstated and implicit between grower and buyer. With either type of contract implicit conventions are important. As Crocker and Masten (1991) explain, contracts rarely exhibit the neat properties assumed in the published theory literature. First, the incomplete nature of contracts means that courts may be called upon to enforce a contract.⁵ Second, there are potential hold-up problems, where one party to the contract undertakes activities at the formation stage of the contract to force disadvantageous terms on the other.⁶ Third, many contracts leave specific terms and duties open to future determination. This implies that contract implementation is not a one-shot game but, rather, an ongoing process of negotiation.

Contract design also needs to deal with problems of adverse selection and moral hazard. Adverse selection is where one party to the transaction is better informed than the other about characteristics of what is being exchanged and is not verifiable after the contract has concluded (*ex ante* contract issue). Moral hazard means that one party has imperfect information concerning action or actions that the other party takes during the implementation of the contract (*ex post* contract issue).

To minimise informational problems a contract will contain a number of elements that have been examined at length in the general theoretical literature (see Tirole 1990 as an example). From an agricultural economics perspective, Hueth *et al.* (1999) identify

⁵ In Australia the Federal Government's preference is for disputes to be settled through mediation as opposed to litigation. The Retail Grocery Industry Ombudsman is available for mediating disputes between growers and wineries.

⁶ There have been several examples in Australia of wineries altering or attempting to alter contractual arrangements in their favour as a means to receive rents from growers. See Fraser (2003) for details.

four ways in which a principal (i.e., the winery) can attempt to minimise the effects of asymmetric information by influencing the behaviour of an agent (i.e., a grower):

1. A winery can measure various aspects of grape quality. Quality measurement can be used to determine the incentives provided to growers. For example, bonus and penalty payments are frequently determined on measures of Baume/Brix as well as grape colour.⁷
2. A winery can exert varying degrees of direct control over vineyard infrastructure and activities. For example, the form of rootstock or the choice of irrigation technology employed, or the timing of irrigation.
3. A winery can make payment for grapes contingent on the price of wine received. The technology to allow a winery to monitor grapes from the vine to bottle (i.e., batch specific production) is improving significantly at present.
4. A winery can monitor grower effort by visiting and inspecting the vineyard during the grape-growing season. Visits might be used to share information about vineyard management, crop development or coordination of harvest activities.

Another factor complicating contract design is risk. The incentives employed in a contract will reflect a trade-off between the extent that the winery is willing to insure the grower against various forms of risk and the need to provide incentives to induce the grower to exert the necessary level of effort to produce grapes of a desired quality. Growers typically face several sources of risk: biological, price and institutional. As such, it is normal to assume that the grower is risk averse. As a result, a grower will be willing to accept a certain payment; that is, a flat fee. However, as the effort exerted by a grower may not be perfectly and costlessly observable by the winery the grower may be able to 'shirk'. That is, the grower can claim a level of payment for the grapes produced which is greater than warranted by the degree of effort employed and the quality of the grapes produced. This means that the winery needs to offer incentives that compensate for risk as the grower will bear no more risk than they are compensated for. To address this problem in practice contracts will frequently contain a flat fee (the risk-sharing component) plus various performance incentives (bonuses and penalties for quality).⁸

There may also be downstream price risk. For example, the price received by a winery for wine produced from grapes is subject to market uncertainty and is exogenous to the grower–winery relationship. If a winery is risk neutral then this need not be an issue for the grower. The winery will be happy to absorb the risk and, as such, the downstream price risk does not impact on contract design. If the winery is risk averse then the contract may well be designed in such a way that part of the risk is passed back to grower. It may mean that the price paid for grapes will include an element reflecting the bottle price of the wine produced, a practice referred to as residual claimancy in the published

⁷ Brix/Baume is a measure of the sugar content of grapes and the potential alcohol yield after fermentation.

⁸ Bonus/penalty payments are, in general, conditioned on grape quality achieved. In the present paper we do not consider issues of imperfect quality assessment. Recent papers that have dealt with issues of imperfect quality assessment in horticulture are Chalfant *et al.* (1999) and Chalfant and Sexton (2002).

economics literature (Tirole 1990). However, the use of residual claimancy can also be employed by a risk-neutral winery as an efficient response to moral hazard.⁹

2.2 Determining the mix of coordination instruments

Hueth *et al.* (1999) argue that there are four sets of variables that influence the mix of coordination instruments observed in agricultural contracts.

1. The most important variable in determining the mix of coordination instruments will be the commodity itself. Specific commodity attributes influence how contracts will be designed and implemented. For example, grape quality is an important component in many contracts because it is tied to bonus/penalty payments. Brix/Baume have traditionally been used to grade fruit quality; although there is frequently a low correlation with this measure and wine quality (Swinburn 2001). Colour is now being used to assess red grapes and there is evidence to support a positive correlation with grape quality (Dambergs *et al.* 2000). However, even this measure of quality is relatively crude as it does not offer any indication of potential wine complexity. As Vagnarelli (2000) notes, 'I would suggest that a colour test is a legitimate way of determining that fruit is good enough or not, for bottle quality.' (p. 32).
2. Local history and institutional structures influence contract design and implementation. For example, grape supply in the Murrumbidgee Irrigation Area of New South Wales (NSW) was in 1933 controlled by the Wine Grapes Marketing Board. The Board was established to operate a statutory marketing authority so as to: 'provide farmers with a means of countervailing the market power of the purchasers of their product' (NSW 2000, p. 7). In 1994 the Board changed its operational mode such that growers could unilaterally enter into contracts to supply grapes to wineries. This change in institutional arrangements altered supply coordination. However, the cultural practices that existed under the marketing board have meant that the adoption of contracts in this region is significantly below that observed elsewhere in Australia (Pritchard 1999a,b; Fraser 2002).
3. Government legislation can impinge on contract design and implementation. Like many other agricultural industries, grape production and marketing were subject to various pieces of State government legislation.¹⁰ For example, until the late 1980s the supply of wine grapes was subject to minimum pricing arrangements.¹¹ However, minimum pricing has now been replaced by indicative pricing. In South Australia the 1991 South Australian Winegrape Industry Act replaced legislated minimum pricing with an indicative pricing structure. Prices are announced in November and December in 1996 in the Riverland and in 1997 in the rest of South

