A real-options analysis of wine grape farming in north west Victoria

Research Paper 2012.4

Paper for presentation at the 2012 annual conference of the
Australian Agricultural and Resource Economics Society
February 7–10, Fremantle, Western Australia

Emayenesh Seyoum[1] and Chris Chan[2]

February 2012

Policy and Strategy Group,
Department of Primary Industries, Victoria

[1] Senior Quantitative Economist, Economics and Policy Research Branch, Department of Primary Industries, Victoria.
[2] Principal Scientist, Economic and Policy Modelling, Economics and Policy Research Branch, Department of Primary Industries, Victoria.

Acknowledgements

The authors would like to thank Dr Anke Leroux of the Department of Economics, Monash University, and Ms Anthea McClintock of NSW Trade and Investment for providing valuable comments on a draft of the paper. Acknowledgement also goes to Dr Deborah Peterson, Ms Deirdre Rose and Mr Gavan Dwyer of the Department of Primary Industries, who rendered assistance and support to the research underpinning this paper. Any errors remaining in the paper are the authors' responsibility. Moreover, the views expressed in this paper are those of the authors and do not necessarily reflect the views of the Department of Primary Industries

If you would like to receive this information/publication in an accessible format (such as large print or audio) please call the Customer Service Centre on 136 186, TTY 1800 122 969, or email customer.service@dpi.vic.gov.au.

Published by the Department of Primary Industries
Economics and Policy Research Branch, February 2012

Authorised by the Department of Primary Industries
1 Spring Street, Melbourne 3000.

Seyoum E, Chan C. 2012. A real-options analysis of wine grape farming in north west Victoria. Research Paper 2012.4. Policy and Strategy Group, Department of Primary Industries (Victoria) Melbourne.

For more information about DPI go to www.dpi.vic.gov.au or phone the Customer Service Centre on 136 186.

A real-options analysis of wine grape farming in north west Victoria

Emayenesh Seyoum and Chris Chan

Abstract

This paper reports a use of a real-options valuation methodology to analyse wine grape farm investment under price and yield uncertainty. Revenue levels to incentivise entry and exit were calculated for three different sizes of wine grape farms in North West Victoria. The modelling identified lower exit and higher entry triggers than indicated by conventional net present value calculation. The wide gap of estimated indeterminacy in farm investment highlights the intertwined influence of numerous economic factors — cost structure, economies of scale, market volatility, transaction costs, and sunk and salvaged asset valuation. Drawing on these determinants of farm investment and disinvestment, the paper discusses the role of investment incentives in affecting industry transformation and the scope for policy intervention to assist structural adjustment of the wine grape sector.

Keywords: Real options, entry and exit, wine grape, North West Victoria

1. Introduction

The history of wine grape farming in North West Victoria goes back to the late nineteenth century. However, it was the rise in wine grape prices in the 1990s that attracted an influx of growers to the industry and, consequently, led to a rapid expansion of the industry in the region. Much of this expansion was associated with increased production of particular grape varieties — especially Chardonnays — that are now out of favour with wine consumers.

Since the early 2000s, the regional wine grape sector has been experiencing economic difficulties. Many factors have contributed to persistent declines in farm revenue, including depressed world prices of wine, long and severe drought in the region followed by damaging floods in 2010, high input costs relative to those in competing countries, the appreciation of the Australian dollar and shifts in consumer taste for particular types of wine in the global market. At the moment many wine grape growers are earning insufficient income to pay for total operating costs of production, and hence are not recovering overhead costs or earning positive returns to capital. Some growers are still harvesting because grape prices, while remaining low, exceed the costs of harvesting. Despite such profit pressures, restructuring in the wine grape sector has been slow.

This study aims to provide an economic explanation for the sluggish adjustment of the wine grape sector. It adopts a real-options modelling approach to explicitly take into account the impact of cost structures and revenue uncertainties on investment.

Wine grape is a perennial crop; its production is characterised by relatively high orchard establishment costs, and uncertain wine grape yields and prices for particular grape varieties. It takes two to three years for vines to produce fruit, and additional years thereafter to reach their highest production potential. The stochastic nature of grape price and yield has important implications for investment decisions. While current farm revenues may be insufficient to pay off variable production costs, it may still be rational for growers to continue farming as seasonal revenue may rise in the future because of its stochastic nature. Exiting the current investment would incur losing part or all of the initial investment and, more importantly, forsaking potentially high profits in the future.

In this paper we show that an economic analysis of investment, if ignoring the characteristics of irreversibility and uncertainty, could underestimate the economic value in waiting and provide misleading evidence for guiding industry policy to facilitate structural adjustment. In section 2, we present an overview of various investment theories. In section 3, we specify a real-options model suitable for analysing investment in wine grape farming. In section 4, we discuss the data sources used for modelling and their limitations. In section 5, we present and discuss baseline results. Section 6 presents sensitivity tests on a selection of farm characteristics. Section 7 concludes the paper with a discussion of lessons for policy development.

2. Investment theories

There is a vast economic literature on investment behaviour that seeks to explain key considerations of individual firms when deciding whether or not to enter and exit particular markets. Understanding the relative strengths and limitations of various related investment theories is essential for selecting a suitable approach to solve the problem at hand.

According to the classical Marshallian theory (Marshall 1920), firms exit the industry whenever output price falls below average variable cost (i.e. operating profit is negative) and enter when price is above long-run average cost (i.e. operating profit exceeds the economic cost of capital). Jorgensen (1963) criticised this theory on the ground that its focus on current profit is too static and narrow.

