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A Cost-Benefit Analysis of Entering and Exiting Vineyard Operations in Niagara: 1997 - 2011

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INTRODUCTION



GOAL

TO EXAMINE THE FINANCIAL VIABILITY AND ECONOMIC SUSTAINABILITY OF VITIS VINIFERA GRAPE PRODUCTION IN NIAGARA WITHIN THE CONTEXT OF GRAPE PRICE UNCERTAINTY OVER THE PERIODS 1997 - 2011.

To examine the financial decision of establishing vineyard production or to abandon vineyard production historically.

To examine the current situation in terms of grape pricing and the financial viability of low end and premium grape production in Niagara.

Dixit and Pindyck (1994) Real Options Model of Entry and Exit

Number of Prior Applications to Agriculture

Price, T., & Wetzstein, M. (1999). Irreversible investment decisions in perennial crops with yield and price uncertainty. *Journal of Agricultural and Resource Economics*. Vol. 24 , 173-185.

Isik, M., Cobleb, K.H., Hudson, D. and House, L.O. (2003). A model of entry–exit decisions and capacity choice under demand uncertainty, *Agricultural Economics* Vol. 28, pp. 215-224.

Tauer, L. W. (2006). When to get in and out of dairy farming: A real option analysis, *Agricultural and Resource Economics Review*, Vol. 35, pp.339-47.

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

Cyr, D., Hanagriff, R., & Kwong, L. (2010). What is Making Investment in the Texas Vineyard Industry Tick? A Real Options Analysis of Entry and Exit. *Journal of Wine Economics*. Vol. 5 , 236-255.



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REAL OPTIONS

The application of financial option based theory and mathematics to investment decisions.

Enables the capturing of flexibility within investment projects, that might be critical to their value, and which is not recognized in standard cost/benefit analysis.

http://en.wikipedia.org/wiki/Real_options_valuation

Real Options: A Practitioners Guide

Thomas Copeland and Vladimir Antikarov

Real Options: Managing Strategic Investment in an Uncertain World

Martha Amram and Nalin Kulatilaka

Real Options: Managerial Flexibility and Strategy in Resource Allocation

Lenos Trigeorgis



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Dixit and Pindyck Model of Entry and Exit

Key Elements of the Model:

V_o = the value of undeveloped land.

Represents an option to invest in a vineyard where the underlying asset is an operating tract of vineyard land V_1 and the exercise price is the cost of establishing including cost of land, establishment and development costs.

V_1 = the value of a developed and operating vineyard.

Has associated with it, the option to abandon the vineyard for the liquidation value X which is largely assumed to the price of undeveloped land.



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Dixit and Pindyck Model of Entry and Exit

Goes beyond basic cost/benefit analysis but looking at critical grape prices it would take to make an investment in an vineyard or to abandon vineyard production.

Option to Invest and Critical Price for Entry

The investment in a tract of land, to develop a vineyard, is not going to take place simply because the current grape price just makes it worthwhile from a cost-benefit analysis. The uncertainty of future grape prices and irreversible nature of the investment will result in rational investment only taking place if the price is high enough to compensate for the uncertainty.

Option to Abandon and Critical Price for Exit

Similarly, the decision to abandon will not take place just because the current grape price is just below the level of profitability from a cost-benefit analysis. The possibility that prices may rise in the future results in abandonment only taking place only once a critical low price is reached.



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Dixit and Pindyck Model of Entry and Exit

The value of the model is in solving for the critical price levels at which it is financially optimal to invest (entry price) or abandon (exit price) given price uncertainty.

Variables defined within the model

V_0 : The value of an idle (non-producing) investment, or tract of land.

V_1 : The value of an active (producing) vineyard.

P : Market price per ton of grapes.

μ : Expected percent growth rate of the market price P of grapes.

σ^2 : Variance of the percentage change of the market price P .

C : Variable cost of a ton of grapes produced from the investment.

K : Total costs of investment (land and other fixed costs) per ton of grapes produced.

X : Net liquidation value, per ton of grapes produced.

ρ : Opportunity cost of capital for the firm where $\rho > \mu$.

H : Critical market price of grapes per ton at which investment (entry) occurs.

L : Critical market price of grapes per ton at which abandonment (exit) occurs.



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Dixit and Pindyck Model of Entry and Exit

Continuous time mathematics based on option pricing modelling.