⁹ This issue is further complicated by what is referred to as the Alchian-Demsetz-type team problem (Tirole 1990). By the time the grapes are converted into wine and bottled the wine may well include grapes from many growers. As a result it may be hard, if not impossible, to measure the performance of an individual grower.

¹⁰ KPMG (1999) provides a detailed outline of price support arrangements in the Victorian and New South Wales (NSW) wine industries.

¹¹ The economic implications of this policy have been examined by O'Mara (1981) and Alston and Smith (1983).

Australia indicative prices were quoted by district, variety and Brix/Baume level. The advent of indicative Brix/Baume levels can be considered as the beginning of price determination based on quality. However, the market for wine grapes in Australia can now be considered unregulated.¹²

4. Technology can impact on contract design. For example, with improved grape quality measurement a winery may be able to reduce monitoring of vineyard practices and rely more on grape quality-based payments. It is very likely that there will be further increases in the use of technology to determine the price of grapes in Australia and that this will manifest itself in the design and implementation of contracts.

2.3 Contract design and empirical analysis

We now outline the various aspects of wine grape contract design and implementation that we empirically examine. As indicated in Section 1, the empirical analysis we undertake in the present paper encompasses aspects of the research by Goodhue *et al.* (2004). However, the structure and focus of the empirical analysis is provided by the four methods identified by Hueth *et al.* (1999) that a winery might attempt to use a contract to influence the behaviour of a grower. In all of the relationships we examine we consider several grower-specific characteristics as well as a regional measure of quality. Our set of explanatory variables allows us to consider various explanations for the differences we identify in contract design and implementation.

We begin by considering whether the proportion of written wine grape contracts (as opposed to oral/handshake arrangements) varies by region or various farm characteristics. The analysis then focuses exclusively on written contracts. We assess the four methods identified by Hueth *et al.* (1999) to manipulate behaviour typically included within a written contract. First we examine whether price incentives (i.e., bonus/penalty payments) are likely to vary by region or farm characteristics. Second, we consider whether winery involvement in viticultural practice and contract content varies by region or farm characteristics. Third, we analyse variations in the basis of contract payments by region and farm characteristics. Finally, we examine whether winery interaction with growers varies by region or farm characteristics. This final part of the analysis is split into two parts. First, we examine the number of visits made to the vineyard by winery representatives. Second, we consider the degree of involvement by the winery in key viticultural decisions.

3. Survey and data

3.1 Survey

During October and November 2001 a survey was conducted to examine the contractual relationships between independent wine grape growers and wineries. The survey

¹² The Winegrape Growers' Council of Australia currently runs the annual National Winegrape Outlook Conference. The conference provides information that can form the basis of negotiations between growers and wineries on establishing indicative prices for grapes by variety and region.

Table 1 Distribution of survey returns by region/state

State/region	Survey returns		Grape crush 2001 (non-winery vineyards) [†]	
	Number returns	Per cent in survey	Per cent state	Per cent Australia
Riverland	169	32	58	27
McLaren Vale	111	21	9	4.2
Barossa	45	9	9	4.3
Eden Valley	16	3	1	0.5
Other South Australia	31	6	23	10
South Australia (total)	372	71	100	46
Murray Valley	72	13	88	29
Victorian Alps	20	4	4	1.4
Central Victoria	9	2	3	1
Yarra Valley	21	4	3	1
Other Victoria	3	1	2	0.6
Victoria (total)	125	24	100	33
Riverina	23	4	75	13
Other NSW	7	1	25	4.3
New South Wales (total)	30	5	100	17.3
Australia	527	100		

[†]Source: AWBC 2001. The 'Per cent Australia' adds to less than 100 because the figures exclude Western Australia, Tasmania and Queensland.

was based on a questionnaire sent out to 2 250 grape growers. The survey was a single mail shot survey. The questionnaire was designed to be simple to complete.¹³

The process of identifying the sample of growers to be contacted was not straightforward. In Australia there is no database that contains the names and addresses of independent grape growers. For this reason, two indirect approaches to the distribution of the questionnaire had to be employed. First, a large number of grape grower associations across Australia were contacted to ask if they would be willing to help distribute questionnaires. Some grower groups responded very enthusiastically, but many did not respond at all. Of those grower associations that responded positively, most did not want to provide direct access to the names and addresses contained on their distribution lists. Therefore, they distributed the questionnaires for us, either in conjunction with a newsletter or by post. Second, in South Australia, the Phylloxera and Grape Industry Board of South Australia (PGIBSA) has a centrally administered database that contains the names and addresses of all grape growers with over half a hectare of grapes. The PGIBSA helped with the distribution of the questionnaire in South Australia in return for a small administrative fee. By providing basic descriptive statistics for all grapes grown in South Australia, it was possible to stratify the distribution to an appropriate mix of growers.