Jorgensen (1963) argued that the calculus for investment decision should include expected profit flows over time. Under Jorgensen's neoclassical perspective, firms should exit when staying in the industry would not deliver a positive net present value (NPV) of current and future cash flows. Discounted cash flow (DCF) models adopt this perspective, prescribing a dynamic decision rule with which the criterion for proceeding with or abandoning an investment is continuously reviewed in line with NPV calculation that reflects latest profitability prospects.

Graham and Harvey (2001) observed that the neoclassical approach to investment appraisal is powerful and useful but limited in two aspects. First, it fails to offer much insight into how uncertainty could influence investment decision. Secondly, it is unable to explain the role of sunk costs in investment decisions.

Harrigan (1981) agreed that sunk costs matter for capital adjustment. Firms may choose to remain in the industry because they have invested heavily in existing assets (physical or intangible) that cannot be fully recovered in the event of business closure.

In the context of agriculture, Johnson (1960) discussed how production response is generally non-symmetric — that is, supply elasticity being smaller for a price decrease than for a price increase. He postulated that fixed investment in land and labour would lead to a delay in entry in response to price increases, as well as a delay in exit except at very low prices. Accordingly, ignoring such delayed responses in investment would undermine the analytical basis for developing policies and programs to bring about responsive adjustment in farm production and resource use.

The advance of financial-options theory opens up a new perspective for understanding firm behaviour in making investment decisions. McDonald and Siegel (1985) and Brennan and Schwarz (1985), among many others, adapted the techniques developed for financial options to explaining determinants of physical asset investment. Dixit (1989; 1991) and Dixit and Pindyck (1994) formalised the application of real-options theory by considering irreversible investment under uncertainty. Since their pioneering work, there have been growing applications of the real-options approach to analyse investment in a variety of industry settings.

Examples for agriculture abound. Using a real-options model, Luong and Tauer (2006) studied coffee growers' investment in Vietnam. Price and Wetzstein (1999) looked at investment in peach orchards in Georgia. Tauer (2006) inquired when farmers in US get in and out of dairy farming. Schmit *et al.* (2009) analysed ethanol plant investment in US. A study by Seo *et al.* (2004) examined table grape farming in California.

The real-options approach is suitable for this study because wine grape farming is characterised by large sunk capital expenditures and uncertain revenues. Wine grape farming requires upfront capital costs for planting grapevines and installing on-farm infrastructure, equipment and machinery. Most of these inputs, once put in place, cannot be recovered, relocated, or used on-site for other purposes. Furthermore, perennial grapevines require careful nurturing and maintenance in the first few years after planting before they can grow to become a fruitful and productive revenue-generating asset. Even then, at a stage of maturity for harvest, revenue is highly uncertain due to many risk factors — such as commodity price fluctuation, demand shift, weather and environmental influences on crop yield.

3. Model

In this study, the focus of analysis is on assessing the strategic value in waiting to exit and enter wine grape farming. We did not consider a broader range of investment options such as mothballing farm operations temporarily, leasing out farm land and water titles, and switching to growing a different variety of grapes. Accordingly, the estimated value in waiting is inclusive of various strategic options that could be relevant to particular farmers. For example, farmers may choose to re-enter with a different variety or mix of varieties from those in existing operations.

Revenue uncertainty was assumed to be the primary source of investment risk. Capital expenditures and other production costs were assumed to be relatively stable and predictable, hence not contributing to uncertainty.

Revenue uncertainty was specified in a similar way to the approach used by both Dixit and Pindyck (1994) and Price and Wetzstein (1999). Dixit and Pindyck (1994) assumed only price uncertainty. Drawing on the work by Hull (1997), Price and Wetzstein (1999) devised a model capable of representing the dual source of price–output uncertainty. In this context, revenue is the product of price and output. Revenue uncertainty reflects not only the separate volatility in price and output but also the correlation between them.

Specifically, both price *p* and yield *q* were assumed to follow a geometric Brownian motion process:

(1) $$dp = \mu_p p dt + \sigma_p p dz_p$$

(2) $$dq = \mu_q q dt + \sigma_q q dz_q$$

where dp and dq respectively represent the change in per ton seasonal price and the change in per hectare seasonal yield rate and, with subscripts p and q denoting price and yield, μ is the drift rate and σ the standard deviation of the stochastic process. Furthermore, dz denotes an increment of the Wiener process with $E(dz_p^2) = E(dz_q^2) = dt$ and $E(dz_{p,} dz_q) = \rho dt$, ρ being the correlation coefficient between p and q.