Grape Price Process

$$dP = \mu P dt + \sigma P dz$$

General Partial Differential Equation for an option based on grape prices

$$dV(P) = \left(V'(P)\mu P + \frac{1}{2} V''(P)\sigma^2 P^2 \right) dt + V'(P)\sigma P dz$$

Value of undeveloped land as an option to invest

$$V_0(P) = BP^\beta$$

Value of developed land as the present value of net revenues plus the option to abandon.

$$V_1(P) = \frac{P}{\rho - \mu} - \frac{C}{\rho} + AP^\alpha$$

$$\alpha = \frac{\sigma^2 - 2\mu - ((\sigma^2 - 2\mu)^2 + 8\rho\sigma^2)^{1/2}}{2\sigma^2} < 0$$

$$\beta = \frac{\sigma^2 - 2\mu + ((\sigma^2 - 2\mu)^2 + 8\rho\sigma^2)^{1/2}}{2\sigma^2} > 1$$

Critical entry price (H) for investing

$$V_0(H) = V_1(H) - K$$

Critical exit price (L) for abandoning

$$V_1(L) = V_0(L) + X$$



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Dixit and Pindyck Model of Entry and Exit

Solution is derived by solving four equations for four unknowns:

A (constant)

B (constant)

H = Critical entry grape price

L = Critical exit grape price

$$\frac{H}{\rho - \mu} - \frac{C}{\rho} + AH^\alpha - BH^\beta - K = 0$$

$$\frac{1}{\rho - \mu} + \alpha AH^{\alpha-1} - \beta BH^{\beta-1} = 0$$

$$\frac{L}{\rho - \mu} - \frac{C}{\rho} + AL^\alpha - BL^\beta - X = 0$$

$$\frac{1}{\rho - \mu} + \alpha AL^{\alpha-1} - \beta BL^{\beta-1} = 0$$



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Inputs into the model

Establishment Costs K (per tonne)

Cost of land plus land preparation, equipment and other establishment costs as well as cost of production up to the beginning of the fourth year. The cost per acre is then divided by the assumed yield (dependent upon grape variety). Land prices were estimated based on current prices adjusted for prior years based on Farm Credit statistics on growth in land prices.

Abandonment Value X

Assumed to be the original value of the land, so as not to confound the analysis with return on investment in land.

Rate of return on investment: $\rho = 8\%$ to 12%

Growth rate in grape prices: $\mu = 0\%$ to 3%

Volatility of grape prices: $\sigma = 7\%$ to 9%

Cost of production per tonne: C

Based upon OMAFRA cost reports 1997, 2001, 2005 and 2009

Grape Varieties: Considered: Riesling, Chardonnay, Cab Franc, Cab Sauv.