In total, 569 returns were returned by growers and of these 527 were useable. A State and regional breakdown of questionnaires returned is presented in Table 1.

¹³ A copy of the survey instrument is available on request from the author.

Table 1 shows that 372 (71 per cent) of returns came from South Australia, 125 (24 per cent) from Victoria and 30 (5 per cent) from NSW. To gauge the representativeness of the distribution of surveys returned, we compare the percentage from a given region with the corresponding importance of that region in terms of the national grape crush for 2001 from non-winery vineyards. From Table 1 we see that the number of returns from some regions is very small (e.g., other Victoria and other NSW). The number of returns from other regions (e.g., McLaren Vale) is greater than the importance of these same regions in national grape production. In terms of the mix of regions covered by the survey we seem to have a reasonably representative sample. The main bulk grape growing regions (Riverland, Sunraysia and Riverina) and most of the main high-quality grape growing regions are represented. This mix of regions is important if we are to examine if there are any regional differences between contract design and implementation. In general, we view the survey as providing reasonable coverage of the key grape growing regions in Australia.

3.2 Data

The survey yielded a large amount of data on grower characteristics, contract type and duration, contract content, pricing arrangements, viticultural practice and winery-grower interactions. Grower characteristics are used in all empirical models to examine the various facets of contract design. The set of farm characteristics employed in the present paper is greater than those used by Goodhue *et al.* (2004). For this reason we expect that there will be several differences in the results reported. Furthermore, as previously noted, we examine several contract issues not considered by Goodhue *et al.* Descriptions and sample means of the explanatory and dependent variables used in the analysis are provided in Table 2.

Most of the variables described in Table 2 are relatively straightforward. However, a few require some further explanation. First, like Goodhue *et al.* (2004), one piece of information we did not ask growers for directly was the price they were paid for the grapes they supplied under contract. The industry sources who provided input into the design, validation and distribution of the survey indicated that it was unlikely that growers would provide this information. The approach employed to introduce regional price into the analysis is to take prices for the regions published in the various wine utilisation surveys. The published prices are average district prices by variety. This means that we attribute an average regional price to all growers in a particular region. Although this means that we do not capture an important aspect of the grower-winery relationship, the prices used do provide a means by which to characterise regions in terms of grape quality. Fraser (2002) explains that opinion in the wine industry is such that between-region price differences are greater than within-region price differences, reflecting industry views that vineyard location is the most important determinant of grape quality.

The need to construct a regional price variable did, however, reduce the number of regions we could include in the analysis. For 'other Victoria' and 'other NSW' the returns came from a very wide geographical spread of areas and as such it was impossible to generate a meaningful regional price. In the case of 'other South Australia',

Table 2 Variable descriptions and samples means

Variable	Unit	Description	Sample means
Explanatory variables			
Vineyard Size	Hectares	Area of holding devoted to contract grape growing	20.5
Experience	Years	Number of years growing grapes	17.2
Use consultants	Binary	If consultants used to help with vineyard management = 1, zero otherwise	0.39-1
Want to make wine	Binary	If wish to make or are making some wine = 1, zero otherwise	0.61-0
Years with winery	Years	Number of years dealing with current winery	0.76-0
Contract history	Binary	If always used a contract to coordinate the supply of grapes = 1, zero otherwise	10.9
Educational qualifications	Ordinal	0 if no educational qualifications, 1 if TAFE course,	0.65-1
	Scale	2 Certificate or Diploma, 3 Degree or higher	0.35-0
Contract duration	Years	Number of years of current contract	0 = 0.79, 1 = 0.11,
Regional price	\$A per tonne	Weighted average by regional yield of the four red and four white main grape varieties.	2 = 0.04, 3 = 0.06
Dependent variables			
Contract type	Binary	If written contract used = 1, zero for oral handshake	6.9
Bonus/penalty payment for Brix	Binary	If bonus/penalty payment clause for Brix is included in contract = 1, zero if no clause	NA

Table 2 continued

Variable	Unit	Description	Sample means
Bonus/penalty payment for colour	Binary	If bonus/penalty payment clause for colour is included in contract = 1, zero if no clause	0.46-1
Viticultural practice specified	Binary	If clause pertaining to need to follow best viticultural practice in the region is in contract = 1, zero if no clause	0.54-0
Chemical use specified	Binary	If clause stating that winery must see chemical records before grapes are purchased is in contract = 1, zero if no clause	0.42-1
Block location specified	Binary	If clause specifying block of land from which grapes will be delivered is in contract = 1, zero if no clause	0.58-0
Yield specified	Binary	If clause specifying exact yield to be delivered to the winery is in contract = 1, zero if no clause	0.88-1
Price for grapes	Category	If price for grapes is determined on quality achieved at harvest $Y = 0$, price paid on quality of wine achieved $Y = 1$, price paid on a combination $Y = 2$	0.12-0
Visits to the vineyard by winery	Ordinal Scale	Number of visits per growing season to the vineyard by a winery representative. 0-5 visits $Y = 0$, 6-10 visits $Y = 1$, and more than 10 visits $Y = 2$	0.8-1
Winery	Ordinal	Grower perception of winery involvement with key viticultural activities: pruning, water use and irrigation and fertilizer use.	0.2-0
Involvement with vineyard activities	Scale	0 no involvement, 4 high involvement	0.41-1
		NA, not applicable.	0.59-0
		Pruning: 0.7	0.64-0
		Water/Irrigation: 0.9	0.17-1
		Fertiliser: 0.9	0.19-2

two regions (Langhorne Creek and Limestone Coast) made up the bulk of the returns. Although geographically separate, these regions are sufficiently similar to allow us to combine their returns and to generate a regional price. As a result of these modifications the data set used in the analysis includes 517 observations.