Dixit and Pindyck (1994) assumed risk neutrality and maximisation of expected net present value from investment. We adopted the same assumptions. A further assumption is the log-normal distribution of revenue, $R = pq$, as the product of price and quantity. Accordingly, the mean and variance of seasonal revenue change are both independent of the revenue level (Hull 1997). The stochastic process of *R* is determined by the differential of the change in logarithm of *R*, $dr = d\ln(R)$. Hence, following Ito's lemma:

(3) $$dr = \frac{\partial r}{\partial p} dp + \frac{\partial r}{\partial q} dq + \frac{1}{2}\frac{\partial^2 r}{\partial p \partial q} dp dq + \frac{1}{2}\frac{\partial^2 r}{\partial p^2} dp^2 + \frac{1}{2}\frac{\partial^2 r}{\partial q^2} dq^2 .$$

Since

$$\partial r/\partial p = 1/p,\ \partial r/\partial q = 1/q, \partial^2 r/\partial p^2 = -1/p^2,\ \partial^2 r/\partial q^2 = -1/q^2, \text{and}\ \partial^2 r/\partial p \partial q = 0,$$

equation (3) reduces to

(4) $$dr = \frac{1}{p} dp + \frac{1}{q} dq - \frac{1}{2p^2} dp^2 - \frac{1}{2}\frac{1}{q^2} dq^2 .$$

Equations (1) and (2) can be substituted for dp and dq in equation (4). As $(dt)(dz)$ is of order $(dt)^{3/2}$, every term with dt raised to a power greater than one approaches zero faster than dt in the limit. This yields:

(5) $$dr = (\mu_p + \mu_q - 1/2\sigma_p^2 - 1/2\sigma_q^2)dt + \sigma_p dz_p + \sigma_q dz_q .$$

Thus, $r = \ln(R)$ follows a Brownian motion of the general form $dr = \mu_r dt + \sigma_r dz_r$, implying that dr over a time interval *T* is normally distributed with mean μ_r equal to:

(6) $$(\mu_p + \mu_q - 1/2\sigma_p^2 - 1/2\sigma_q^2)T$$

and variance σ_r^2 equal to:

(7) $$(\sigma_p^2 + \sigma_q^2 + 2\rho\sigma_p\sigma_q)T .$$

Applying Ito's lemma to $R = e^r$ yields the geometric Brownian motion for revenue change:

(8) $dR = \mu_R R dt + \sigma_r R dz_R$

where $\mu_R = \mu_r + 1/2\sigma_r^2$.

Based on the stochastic process of revenue, the real-options model of investment can be expressed as:

(9) $V_0(R) = BR^{\beta}$

(10) $V_1(R) = R/(\delta - \mu_R) - C/\delta + AR^{-\alpha}$

where $V_0(R)$ denotes the expected present value of entering into wine grape production (idle project) with revenue *R* based on the stochastic process (8) and $V_1(R)$ denotes the expected present value of existing wine grape production (active project). Furthermore, parameters α and β denote the two roots of the quadratic equation (Dixit 1991), δ the opportunity cost of capital (or the discount rate), μ_R the revenue drift rate and *C* the total variable cost of production.

Dixit and Pindyck (1994) formulated the optimal strategies for entry and exit in terms of two revenue triggers, R_H and R_L. Accordingly, new investors enter into wine grape production as long as revenue reaches R_H and growers currently in production continue farming until revenue falls to below R_L. Between the entry and exit triggers is an indeterminate range for both entry and exit decisions — a zone of hysteresis or inactivity where investment incentives are muted because it is costly to reverse economic actions and, as a result, inaction is an optimal response.

These revenue triggers can be derived based on the value-matching condition and the smooth-pasting condition. The value-matching condition stipulates that, at the entry trigger point R_H, the value of a new investment (i.e. the value of option to invest) must be equal to the value of the existing investment minus the sunk cost K (equation 11). At the exit trigger point R_L, the value of the option to abandon production is equal to the value of the existing investment minus the cost of abandonment X (equation 13). These triggers define the critical levels of revenue at which the new and incumbent investor finds it optimal, respectively, to enter (R_H) and to abandon (R_L). The smooth-pasting condition requires that the two investment value functions meet tangentially at those revenue levels. These two equalities lead to a system of four equations:

(11) $R_H/(\delta - \mu_R) - C/\delta + AR_H^{-\alpha} - BR_H^{\beta} = K$

(12) $1/(\delta - \mu_R) - \alpha AR_H^{-\alpha-1} - \beta BR_H^{\beta-1} = 0$

(13) $R_L/(\delta - \mu_R) - C/\delta + AR_L^{-\alpha} - BR_L^{\beta} = -X$

(14) $1/(\delta - \mu_R) - \alpha AR_L^{-\alpha-1} - \beta BR_L^{\beta-1} = 0$

where *A* and *B* are coefficients to be determined along with R_H and R_L.

As these equations are nonlinear in the trigger point variables R_H and R_L, no closed-form analytical solution exists. The revenue trigger for entry (R_H) and that for exit (R_L) were obtained by solving equations (11) to (14) simultaneously using Matlab programming of iterative solution procedures.

The Marshallian revenue triggers were also derived to provide a basis of comparison. Under this alternative approach, the entry trigger is estimated as ($C+\delta \times K$) and the exit trigger is equal to *C*, with being the total variable cost, δ the opportunity cost of capital (the discount rate), and *K* the cost of investment.

4. Data sources and limitations

Two types of data were used for modelling: (i) cost and revenue data to calibrate wine grape production as at 2005-06; and (ii) price and yield data series to derive the stochastic property of revenue uncertainty. For the latter, statistical analysis was conducted separately for the price and yield series as there are no time-series data available for directly measuring seasonal revenues of wine grape farms in North West Victoria. Moreover, seasonal revenues cannot be derived as a product of the price and yield series due to differences in data measurement and classification.