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Cabernet Franc

2011 costs of production based on OMAFRA reports

Preplant Year (t=0)		Planting Year (t=1)		Second Year (t=2)		Third Year (t=3)		Fourth Year (t=4)		Mature Vineyard (t=5)	
Activity	Variable	Activity	Variable	Activity	Variable	Activity	Variable	Activity	Variable	Activity	Variable
Labour: Machinery Operator 4.2 hours	\$72	Labour: Hand, 28.0 hrs	\$347	Labour: Hand, 22.6 hr	\$280	Labour: Hand, 44.1 hrs	\$547	Labour: Hand, 44.0 hrs	\$546	Labour: Hand, 71.5 hrs	\$887
Custom Plowing	\$23	Machine Operator, 19.8 hrs	\$341	Machine Operator, 28.4 hr	\$427	Machine Operator, 30.7 hrs	\$528	Machine Operator, 26.5 hrs	\$456	Machine Operator 31.7 hrs	\$545
Cover Crop	\$46	Fertilizer Ammonium Nitrat	\$2	Fertilizer: Ammonium nitra	\$3	Fertilizer: Ammonium nitra	\$7	Fertilizer: Ammonium nitrate, 2	\$17	Fertilizer: Ammonium Nitr	\$22
Machine Costs :Repairs and maintenance	\$33	Muriate of Potash, 17 kg	\$12	Muriate of Potash, 17 kg	\$14	Muriate of Potash, 39 kg	\$46	Muriate of Potash, 48 kg	\$56	Muriate of Potash, 61 kg	\$61
Fuel	\$36	Insecticides	\$0	Insecticides	\$43	Insecticides	\$86	Insecticides	\$130	Insecticides	\$130
Consulting Fees	\$32	Fungicides	\$63	Fungicides	\$178	Fungicides	\$357	Fungicides	\$541	Fungicides	\$541
Interest on operating capital	\$65	Grape vines, (\$2.70/vine)	\$3,267	Herbicides	\$19	Herbicides	\$36	Herbicides	\$45	Herbicides	\$56
Land Preparation (levelling etc.)	\$850	Custom Trellis:Materials, la	\$5,306	Replacement vines, 2%	\$101	Replacement vines, 1%	\$50	Replacement vines, 1%	\$50	Replacement Vines 1%	\$50
Total Variable Costs	\$1,157	Training: Stakes, material	\$1,162	Cover crop seed	\$23	Cover crop seed	\$23	Cover crop seed	\$23	Cover crop seed	\$23
Activity	Fixed	Cover crop seed	\$46	Machine Costs: Repairs and	\$113	Machine Costs: Repairs and	\$127	Machine Costs: Repairs and mai	\$127	Wind Machine	\$411
Machine Costs: Depreciation	\$59	Machine costs: Repairs and	\$90	Fuel	\$243	Fuel	\$262	Fuel	\$226	Machine Costs: Repairs & r	\$174
Interest on investment	\$13	Fuel	\$156	Custom Pruning - \$.25/vine	\$303	Custom Pruning - \$.31/vine	\$375	Custom Pruning - \$.36/vine	\$436	Fuel	\$271
Other overhead	\$107	Custom Planting	\$724	Custom Tying - \$.15/vine	\$182	Custom Tying - \$.18/vine	\$218	Custom Tying - \$.19/vine	\$230	Custom pruning \$.37/vine	\$448
Measurable Fixed Costs	\$179	Irrigation	\$171	Tying material	\$25	Tying material	\$25	Tying material	\$25	Custom Tying - \$.19/vine	\$230
Total Measurable "Preplant Year" Costs	\$1,336	Consulting Fees	\$32	Irrigation	\$171	Irrigation	\$171	Irrigation	\$171	Tying Material	\$25
		Interest on operating capita	\$513	Consulting Fees	\$32	Bird Control	\$124	Bird Control	\$124	Irrigation	\$171
	\$26,566	Total Variable Costs	\$12,232	Interest on operating capita	\$602	Marketing Board Fees	\$29	Custom harvest/delivery	\$182	Bird Control	\$124
	\$6,642	Activity	Fixed	Total Variable Costs	\$2,759	Crop Insurance	\$156	Marketing Board Fees	\$59	Custom harvest/delivery*	\$324
		Machine Costs: Depreciatio	\$144	Activity	Fixed	Consulting Fees	\$32	Crop Insurance	\$312	Marketing board fees*	\$104
		Interest on investment	\$31	Machine Costs: Depreciatio	\$178	Interest on operating capita	\$726	Consulting Fees	\$32	Crop Insurance* \$139 per	\$485
		Other overhead	\$214	Interest on investment	\$39	Total Variable Costs	\$3,925	Interest on operating capital	\$811	Consulting Fees (soil, leaf,	\$32
		Measurable Fixed Costs	\$389	Other overhead	\$214	Activity	Fixed	Total Variable Costs	\$4,598	Interest on operating capit	\$164
		Total Measurable "Planting"	\$12,621	Measurable Fixed Costs	\$431	Machine Costs: Depreciatio	\$192	Activity	Fixed	Total Variable Costs	\$5,278
				Total Measurable "Second "	\$3,190	Interest on investment	\$42	Machine Costs: Depreciation	\$192	Activity	Fixed
						Other overhead	\$214	Interest on investment	\$42	Machine Costs: Depreciatio	\$248
						Measurable Fixed Costs	\$448	Other overhead	\$214	Interest on investment	\$51
						Total Measurable "Third Ye	\$4,373	Measurable Fixed Costs	\$448	Other overhead	\$214
								Total Measurable "Fourth Year"	\$5,046	Measurable Fixed Costs	\$513
										Total Measurable Cost	\$5,791



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Cabernet Franc Example

4 tonnes per acre

Table 3. Historical Entry and Exit analysis for Cabernet Franc at $\sigma = 0.07$.