Second, the dependent variable 'viticultural practice specified' refers to a clause used in contracts to avoid the need to provide a prescriptive description of vineyard management. This clause allows a winery to make reference to best industry practice within a region with the expectation that a grower will operate a vineyard in the same or similar manner. Clearly, this sort of clause is open to interpretation. However, there exists a Code of Good Manufacturing Practice for the Australian Grape and Wine Industry (AWRI 1999) that acknowledges that clauses in contracts that require a grower to implement best viticultural practice are vague and, as a result, can be the source of disputes. The Australian Wine Research Institute claim that the Code, if followed, reduces likely reasons for disputes to arise. Third, a 'chemical use specified' clause is frequently included in a contract because of government legislation relating to limits on chemical residues (i.e., fungicide, insecticide or herbicide) found in food. This is particularly important for growers whose grapes are used to make wine that is exported. There is a published list of agrochemicals available for use in agriculture (AWRI 2001).

Third, like Goodhue *et al.* (2004), we employ contract duration as an independent variable. We acknowledge that this variable might be potentially endogenous within the specifications estimated here. However, we would argue that the decisions regarding contract duration are made before contract content. As a result, our results are conditional on the maintained hypothesis that right-hand-side variables are exogenous relative to left-hand-side variables for all specifications.¹⁴

4. Results

Given the nature of data collected and the various relationships to be examined we estimate several discrete dependent variable models: logit, multinomial logit and ordered logit. All models are estimated using LIMDEP (Greene 2000).

4.1 Contract type

We begin by presenting results that examine the choice of contract type; that is, whether a grower has a written or oral/handshake contract to coordinate the supply of grapes. From the data we know that 85 per cent of growers have a written contract and 15 per cent have an oral/handshake contract. Estimated coefficients of logit models of contract type are presented in Table 3.

The majority of the explanatory variables are statistically significant. The results indicate that vineyard size, experience as a grape grower, the use of consultants,

¹⁴ We did try to identify an exogenous instrument, but were unable to find any statistically meaningful variables. We also found that our results were robust to alternative model specifications that excluded contract duration. Any significant sign change or substantial change in parameter magnitude would have raised more concerns regarding possible endogeneity.

Table 3 Estimated logit coefficients: contract type

Explanatory variables	Contract type	
	Y = 1: written; Y = 0: Handshake/oral	Estimate
		p-value
Constant	-0.014	0.712
Regional price (\$A)	-0.00004	0.142
Vineyard size (hectares)	0.0031	0.000***
Experience (years)	0.0024	0.036**
Use consultants (yes/no)	0.037	0.069*
Want to make wine (yes/no)	-0.066	0.057*
Years with winery (years)	0.002	0.184
Contract History (yes/no)	0.206	0.000***
Educational qualifications	0.126	0.000***
Qualifications/experience	-0.009	0.000***
Log likelihood	-161.5	
McFadden R^2	0.25	
Sample size	517	

*Significant at 10 per cent level, **significant at 5 per cent level, ***significant at 1 per cent level.

contract history,¹⁵ and educational qualifications are positively related to having a written contract. The desire to make wine from own grapes and the interaction of education and experience are negatively related to having a written contract.

The negative relationship (albeit statistically insignificant) between regional price and having a written contract indicates that growers in lower quality grape growing regions are more likely to have a contract. This finding is also consistent with the negative relationship between making wine and having a written contract. We would expect that growers who wish to make wine do not want to lock themselves into a long-term formal contract that will impinge on their choice to make wine.¹⁶ Also, the lower quality grape growing regions (i.e., Riverland, Sunraysia and Riverina) can be thought of as being 'factory' growing areas. In these regions growing grapes is the major farming objective; there is very little, if any, interest in making own-wine (Pritchard 1999a,b). For this reason we would expect *a priori* high use of written contracts to coordinate the supply of grapes.

The negative result for the interaction term between educational qualifications and experience needs to be interpreted carefully with respect to the probability of having a written contract. It is necessary to derive the marginal effect by combining the direct and indirect effects (through the interaction term) at a given level (i.e., mean/mode) of the data. The interaction effect indicates that the marginal effect of education and experience is less for older growers. This is, perhaps, not a surprising result. What it possibly indicates is that older growers have had time to learn how to grow grapes.

¹⁵ The importance of this result is that once a contract is used then it appears that a contract will always be used: this could be noted in terms of the potential use of other risk tools, such as futures, mentioned by Taylor (2000).

¹⁶ This finding is consistent with written comments that accompanied some survey returns.