To represent production, the model requires data on the establishment capital cost, variable cost, abandonment cost, revenue and discount rate. Data availability dictated the selection of 2005-06 as the reference year for modelling. Annual cost and revenue data were obtained from two studies: (i) the 2007 ABARES study of horticultural farm performance commissioned by the Mildura–Wentworth Horticultural Task Force (Mues and Rodriguez 2007); and (ii) the 2007 study conducted by Scholefield Robinson Mildura Pty Ltd on behalf of the Australian Dried Fruits Association (Swinburn and MacGregor 2007).

ABARES' Australia-wide wine grape price series over the period 1991-92 to 2009-10 were used as a proxy for North West Victoria regional varietal prices. An examination of shorter, region-specific varietal price series confirmed high correlation between the national and regional seasonal prices and, hence, the suitability of the ABARES series for the statistical analysis. These alternative price data were available from the Murray Darling / Swan Hill Wine Grape Crush Survey conducted by the Department of Primary Industries. For the period 1999 to 2010, the average grape price series (weighted by varietal production) in the region shows a statistical correlation of 0.8 with the ABARES series; the correlation for the Chardonnay price series with the ABARES series is 0.7. Chardonnays accounted for around 50 per cent of the total regional wine grape supply in 2010, compared with about 30 per cent in 2000.

Wine grape yield rate series were sourced from the Australian Bureau of Statistics (ABS) wine and grape industry survey. These data are specific to the wine grape growing areas in North West Victoria.

Several data limitations necessitate caution in interpreting modelling results. First, the latest information on costs and revenues of grape farms in North West Victoria is available only up to 2006. Without access to more up-to-date data, we cannot and do not make claims to the relevance of the study to current conditions.

Second, the data on operating costs and crop revenues represent a combination of wine grape, table grape and dried vine fruit production. The data source (ABARES) provides no separation of cost data for these activities. Using the combined dataset to calibrate the model for wine grape farming could lead to moderate overstatement of both costs and revenues — because, on the cost side, wine grape farming is less labour intensive than the production of non-wine grapes and, on the revenue side, wine grapes command lower prices than the other grape varieties. The offset between overstated costs and overstated revenues mitigates possible, albeit likely limited, errors in the measurement of net revenues.

Third, the data on farm establishment costs from the Scholefield Robinson report are pertinent to dried grape production. Using these data could lead to overstatement of vine planting costs and understatement of machinery costs which offset each other to a degree. The reason for such cost differences between dried grape and wine grape production is twofold. In the establishment period, dried grape vineyards require more labour input than wine grape vineyards. Furthermore, hand harvesting is required for dried grape production while harvesting of wine grapes is mostly done with machines.

The modelling was conducted separately for three farm sizes based on the survey stratification by ABARES. The first refers to a group of small farms with a planting area of six hectares per farm on average. The second refers to a group of medium-sized farms with a planting area of 13 hectares on average. The third comprises those larger farms with a planting area of 52 hectares on average. The 2005-06 average crop revenue per hectare was $14,382 for small farms, $12,537 for medium farms and $11,716 for large farms.

Wine grapes are a perennial crop with a life cycle of 20 to 30 years. It takes about three years for a new vineyard to yield the first commercial harvest and additional years to reach its maximum potential. To establish a new vineyard, sunk costs are incurred for purchasing land and water titles, for constructing irrigation systems, for trellising and other vine establishment costs, and for acquiring machinery and equipment. Estimates of these costs are listed in table 1 for each farm size.

Table 1: Establishment costs by farm size ($/hectare)

Item	Small	Medium	Large
Land and water	32,328	30,607	28,578
Irrigation infrastructure costs	6,860	6,680	6,860
Vine establishment costs	13,377	13,377	13,377
Contract operations	4,330	4,330	4,330
Machinery purchase costs	16,325	12,057	7,510
Total	73,213	67,224	60,648

Source: Swinburn and MacGregor (2007).

Averaged estimates of variable costs by farm size are listed in table 2. Labour (inclusive of hired and family labour) is a major part of the total variable cost. Grape farming is labour intensive. Weeding, pruning and harvesting are mostly done by manual labour, although larger-scale wine grape production tends to be mechanised. Depreciation, as another key cost component, was imputed and added to the variable cost. Following Dixit and Pindyck (1994), it was assumed that the investment in vineyard production has an infinite life and therefore depreciable assets need re-investment to maintain the capital capacity.

Table 2: Variable costs by farm size ($/hectare)

Operating activities	Small	Medium	Large
Hired labour	2,036	1,665	1,239
Fertilisers	449	199	339
Chemicals	654	473	293
Fuel, oil and grease	882	372	339
Repairs and maintenance	974	642	583
Contracts	1,325	1,023	990
Depreciation	1,461	1,075	471
Family labour	5,362	3,308	906
Other costs	5,773	4,393	2,691
Total	18,915	13,150	7,849

Source: Mues and Rodriguez (2007).

As shown in tables 1 and 2, wine grape farming costs vary with farm size. The unit cost savings for larger farms are attributable to economised use of labour and other key inputs such as fertilisers, chemicals and fuels. Per hectare land cost estimates are also lower for larger farms, reflecting cost savings associated with higher planting ratios per whole-farm area and lower unit costs of land preparation work. On the other hand, crop yield rates show only modest variation across different farm sizes. Together, the unit cost of production and the yield rate suggest significant economies of scale in wine grape production.