Year	Entry Price	Exit Price	μ	σ	ρ	C	K	X
2011	\$2,644.08	\$1,473.04	0.03	0.07	0.08	\$1,536.00	\$11,596.02	6,023.50
2010	\$2,557.26	\$1,417.14	0.03	0.07	0.08	\$1,492.00	\$11,134.62	5,658.54
2009	\$2,470.42	\$1,360.84	0.03	0.07	0.08	\$1,448.00	\$10,673.22	5,293.30
2008	\$2,345.79	\$1,274.32	0.03	0.07	0.08	\$1,358.00	\$10,346.10	5,034.85
2007	\$2,221.14	\$1,188.04	0.03	0.07	0.08	\$1,268.00	\$10,018.96	4,776.40
2006	\$2,096.48	\$1,102.16	0.03	0.07	0.08	\$1,178.00	\$9,691.82	4,517.95
2005	\$1,971.84	\$1,016.72	0.03	0.07	0.08	\$1,088.00	\$9,364.68	4,259.50
2004	\$1,853.19	\$946.61	0.03	0.07	0.08	\$1,011.25	\$8,942.46	4,035.85
2003	\$1,734.57	\$876.56	0.03	0.07	0.08	\$934.50	\$8,520.23	3,812.18
2002	\$1,615.95	\$806.86	0.03	0.07	0.08	\$857.75	\$8,098.00	3,588.51
2001	\$1,497.34	\$737.00	0.03	0.07	0.08	\$781.00	\$7,675.77	3,364.84
2000	\$1,429.24	\$708.34	0.03	0.07	0.08	\$749.75	\$7,273.52	3,220.38
1999	\$1,361.18	\$679.58	0.03	0.07	0.08	\$718.50	\$6,871.27	3,073.92
1998	\$1,293.14	\$651.01	0.03	0.07	0.08	\$687.25	\$6,469.01	2,928.46
1997	\$1,225.06	\$622.41	0.03	0.07	0.08	\$656.00	\$6,066.76	2,783.00



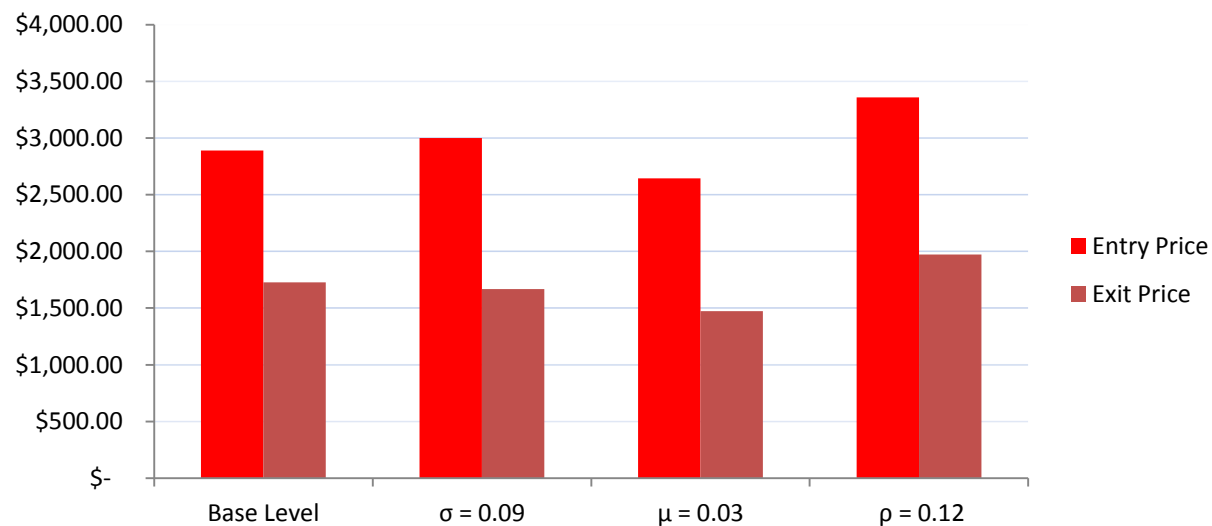
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Cabernet Franc Example

Sensitivity to Assumptions (2011 analysis)

Cab Franc	Entry Price (H)	Exit Price (L)	μ	σ	ρ	C	K	X
Base Level $\sigma = 0.07$, $\mu = 0.0$ $\rho = 0.08$	\$2,888.39	\$1,727.68	0.00	0.07	0.08	\$1,536.00	\$11,596.02	\$6,023.00
$\sigma = 0.09$	\$3,000.67	\$1,667.70	0.00	0.09	0.08	\$1,536.00	\$11,596.02	\$6,023.00
$\mu = 0.03$	\$2,644.08	\$1,473.19	0.03	0.07	0.08	\$1,536.00	\$11,596.02	\$6,023.00
$\rho = 0.12$	\$3,356.95	\$1,973.63	0.00	0.07	0.12	\$1,536.00	\$11,596.02	\$6,023.00