Newer entrants into the industry do not have the freedom of more experienced growers; they must be able to produce grapes of the demanded quality immediately and this requirement has been further emphasised during the current period of excess grape supply. The educational attainment of new growers can also be taken as a signal, along with the investment in a vineyard, that they intend to grow grapes as a serious business venture. The positive relationship between having a qualification and having a written contract also indicates that wineries will reward educational investment.¹⁷

Goodhue *et al.* (2004) also estimated a logit regression for the choice between written versus oral contracts. They found that experience and vineyard size were positively related to having a written contract. However, unlike the results reported here, they found that regional price was statistically positively related to having a contract. Our results provide marginal evidence to support the conjecture that the industry is sufficiently 'industrial' and that the proportion of growers who use a written contract compared to an oral/handshake contract does not vary by region or grower characteristics. Goodhue *et al.* also found that growers who have a longer relationship with a winery are more likely to have a contract. We found some evidence of this but, in our case, the result was not statistically significant.

4.2 Contract content

From this point onward in the analysis we only consider written contracts, dropping the oral/handshake contracts from the sample. As a result, our sample now contains 441 observations. In addition, we include contract duration as an explanatory variable. As we shall see, contract duration is an important explanatory variable.

We examine three specific aspects of contract content: bonus/penalty payments, viticultural management and other contract content.¹⁸ Coefficient estimates are presented in Table 4.

We first consider Brix/Baume and colour as measures upon which bonus/penalty payments are made. In the case of Brix/Baume we find that the only statistically significant variable is regional price. There is a negative relationship here indicating that measures of Brix/Baume are more likely to be included in a contract in lower quality grape growing regions. When we examine colour we again find a negative relationship for regional price. If we restrict attention to positive significant explanatory variables only, we find that contract duration is positively related, as is the level of educational qualification. The negative coefficient on regional price for colour is not surprising given recent events in the Australian wine industry: there have been significant moves

¹⁷ Various joint and squared terms were used in an attempt to improve the fit of the estimated relationships, and the coefficients of these terms were tested using a log-likelihood ratio test. However, the only term that significantly affected the results was the joint education–experience term. This term was dropped from the relationships reported later in the present paper because in those relationships it did not provide additional explanatory power.

¹⁸ Table 4 presents results for six regressions. We only report those regressions that are statistically robust. For example, in the case of bonus/penalty payments we also considered measures of pH, disease damage, physical damage and 'matter other than grapes', which are used by wineries to determine bonus/penalty payments. For these alternatives we obtained weak statistical evidence and so they are not reported here.

Table 4 Estimated logit coefficients: contract content

Explanatory Variables	Dependent variables			
	Bonus/penalty payments		Viticultural management	
	Y = 1: Brix specified	Y = 1: colour specified	Y = 1: Viticultural Practice Specified	Y = 1: chemical use specified
Y = 0: Brix not specified	Y = 0: colour not specified	Y = 0: Viticultural practice not specified	Y = 0: chemical use not specified	Y = 0: chemical use not specified
Constant	0.287***	0.239*	-0.336*	0.126**
Contract duration	0.0036	0.034***	0.011**	0.007**
Regional price (\$A)	-0.0001***	-0.0006***	0.0001*	-0.00007**
Vineyard size (hectares)	0.001	-0.0004	-0.000002	0.0001*
Experience (years)	-0.001	0.0005	0.003	-0.0004
Use consultants (yes/no)	0.011	-0.069	0.109**	0.004
Want to make wine (yes/no)	0.024	-0.034	-0.043	-0.067*
Years with winery (years)	-0.00003	0.005	-0.005*	0.004**
Contract history (yes/no)	0.002	0.052	-0.004	0.003
Educational qualifications	0.006	0.066*	0.029	0.007
Log likelihood	-161.3	-243.7	-294.9	-127.8
McFadden R^2	0.04	0.21	0.03	0.12
Sample size	441	441	441	441

* Significant at 10 per cent level, ** significant at 5 per cent level, *** significant at 1 per cent level.

by wineries to introduce colour testing of red grapes in the bulk grape growing regions.¹⁹ These results are consistent with those presented by Goodhue *et al.* (2004).

Next we consider viticultural management. We see that a clause in a contract relating to viticultural practice is positively related to regional price, contract duration and the use of consultants, but negatively related to years with the winery. The implication of our findings is that when entering into a contract, a strategy to reduce problems associated with making a long-term contract too specific or prescriptive is to include a clause that links current viticultural practice with best-practice in the local grape growing region. In this way, as regional practice evolves and improves, a grower needs to adapt, and this can be achieved without clauses that stipulate specific viticultural practices that must be adhered to. The positive relationship with regional price indicates that wineries take more interest in viticultural practice for grapes of a higher quality. A positive relationship between regional price and viticultural practice was also found by Goodhue *et al.* (2004). The use of consultants can be explained by the need for growers to satisfy the viticultural practice requirements.

The negative relationship between viticultural practice and years with the winery would suggest that once trust/understanding is established between both parties over time, this negates the need to have a formal clause in a contract stipulating viticultural practice. The importance of trust to the grower–winery relationship has been highlighted by a number of researchers. Of maybe most significance are the comments of Taylor (1996), a lawyer, in a paper explaining the need to have a properly designed contract. Despite the importance he attaches to the written contract, he concludes that a written contract is not 'a replacement for a relationship of trust between producer and grower or producer and distributor' (p. 170). It should be noted that our negative finding for years with the winery conflicts with that of Goodhue *et al.* (2004).