It was assumed that upon farm closure, 10 per cent of the infrastructure and vine establishment costs and 20 per cent of machinery costs can be recovered through the sale of such assets. Land and water can be sold at market prices. There exists a cost associated with removing the abandoned vines and irrigation infrastructure. Farmers may also need to pay termination fees for transfer of water titles out of their irrigation district. The estimates of salvaged asset values are summarised in table 3.

Table 3: Salvage asset values by farm size ($/hectare)

Item	Salvage rate	Small	Medium	Large
Land and water	100%	32,328	30,607	28,578
Irrigation infrastructure costs	10%	686	686	686
Vine establishment costs	10%	1,338	1,338	1,338
Contract operations	0%	0	0	0
Machinery purchase costs	20%	3,265	2,411	1,502
Minus: Sales 3% commission on land and water		970	918	857
Termination fees		4,734	4,734	4,734
Removal of planting and irrigation infrastructure		3,540	3,540	3,540
Total		28,372	25,850	22,973

Source: Authors' estimation based on expert advice.

The premise underlying real-options analysis requires that the stochastic variables of price and yield each follow a random walk. This was confirmed by unit root tests as follows.

Annual per hectare yield rate *q* and per ton price *p* were both modelled in the form of:

(15) $$D_{it} = \lambda D_{it-1} + u_{it}$$

where λ=1, D_{it} alternately represents the price and quantity at time *t*, and u_{it} is independent error with zero mean and constant variance σ_u^2. Subtracting D_{it} from both sides of equation (15) yields:

$$D_{it} - D_{it-1} = \lambda D_{it-1} - D_{it-1} + u_{it}$$

$$\Delta D_{it} = \gamma D_{it-1} + u_{it}$$

where $\gamma = (\lambda - 1)$.

Under the null hypothesis that the coefficient $\gamma = 0$ (i.e. $\lambda = 1$), the formulation is consistent with a random walk model. The hypothesis was tested for three variants of the random walk model: (i) no constant and no trend; (ii) with constant and no trend; and (iii) with constant and trend:

$$\Delta D_{it} = \gamma D_{it-1} + u_{it}$$

$$\Delta D_{it} = \alpha_{it} + \gamma D_{it-1} + u_{it}$$

$$\Delta D_{it} = \alpha_{it} + \gamma D_{it-1} + \kappa t + u_{it}.$$

Using annual price data from 1992 to 2008, the Dickey–Fuller unit root test did not reject at 5 per cent of statistical significance the null hypothesis that the price series follows a random walk for all three variant models. Similar test results were obtained for the averaged North West Victoria regional price series. When performed for the Chardonnay price series, the unit root test was not rejected for only the first two random walk equations. The rejection of price randomness under the third equation (which has a constant and a trend variable) might provide evidence of some trend in Chardonnay prices attributable to a more pronounced price decline during the second half of the 2000s than the price decreases for other grape varieties.

For the yield series, the null hypothesis was not rejected for the first two random walk equations but was rejected for the third one. Given these unit root test results, it was considered reasonable to assume that both the price and the yield series follow a random walk.

The estimates of the drift and variance for the price and yield series were derived using the method outlined by Hull (1997). Table 4 shows the baseline parameter values of the real-options model.

Table 4: Baseline model parameters

Parameter	Description	Estimate
μ_p	Price drift rate	0.0417
σ_p^2	Price variance	0.0281
μ_q	Yield drift rate	0.0161
σ_q^2	Yield variance	0.0443
ρ_{pq}	Price and yield correlation	-0.1983
$\sigma_r^2 = \sigma_q^2 + \sigma_p^2 + 2\rho_{pq} * \sigma_q \sigma_p$	Revenue variance	0.0584
$\mu_R = \mu_r + 1/2\sigma_r^2$	Revenue drift rate	0.0507
δ	Opportunity cost of capital	0.08

Source: Authors' estimation.

5. Baseline results

In table 5, estimates of the revenue triggers for entry and exit under the conventional NPV and real options approaches are presented. As a basis for comparison, the NPV triggers represent the entry and exit criteria based on a static assessment of investment value. Between the entry and exit triggers is an indeterminate revenue range where investment and disinvestment incentives are muted. This inactivity reflects the significance of sunk costs in discouraging exit of an operating business from the investment that no longer has the prospect for yielding the required return on capital.

Table 5: Estimates of revenue triggers for entry and exit by farm size

	Small	Medium	Large
NPV approach			
Entry ($/hectare)	24,772	18,528	12,701
Exit ($/hectare)	18,915	13,150	7,849
Real-options approach			
Entry ($/hectare)	34,273	28,983	18,119
Exit ($/hectare)	13,011	8,978	5,377

Source: Authors' estimation.

By accounting for the effect of revenue risk in a real-options context, the modelling produced higher estimates of the entry trigger and lower estimates of the exit trigger than under the NPV approach. Price and yield uncertainties were modelled to widen the gap between these triggers, adding to the propensity for muted investment response. This widened tolerance range for inactivity reflects investment hysteresis resulting from the interaction between sunk cost and uncertainty. If there were no sunk costs, there would be no hysteresis; with sunk costs, uncertainty becomes an important factor in the decision to invest or disinvest.

The real-options approach rectified the omission of strategic investment value in the NPV calculation, yielding a more rigorous estimate of the exit trigger at $13,011 for small farms. This represents a 32 per cent downward adjustment from the NPV breakeven point, reflecting the real-options value in waiting to exit later. The farms may operate at a loss, and yet stay in business with the expectation that the future will be better. However, exit will be rational if their revenue falls below the critical level where the loss is too great to offset against the value in waiting.