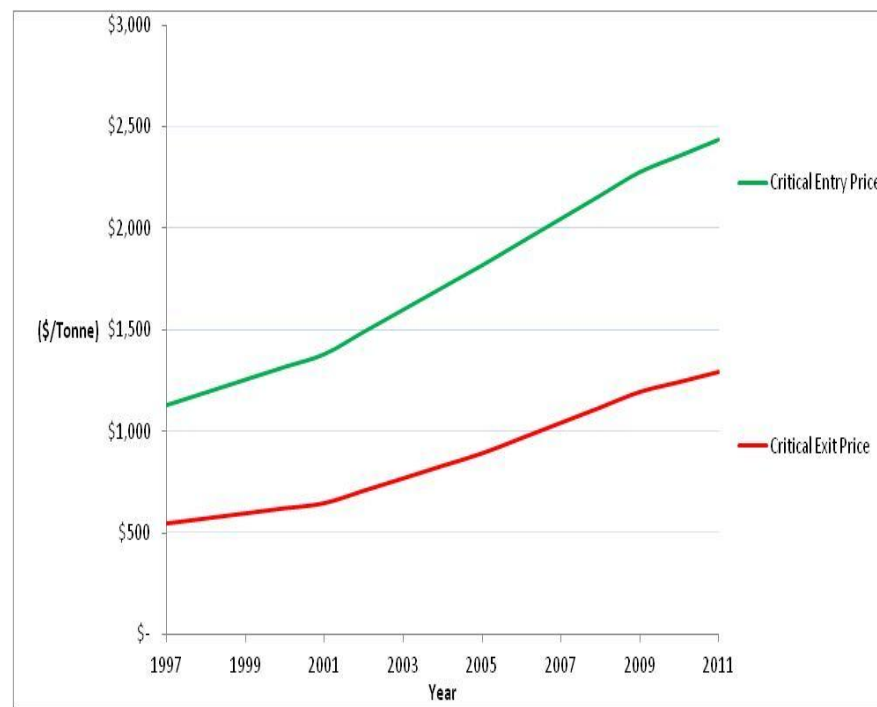
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Entry and Exit Prices Historical

Based on $\mu = .03, \sigma = .09, \rho = .08$, yield = 4.5 tonnes/acres
Average OMAFRA costs across four grape varieties

Year	Entry		Exit	
2011	\$	2,439	\$	1,289
2010	\$	2,359	\$	1,240
2009	\$	2,279	\$	1,191
2008	\$	2,165	\$	1,115
2007	\$	2,050	\$	1,039
2006	\$	1,935	\$	964
2005	\$	1,820	\$	889
2004	\$	1,711	\$	828
2003	\$	1,601	\$	766
2002	\$	1,492	\$	705
2001	\$	1,382	\$	644
2000	\$	1,319	\$	619
1999	\$	1,257	\$	594
1998	\$	1,194	\$	569
1997	\$	1,131	\$	544