The second aspect of viticultural management we consider is whether or not a winery requires details of chemical use before fruit is accepted. Here we find a positive relationship between contract duration, vineyard size and years with the winery; but a negative relationship between regional price, and whether a grower wants to make wine. These results indicate that grapes supplied from lower quality regions are more likely to have the chemical use clause in their contract. The reason for this result is likely to do with the fact that it is the grapes grown in the lower quality regions that are used to make wine that is exported. As previously noted, wine exporters need to take account of potential chemical residues resulting from chemical applications to the grapes. However, grapes from the high quality regions are used to produce wine sold in the domestic market where there are less stringent requirements in relation to chemical use. Interestingly, Goodhue *et al.* (2004) report weak statistical results for chemical use and this might be explained by differences in prevailing legal requirements governing chemical use.

Finally, we consider other aspects of contract content. First, we consider if a contract includes a clause detailing block location. In this case we find that only contract duration is statistically positively related to the inclusion of this clause. Next, we consider

¹⁹ Fraser (2003) examines in detail current issues of colour testing in relation to contracts in the Australian wine industry.

if a contract includes a clause relating to expected yield per hectare. Again we find that there is a positive relationship with contract duration but also a negative relationship with the desire to make wine.

Although the two sets of regression results that relate to contract content are relatively weak, they do indicate that longer duration contracts tend to be more inclusive in terms of the number and specificity of clauses. It may well be the case that this result captures the fact that when entering into a long-term contract, it is in the interests of both parties to design the contract to be as complete as possible.

4.3 Price determination

The next set of regression results we consider is for price determination. We noted in Section 2 that a winery faces price uncertainty for the wine it sells. As a result they may wish to pass some of the uncertainty back to the grower (i.e., residual claimancy). The purpose of this part of the analysis is to see if there is any evidence of residual claimancy and if there are any regional differences in grape price determination. Evidence of residual claimancy may indicate that wineries are acting in a risk-averse manner; although, as previously noted, residual claimancy can be an efficient response to the existence of moral hazard.

Unlike the previous relationships estimated, this time the dependent variable has more than two possible outcomes; that is, price paid on quality of harvested fruit, price paid on quality of wine and a combination of the two. In this case we employed a multinomial logit specification to estimate the relationship between form of price determination and grower characteristics. Coefficient estimates are presented in Table 5.

First, we find a statistically significant negative estimate with regard to regional price paid based on grape quality at harvest. This implies that price based on grape quality assessment at harvest is more likely in lower quality regions. In addition, there is a positive relationship for duration of contract.

Table 5 Estimated multinomial logit coefficients: price incentives

Explanatory variables	Probability (Y = 0): price paid on quality achieved at harvest	Probability (Y = 1): price paid on quality of wine	Probability (Y = 2): price paid on combination
Constant	0.666***	-0.2**	-0.47***
Contract duration	0.01*	-0.008*	-0.002
Regional price (\$A)	-0.0004***	0.0002**	0.0002***
Vineyard size (hectares)	-0.0002	0.00005	0.0002
Experience (years)	0.0034	-0.005**	0.002
Use consultants (yes/no)	-0.009	-0.02	0.03
Want to make wine (yes/no)	-0.013	0.044	-0.03
Years with winery (years)	-0.006**	0.005**	0.0005
Contract history (yes/no)	-0.032	-0.04	0.07
Educational qualifications	0.04	-0.02	-0.02
Log likelihood	-352.5		
Sample size	441		

*Significant at 10 per cent level, **significant at 5 per cent level, ***significant at 1 per cent level.

When we consider grape price determined on the bottle price of wine we find a positive relationship with regional price as well as years with the winery. These two results indicate that growers in higher quality regions are more likely to be paid a price determined on bottle price, and that growers who have been with wineries for longer receive a price based on bottle quality. However, there is a negative relationship with contract duration and experience in growing grapes generally. When we consider the combination we find a similar result for regional price. The implication here is that there is a higher probability in higher quality grape growing regions that grape prices explicitly take account of the quality of wine produced. This result provides potential evidence that wineries are implementing contracts that incorporate an element of risk sharing through redistribution of risk back to growers.

4.4 Winery visits and vineyard involvement

The final set of results we report examine winery visits to vineyards and growers' perceptions of winery involvement with key viticultural activities. Both these aspects of the grower–winery relationship are based on subjective grower assessment. They can be considered as capturing part of the implicit contract between both parties. We report two sets of results, both of which are estimated using an ordered logit model. Estimated marginal effects are reported in Tables 6 and 7.