Likewise for medium-sized farms, the estimated exit trigger at $8,978 (compared with the NPV breakeven point at $13,150) highlights the economic rationale for enduring operating losses. Large farms would have little propensity to disinvest while earning revenues in excess of both the real-options and the NPV triggers for exit.

Across all farm-size groups, the strategic entry trigger point was estimated to be much higher than the conventional trigger for new investment. This amounts to increasing the required return on capital from an assumed rate of 8 per cent to roughly 21 per cent. Consequently, the NPV approach understates the financial hurdle for attracting new investment to wine grape farming in North West Victoria.

6. Sensitivity analysis of exit propensity to farm characteristics

We analysed the sensitivity of exit trigger estimation to revenue variability, total variable cost and liquidation value in order to examine how these farm characteristics could affect exit and entry decisions. The analysis was conducted primarily for small farms because they dominate the sector and are generally considered most vulnerable to exit pressures (as confirmed by baseline modelling results).

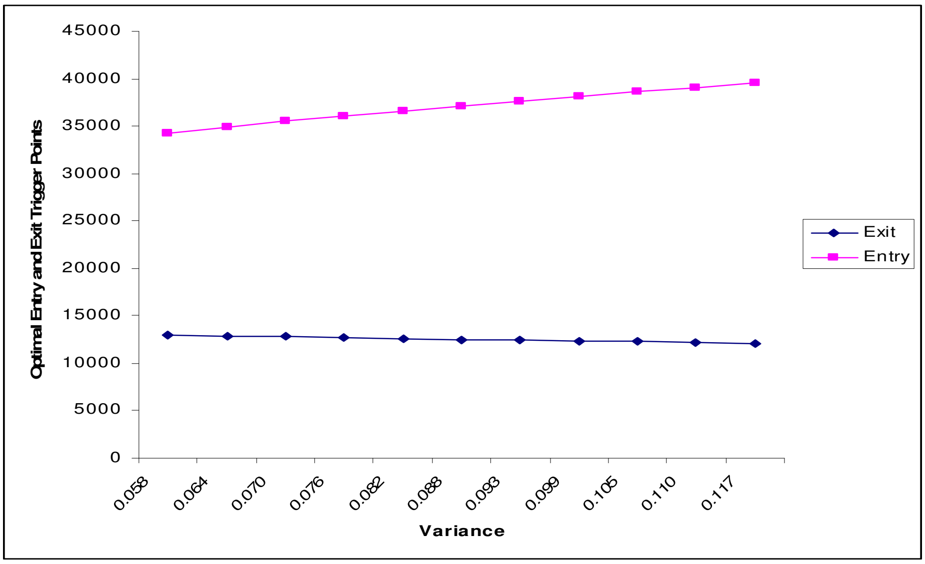
6.1 Change in volatility of revenue

We drew on Tauer and Dressler (2009) for the calculation of exit probabilities at specific revenue levels. The baseline probability was calculated for the 2005-06 revenue level. Small farms were assessed to have a 39 per cent probability for exiting wine grape farming. This compares with the exit probabilities of 11 per cent for medium farms and 0.1 per cent for large farms. This assessment confirms that low-cost production associated with scale economies is the key to business endurance at times of market downturn.

To examine how the variance of revenue change could affect exit and entry decisions, we looked at a number of step changes in revenue variance. For a 10 per cent increase in revenue variance from the baseline level (i.e. from 0.058 to 0.064), the exit trigger was estimated to fall from $13,011 to $12,901, and the entry trigger to rise from $34,273 to $34,891. If the variance were to double from the baseline (i.e. reaching 0.117), the entry trigger would be adjusted upwards to $39,537 and the exit trigger would be adjusted downwards to $12,110. The sensitivity test results for a broader range of variance changes are plotted in figure 1, confirming the widening of the inactivity gap with increased revenue variance.

Increased revenue variance means greater potential for revenue increases in the future, and implies a greater incentive for potential investors to delay entry into the sector upon the confirmation of more favourable revenue prospects. By the same token, existing farms would be more strongly incentivised to stay in operation by greater possibility of revenue improvement. This explains the inertia of many farms to stay in business despite sustained profit pressures amid increased revenue uncertainty.

Figure 1: Widening gap of inactivity with increased revenue variance



Source: Authors' estimation.

6.2 Change in variable cost

Ryan (2007) discussed business strategies involving collaboration and cooperation for horticultural properties to achieve economies of scale. Collaboration could be as simple as two neighbouring growers getting together to combine growing areas or share machinery, labour and irrigation equipment. Alternatively, groups of growers could form alliances to share access to technology and market information. Positive outcomes from these and other strategies in achieving a lower unit cost of production could help growers endure cyclical economic downturns.

A distinctive advantage of collaboration and cooperation as a way to attain economies of scale is that these strategies do not require existing farmers to disinvest and liquidate their farms. By contrast, sectoral consolidation that involves some farms or new investors acquiring other existing farms would incur considerably higher transaction costs. Such a consolidation process is also likely to face the hurdle relating to investment indeterminacy — i.e. the difficulty in getting the incumbent and new investors to have compatible revenue expectations in order to incentivise entry and exit as necessary for deal making success. Notwithstanding the potential for improving business viability and endurance, critical factors necessary to yield successful outcomes from farming on a larger scale should not be overlooked.