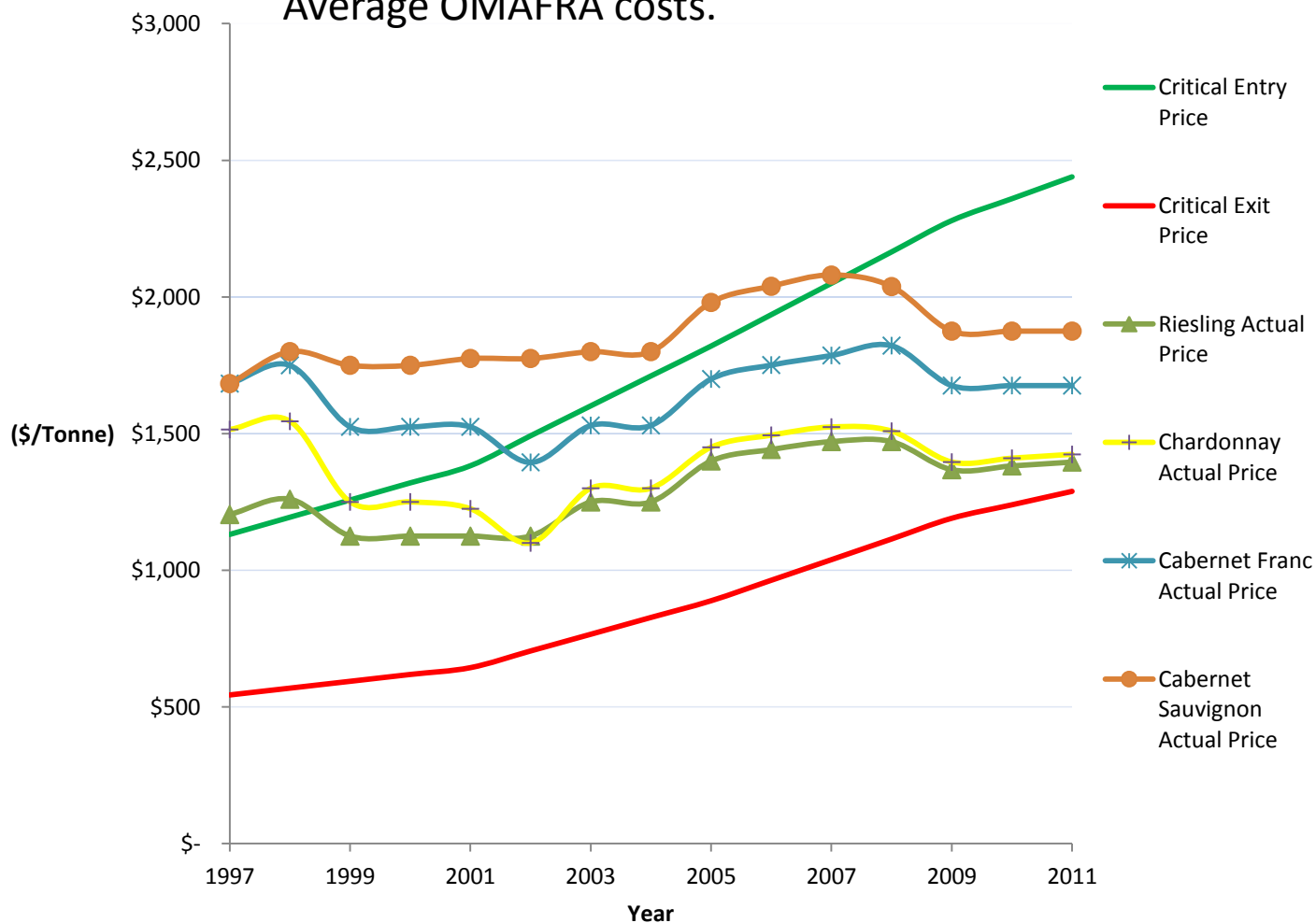
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Entry and Exit Prices Versus Actual

$\mu = .03, \sigma = .09, \rho = .08$, yield = 4.5 tonnes/acres

Average OMAFRA costs.





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Entry and Exit Prices Versus Actual

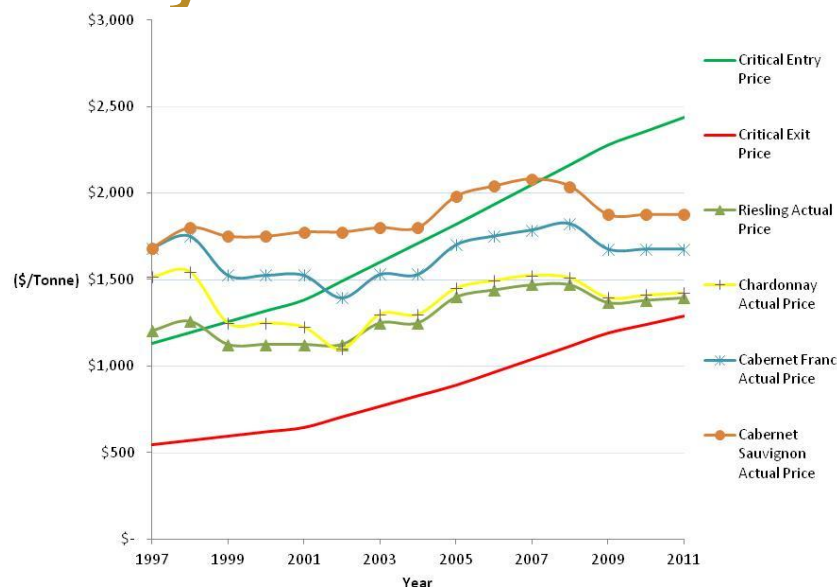
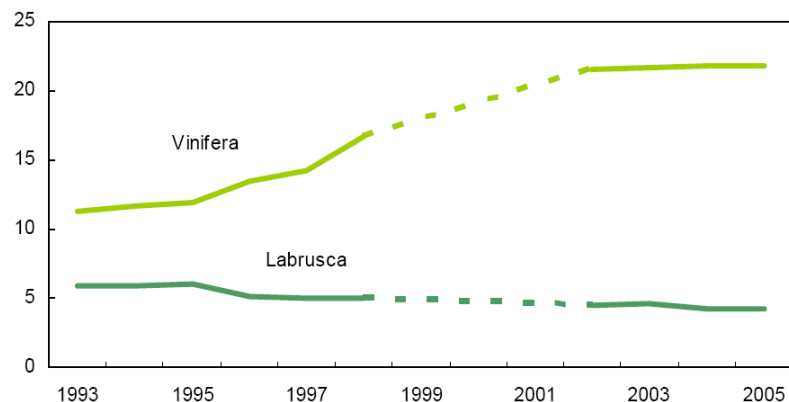