The results in Table 6 indicate that higher regional prices lead to an increase in the number of visits to a vineyard. Wineries visit vineyards in higher-quality grape growing regions more frequently than in the lower-quality growing regions. We also find a negative relationship for vineyard size and a low number of visits, but a positive relationship as the number of visits increases. Theory tells us that, for any variable, the marginal effects in the lowest choice category will always be opposite in sign to the marginal effects in the highest choice category. Moreover, if the marginal effect is

Table 6 Ordered logit estimates of marginal effects: visits to the vineyard

Explanatory variables	Probability (Y = 0): 0–5 visits per annum	Probability (Y = 1): 6–10 visits per annum	Probability (Y = 1): more than 10 visits per annum
Contract duration	0.005	−0.001	−0.004
Regional price (\$A)	−0.0005***	0.00013***	0.0003**
Vineyard size (hectares)	−0.0017*	0.0005*	0.001*
Experience (years)	0.005*	−0.0014*	−0.004**
Use consultants (yes/no)	−0.009	0.003	0.007
Want to make wine (yes/no)	−0.02	0.004	0.01
Years with winery (years)	−0.0005	0.0001	0.0004
Contract history (yes/no)	0.08**	−0.02***	−0.06
Educational qualifications	0.08**	−0.023**	−0.06**
Log likelihood	−411		
Sample size	441		

Marginal effects: partial derivative of probabilities with respect to characteristics at mean values of Xs for continuous variables and for dummy variables we evaluate at $P(y = 1 | x = 1) - P(y = 1 | x = 0)$. When estimating marginal effects the constant is assumed to be a fixed parameter.

*Significant at 10 per cent level, **significant at 5 per cent level, ***significant at 1 per cent level.

Table 7 Ordered logit estimates of marginal effects: winery involvement with vineyard activities (y = 0 zero involvement, y = 4 high involvement)

Explanatory variables	Probability (Y = 0)	Probability (Y = 1)	Probability (Y = 2)	Probability (Y = 3)	Probability (Y = 4)
Pruning					
Contract duration	-0.006	0.002	0.002	0.001	0.0004**
Regional price (\$A)	-0.0002***	0.0001***	0.0001***	0.0001	0.00002**
Vineyard size (hectares)	0.00001	-0.000004	-0.00001	-0.000003	-0.000001
Experience (years)	0.0045*	-0.0013*	-0.002*	-0.001	-0.0003
Use consultants (yes/no)	0.02	-0.005	-0.01	-0.004	-0.001
Want to make wine (yes/no)	0.062**	-0.02***	-0.03	-0.013	-0.005
Years with winery (years)	-0.001	0.0002	0.0003	0.0002	0.0001
Contract history (yes/no)	0.043*	-0.01**	-0.02	-0.01	-0.003
Educational qualifications	0.06*	-0.02*	-0.02*	-0.013	-0.005
Log likelihood	-486.85				
Water and irrigation					
Contract duration	0.0003	-0.0001	-0.0001	-0.0001	-0.00003***
Regional price (\$A)	-0.0002***	0.00003***	0.0001***	0.0001	0.00002***
Vineyard size (hectares)	-0.001	0.0002	0.001	0.0003	0.0002
Experience (years)	0.004*	-0.0008*	-0.002	-0.001	-0.001
Use consultants (yes/no)	0.003	-0.0006	-0.002	-0.001	-0.0004
Want to make wine (yes/no)	0.1***	-0.02***	-0.043*	-0.002	-0.01
Years with winery (years)	-0.003	0.0006	0.002	0.001	0.0004
Contract history (yes/no)	-0.02	0.003	0.008	0.004	0.002
Educational qualifications	0.07**	-0.012*	-0.032*	-0.02	-0.01*
Log likelihood	-536.6				
Fertiliser practices					
Contract duration	-0.01	0.002	0.003	0.001	0.001**
Regional price (\$A)	-0.0001*	0.00003*	0.00005**	0.00002	0.00001**
Vineyard size (hectares)	0.0003	-0.0001	-0.0001	-0.0001	-0.00003
Experience (years)	0.005**	-0.001**	-0.002*	-0.001	-0.001
Use consultants (yes/no)	-0.04*	0.01	0.02	0.01	0.004
Want to make wine (yes/no)	0.07***	-0.02***	-0.03	-0.01	-0.01
Years with winery (Years)	-0.001	0.0002	0.0003	0.0001	0.0001
Contract History (yes/no)	0.03	-0.01	0.01	-0.005	-0.003
Educational qualifications	0.07**	-0.02*	-0.03*	-0.01	-0.01
Log likelihood	-466.5				

Marginal Effects: partial derivative of probabilities with respect to characteristics at mean values of Xs for continuous variables and for dummy variables we evaluate at $P(y = 1 | x = 1) - P(y = 1 | x = 0)$. When estimating marginal effects the constant is assumed to be a fixed parameter.

*Significant at 10 per cent level, **significant at 5 per cent level, ***significant at 1 per cent level.

negative in the lowest choice category, then a marginal increase in that variable will always lead to a marginal increase in the number of visits. The results indicate a negative relationship between the number of years of experience, contract history, educational qualifications and vineyard visits. These results can be explained in terms of a grower's ability to signal their competencies to the winery. That is, experience, contract history and educational qualifications are taken by the winery as a signal of the ability of the grower to achieve the desired level of output (quantity and/or quality).

The final sets of results we consider in Table 7 are for winery involvement in various aspects of vineyard activity: pruning, water and irrigation, and fertiliser practices. In

general, we find that increases in regional prices give rise to increasing levels of winery involvement. This corresponds with the results reported in Table 6. That is, wineries get more involved with growers in higher quality grape growing regions. This type of behaviour by the winery can be justified as a rational response to the existence of moral hazard. That is, the choice of clause or clauses in a contract to deal with the moral hazard problem is a function of the costliness to the winery. When the cost to wineries of moral hazard is low we have found that bonus/penalty payments are employed. When the cost to wineries of moral hazard is high we have found statistical evidence of higher involvement and numbers of visits. This choice of which contractual arrangements to use is directly related to the expected benefits from controlling grape quality. Higher benefits for higher quality wines can only be delivered by more intervention and monitoring.