According to the cost estimates shown in tables 1 and 2, with two small wine grape farms in North West Victoria combining to operate on a medium scale, per hectare total establishment cost could decline by 8 per cent while the resulting reduction in total operating cost could be even greater, at 30 per cent. Similarly, medium-sized farms that are able to catch up with large farms in efficiency terms would see their operating costs reduced by 40 per cent. However, it would require merging up to four farms of a medium size to achieve a cost reduction of this magnitude.

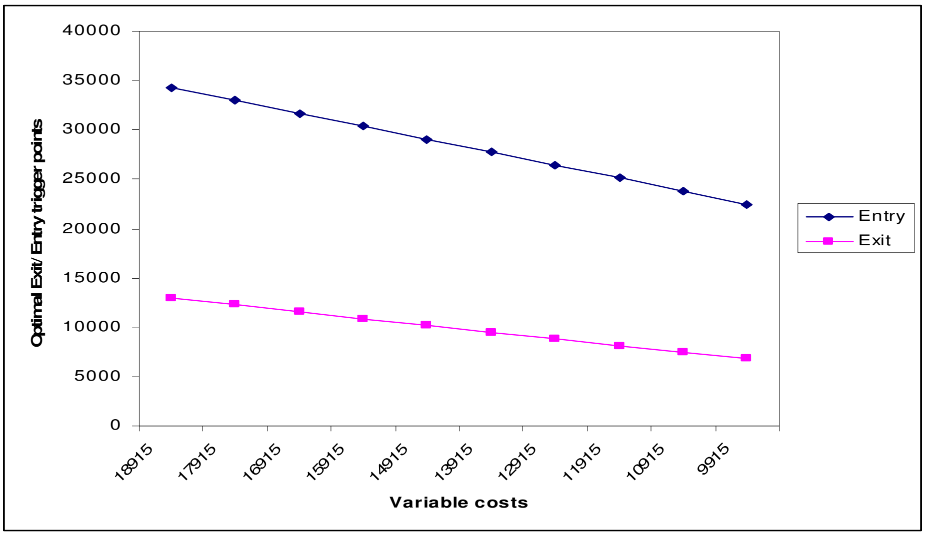
The dependence of investment incentives on scale economies was tested by modelling reductions in total variable cost while holding constant the levels of revenue, total establishment cost and salvage value. With this method, the first type of sensitivity test on scale economies simulated small farms merging to operate in a medium scale and medium farms merging to operate in a large-farm scale.

Results show that both the entry and exit triggers would fall with the assumed expansion in farm scale. With the upsizing of small farms, the probability of exit would diminish from 39 per cent to 5 per cent. With the upsizing of medium farms, the probability of exit would diminish from 11 per cent to 0.04 per cent.

Improved cost efficiency does not necessarily have to come from merging activities; it could also result from incremental productivity gains. To simulate the latter case, we conducted sensitivity analysis of incremental cost reductions for small farms.

A reduction of total variable cost by $1,000 from the baseline, for instance, would reduce the probability of exit by 9 percentage points. If total variable cost falls by $3,000, not surprisingly the probability of exit would lower by even more, at 24 percentage points compared to baseline. The estimated relationships between the revenue triggers for entry and exit and total variable cost are displayed in figure 2.

Figure 2: Narrowing gap of inactivity with reduced total variable cost



Source: Authors' estimation.

6.3 Liquidation value

Sensitivity analysis was also conducted on salvageable infrastructure which, upon exit, might be resold or used for some other purpose. The implications for investment incentives were analysed by adjusting upwards the salvage rate of irrigation infrastructure assets from 10 per cent to 50 per cent. This could represent an outcome of research and development in portable irrigation systems aimed at increasing salvage or liquidation value. The use of mobile infrastructure would have an effect of increasing the probability of exit from 39 per cent to 43 per cent for small farms, and from 11 per cent to 13 per cent for medium-sized farms. Consequently, infrastructure portability is a weak driver of exit decisions as this infrastructure cost is small relative to total establishment cost.

7. Conclusion

This study set out to investigate the sluggish adjustment of the wine grape sector in North West Victoria in response to persistent profit pressures in recent years. Through the lens of real-options valuation, the study analysed the investment incentives behind farmers' decision to exit or stay in business under revenue uncertainty.

Significant sunk costs and volatile seasonal revenues for wine grape farming were found to have underpinned a significant economic value in waiting to exit and enter. The modelling identified wide tolerance for low revenues where existing farmers could find it worthwhile to stay in business despite not earning an attractive rate of return on their capital investment, or even not earning enough to cover operating costs. The real-options value in waiting provides an economic rationale for enduring operating losses over an extended period. The sunk costs incurred give farmers an incumbency advantage to hang on. The volatile revenues give them hope for a better future. For new investors, initial capital requirements represent a high price for entering the sector to start farming. Revenue volatility adds to the rationality of entering at a later time when the revenue outlook becomes sufficiently attractive.

It should be noted that these findings might not fit with the experiences and circumstances of particular farmers because they were based on the modelling of averaged price and yield behaviour as well as averaged cost structures of wine grape production. In particular, the steep decline in Chardonnay grape prices in the past decade could perpetuate expectations of some that the sector will never recover from the price collapse in the 2000s unless the farmers can switch to other varieties — such as Sauvignon Blanc as witnessed in the current expansion in New Zealand. This type of price expectations was not captured through the statistical analysis in this study.