Chart 1 Grapes growers switched from table grapes to higher quality wine grapes

thousands of acres planted



Note(s): Data from 1999 to 2001 are confidential. Consequently, the dotted lines are linear projections.

Source(s): Statistics Canada, Agriculture Division.



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Current Grape Price Analysis

LOW END PRODUCTION:

6 tonnes/acre, C = \$5,728 per acre or \$954.67 per tonne

Entry Price

\$1,752 per tonne

Exit Price

\$ 912 per tonne

Riesling

18.0 Brix

\$1,200 per tonne

Chardonnay

20.0 Brix

\$1,200 per tonne

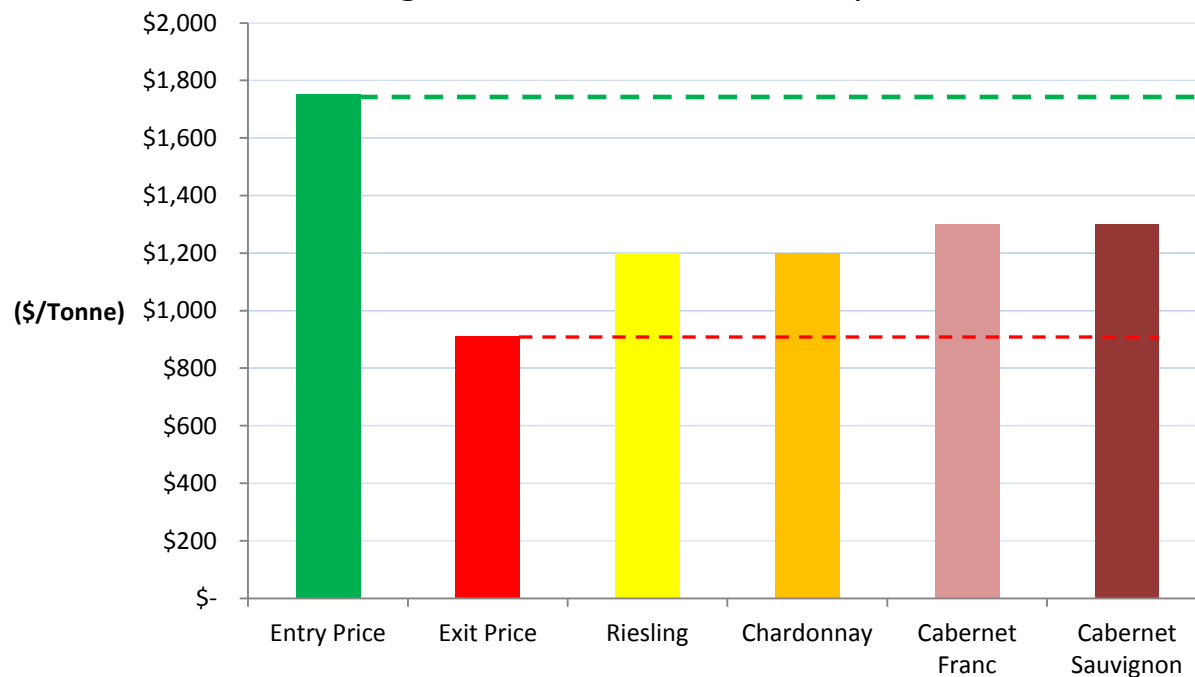
Cabernet Franc

20.3 Brix

\$1,300 per tonne

Cabernet Sauvignon 20.4 Brix

\$1,300 per tonne





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Current Grape Price Analysis