5. Summary and conclusions

In the present paper we have analysed contractual arrangements between grape growers and wineries in Australia. The results presented add to a small but growing published literature on contract design and implementation in agriculture generally and the wine industry more specifically (in particular, Goodhue *et al.* 2004). We have been able to identify regional differences in the role of various instruments within contracts. Although we cannot directly examine the relative importance of the various mechanisms by which a winery might attempt to coordinate supply of grapes from a vineyard, our results do indicate certain stylised findings. There are differences in the mix of instruments used to motivate grower behaviour between regions of different grape quality.

Given the breadth of results presented it is useful to link the themes that have emerged in terms of contract design and implementation. Perhaps of most significance is the observation that different contract specifications are employed by wineries to motivate particular desired behaviours by growers in different regions. Goodhue *et al.* (2004) also provide support for this finding. This result has important implications for the adoption and design of contracts in the industry. In particular, although there is merit in informing growers of the need to ensure that they have a contract that includes a basic set of clauses, it needs to be understood that the content and emphasis placed upon certain aspects of these clauses will differ between grape growing regions. Furthermore, the importance of trust and the implicit aspects of coordination cannot be overstated. This has been found to be particularly so in the high-quality grape regions.

In terms of specific aspects of contract design to deal with problems of moral hazard, we find that price incentives in the form of bonus/penalty clauses are more likely to be incorporated in a contract in low-quality grape-growing regions. At the same time, we find that winery representatives make significantly less visits to growers in lower-quality grape regions. This finding is entirely consistent with the idea that a winery will have at its disposal a number of ways in which to ensure it receives the quantity and quality of grapes required. Depending on the technology available and specific aspects of derived demand, we would expect that the mix of these instruments would differ

across the spectrum of wine makers. The greater reliance on grape quality assessment in the lower-quality grape regions is consistent with the current state of the technology. The various tests currently available to assess grape quality are able to differentiate between bad grapes and good grapes, but they cannot provide a good measure of quality as is necessary when identifying grapes for premium quality wines.

In contrast, reference to best local viticultural practice, more vineyard visits and more active involvement in viticultural activities is associated with contracts used in high-quality grape-growing regions. These findings indicate that the mix of instruments used within a specific contract to motivate behaviour does differ depending on the demands of the winery. This is not to say that all the instruments are not used in some contracts across all regions, just that the statistical evidence indicates a greater likelihood of a particular subset of instruments in regions of a given level of grape quality.

Another important finding is that contract duration is positively related to the various aspects of contract content examined. The results indicate that longer-term contracts are more likely to be comprehensive and detailed. However, the results on price determination indicate that a longer duration contract is associated with grape price determined at harvest and that this is associated with lower-quality grape-growing regions. Indeed, when the price received by growers is determined as a result of wine quality, contract duration is likely to be shorter. All these results taken together indicate that longer contracts are entered into by growers in lower-quality grape-growing regions.

In terms of the grower-specific characteristics, the results we report are less clear. Although in certain contexts particular grower characteristics are important (e.g., years with winery and viticultural practice clause) there is no prevailing theme. These results indicate that, for our sample data, grower-specific characteristics do not determine contract design and implementation. This result is maybe not surprising given that most growers do not interactively engage in contract design. From the anecdotal evidence available, most wineries make a take-it-or-leave-it offer with regard to the contract offered, and these contracts are relatively homogenous within a grape growing region. This approach to contract design is also consistent with the observation that it is the winery that determines the contract terms because it is in the stronger bargaining position. The limited importance of individual grower characteristics to contract design in agriculture more generally is noted by Sykuta and Cook (2001).

There may be important policy implications stemming from this finding as a result of recent changes to the Trade Practices Act. There is now the facility to allow collective negotiation with respect to contracts and prices for goods supplied by small businesses with big businesses. The benefit of these changes has already been felt in agriculture, with a ruling allowing dairy farmers to collectively negotiate prices with milk processors. With little statistical evidence of individual differences in grape supply contracts, it may well be more efficient to allow grape growers to negotiate prices collectively with wineries and, as a result, redress some of the imbalances in contract negotiation that characterise parts of the industry at present. The type of industrial re-organisation implied by this change of business relationship has already been identified in contract farming in the USA and has been the subject of research under the heading

of organisational economic analysis.²⁰ There is clearly a need for similar research in Australia.

Finally, it needs to be noted that, although we have not been able to identify the significance of grower characteristics on contract design, a more detailed survey of grower contract information might reveal differences. For example, it is highly likely that there will be differences in grape quality requirements such as Brix/Baume levels specified for different growers as well as prices paid. Indeed, the analysis and interpretation of results presented in the paper is limited by the nature of the data. For example, we cannot infer anything regarding the relative significance in high-quality and low-quality grape regions of the various contractual instruments that have been identified as being important. We cannot determine for contracts in high-quality grape-growing regions what is more important in terms of motivating behaviour; that is, viticultural practice or the number of visits made by winery representatives. To examine this issue we would need to collect a much richer data set from wineries and match these to specific grower requirements.

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²⁰ For more details readers should consult the American Journal of Agricultural Economics (2004), Number 3, which presents a number of recent conference papers on this theme.

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