Both the real-options and NPV approaches identify a range of revenue levels compatible with indeterminate entry and exit decisions. The NPV approach is, however, deficient in capturing the strategic value in waiting and, as a result, fails to robustly explain the prevalence of hysteresis or inactivity as a rational response to uncertainty when making decision on irreversible investment. Real-options analysis rectifies this deficiency by highlighting a much wider revenue range for investment indeterminacy to reflect the undertaking of a 'wait-it-out' strategy.

Investment indeterminacy has significant implications for industry policy aimed at facilitating sectoral restructuring and transformation. This phenomenon signifies the inertia in capital adjustment, which manifests itself in the inability of market mechanisms to align investment incentives in order to overcome investment hysteresis at times of adverse market conditions. Specifically, an existing farm business holds the valuable option of waiting despite minimal or even negative profitability. With this option in place, prospective buyers of the farm business or its key assets such as the land would have to pay for all or part of the owner's option in order to induce a sale — even if the option carries little value to them.

Where market mechanisms are frustrated by non-compatible investment incentives, there can be a legitimate role for government intervention to ease the adjustment process in order to expedite the realisation of efficiency gains from industry restructuring. There have been farm programs in Australia and overseas (e.g. the United States) that provide exit assistance to farmers leaving the sector. Such policy initiatives help strengthen farmers' propensity to exit from loss-making production.

A more fundamental policy objective is to reduce the likelihood of investment indeterminacy in farm asset markets, thereby improving the responsiveness and effectiveness of market mechanisms in bringing about necessary sectoral adjustments to ensure efficient investment and production.

In this connection, the study looked at the outcome of promoting larger-scale production to reduce the revenue range that is susceptible to muted investment response. The existence of economies of scale was shown to have the effect of reducing the relative significance of sunk costs in total costs and, hence, the scope for creating the strategic value (i.e. opportunity cost) in waiting to exit and enter for farms of a larger size.

The study also identified an inverse relationship between increased revenue variance and increased investment hysteresis. Accordingly, a reduction in policy uncertainty that contributes to the perception of revenue volatility could help elicit responsive farm adjustments by strengthening the profit incentives for investment and disinvestment. This would call for consistency in farm policies between the objectives of facilitating exit and sustaining continuous production.

References

ABS (Australian Bureau of Statistics) various years, *Australian Wine and Grape Industry Survey*, Cat. no. 1329.0, ABS, Canberra.

Brennan, M. and Schwartz, E. 1985, Evaluating natural resource investments, Journal of Business, **58**, 135–57.

Dixit, A. K. 1989, Entry and exit decisions under uncertainty, Journal of Political Economy, **97**, 451–71.

—— 1992, Investment and hysteresis, Journal of Economic Perspective, **6**, 107–32.

—— and Pindyck, R. S. 1994, Investment under Uncertainty, Princeton NJ: Princeton University Press.

Graham, J. R. and Harvey, C. R. 2001, The theory and practice of corporate finance: evidence from the field, Journal of Financial Economics, **60**, 187–43.

Hull, J. C. 1997, *Options, Futures, and other Derivatives*, Englewood Cliffs NJ: Prentice-Hall.

Johnson, G. L. 1960, The state of agricultural supply analysis, *Journal of Farm Economics,* **42**, 432–52.

Harrigan, K. R. 1981, Deterrents to divestiture, *Academy of Management Journal,* **24**, 306–23.

Jorgensen, D. 1963, Capital theory and investment behaviour, *American Economic Review,* **53**, 247–57.

Luong, Q. V. and Tauer, L. W. 2006, A real options analysis of coffee planting in Vietnam, *Agricultural Economics*, **35**, 49–57.

Marshall, A. 1920, *Principles of Economics: An Introductory Volume*, Macmillian: London.

McDonald, R. and Siegel, D. 1985, Investment and the valuation of firms when there is an option to shut down, *International Economic Review*, **26**, 331–49**.**

Mues, C. and Rodriguez, B. V. 2007, Mildura–Wentworth, a Case Study of Horticultural Farm Performance, ABARE Research Report 07.6, ABARE, Canberra.

Price, J. T. and Wetzstein, M. E. 1999, Irreversible investment decisions in perennial crops with yield and price uncertainty, *Journal of Agricultural and Resource Economics*, **24**, 173–85.

Ryan, S. 2007, Opportunities for Gaining Economies of Scale through Collaboration, Street Ryan and Associates Pty Ltd.

Schmit, T. M., Luo, J. and Tauer, L. W. 2009, Ethanol plant investment using net present value and real option analysis, *Biomass & Bioenergy*, **33**, 1442–51.

Seo, S. Salin, V. Mitchell, P. and Leatham, D. 2004, Effect of Revenue Insurance on Entry and Exit Decisions in Table Grape Production: A Real Option Approach, Paper presented at American Agricultural Economics Association Meeting, Denver, Colorado, USA August 1–4.

Swinburn, G. and MacGregor, A. 2007, Economic Sustainability of Dried Grape Production, Scholefield Robinson Horticultural Services.

Tauer, L. W. 2006, When to Get In and Out of Dairy Farming: A Real Option Analysis, Paper presented at American Agricultural Economics Association Meeting, Long Beach, California, USA, July 24–26.

Tauer, L. W. and Dressler, J. 2009, When to Exit Dairy Farming: The Value of Waiting, Applied Economics and Management, Cornell University.