PREMIUM PRODUCTION:

3.5 tonnes/acre, C = \$7,340 per acre or \$2,097.14 per tonne

Entry

\$3,515 per tonne

Exit

\$1,930 per tonne

Riesling

21.1 Brix

\$1,640 per tonne

Chardonnay

23.0 Brix

\$1,673 per tonne

Cabernet Franc

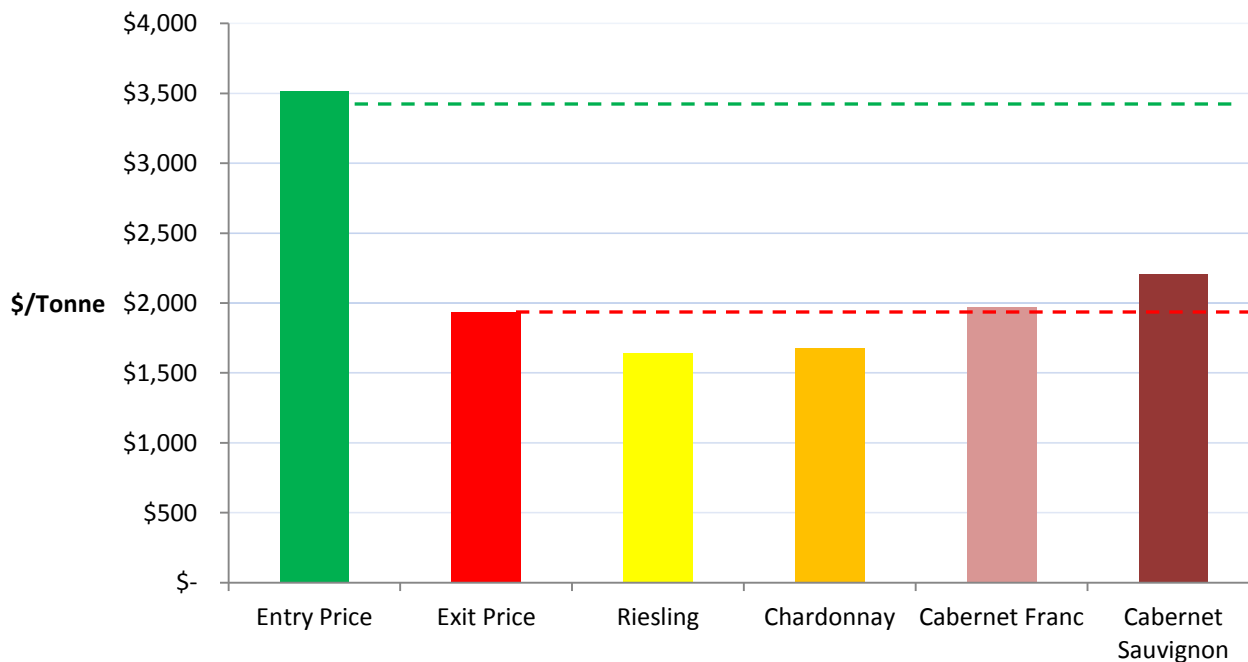
23.3 Brix

\$1,969 per tonne

Cabernet Sauvignon

23.4 Brix

\$2,203 per tonne





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Historical and Current Grape Price Analysis Summary

Historical Analysis

Growth of wine grape production acreage in Niagara is probably consistent with the analysis – high growth up until early 2000's. Grape prices generally exceeding critical entry price for investment purpose.

Current Grape Price Analysis

Low end grape price production is currently more attractive than premium grape price production.

Premium grape prices are approaching critical Exit Price levels, particularly in the case of the Riesling and Chardonnay grape varieties.



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CAVEATS

Broad Average Analysis – individual producers face different cost structures and conditions.

Does not take into account all the individual complexities in making the decision to enter or exit vineyard production.

Other Sources of Uncertainty

- Yield per acre
- Variable cost C per tonne
- Abandonment value

Modelling becomes intractable – can be approximated somewhat by increasing volatility of grape price.

Land value in terms of abandonment has been kept constant in the model. Increasing abandonment value will narrow the difference between exit and entry prices.



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THE END

