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Development Strategies for a Premium Wine Region of Australia: an application of value chain modelling

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Development Strategies for a Premium Wine Region of Australia: an application of value chain modelling¹

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Abstract

The wine industry in Western Australia, like its counterparts in some other wine-making regions across the globe, faces some interesting investment choices regarding the relative merits of expenditure on promotion or production and whether export or domestic markets should be the focus for sales growth. This paper uses value-chain modelling to examine the economic consequences of investment scenarios involving promotion and the enhancement of the productivity of premium wine grape production. A value-chain model is constructed that considers grape growers, wineries, wholesalers, retailers and exporters. The model is applied to estimate the economic ramifications of three different investment scenarios. The main findings are that promotion activity in overseas markets that stimulates premium wine grape production in Western Australia, generates the greatest economic gains for the Western Australian wine industry. By contrast, if investment solely occurs in production research that boosts the productivity of premium wine grape production, then it generates the smallest economic gains relative to other investment options that include promotion.

Keywords: wine, value chains, premium wines, promotion, productivity

1. Introduction

Like some other Southern hemisphere wine producers over the last decade, the Australian wine industry experienced initial boom conditions followed by global oversupply (Anderson, 2010a; WFA, 2009; Bell, 2010; Davis *et al.*, 2010). Australian wine grape production increased rapidly from 539 kT in 1990-1 to peak at 1938 kT in 2004-5 (see Figure 1). During this period, export growth was a major source of revenue for the industry. Export sales of wine were \$Aus599 million in 1996/6 at a unit price of \$Aus3.86 per litre. By 2004-5 these sales had increased to \$Aus2748 and the unit price had risen to \$Aus4.16 per litre. However, by 2010-11 wine grape production was 20 percent below the peak in 2004-5 and the export sales had declined by almost 30 per cent to be only \$Aus1957 million and the unit price had dropped to \$Aus2.69 per litre. The structural shift from expanding production to a subsequent rapid exposure to global competition and oversupply has tested the economic resilience of many wine grape-growing regions of Australia.

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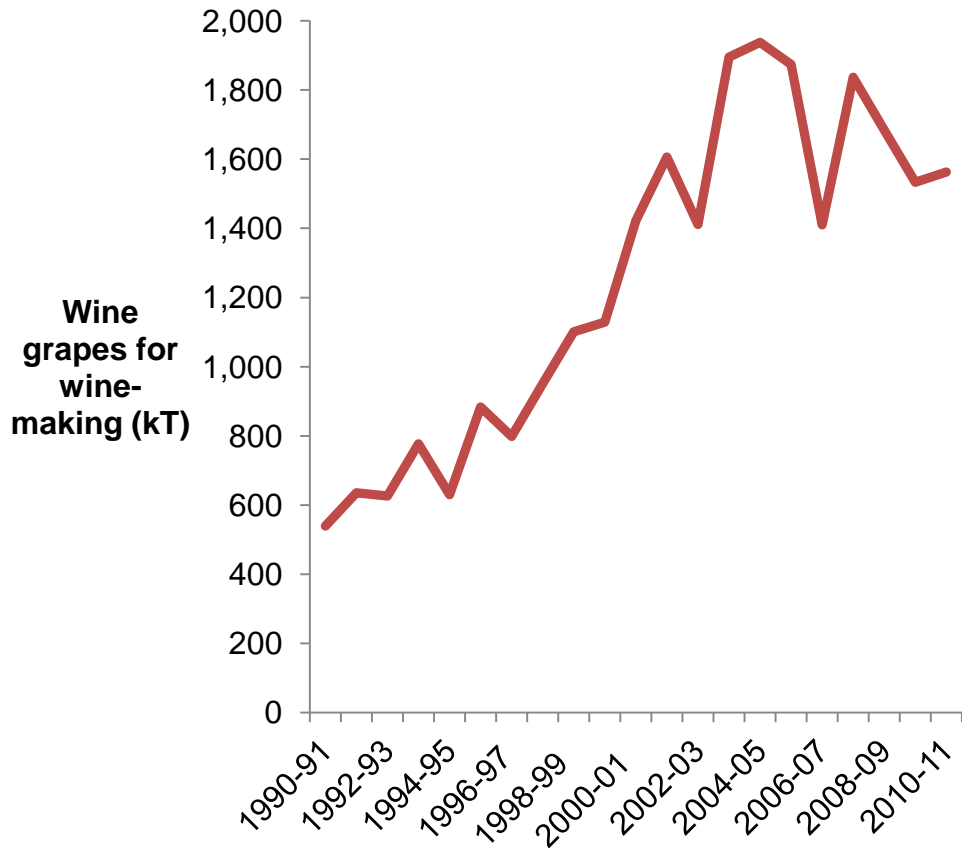


Figure 1. Wine grape production in Australia: 1990-1 to 2010-11.

One of Australia’s most famous premium wine regions, known as the Margaret River region, is located in the cool far south west corner of Western Australia (see Figure 2) where a Mediterranean-type climate prevails. Wines from this region have achieved an excellent reputation for quality, such that although the region only currently supplies 4% of Australia’s wine by volume, it equates to nearly 20% of the value of Australian wine and supplies 30% of Australia’s high value wines. The region’s premium quality wine grape varieties are used to make super premium, ultra premium and icon wines and the industry has invested heavily in vineyard and wine making technology.



Figure 2: Wine growing regions of Western Australia

Source: <http://www.thetrail.com.au/images/wawineandfood/WAWineRegionsMap.jpg>

Complementing the wine production from the Margaret River region is production from adjacent warmer inland regions (see Figure 2). Wine produced in many of these adjacent regions is principally commodity wine that sells for retail prices less than \$Aus10 per litre. In the past two decades wine production in Western Australia has expanded faster than the national industry (DAFWA, 2007) and yet, on average, the export price of wines from Western Australia is almost double the price received by wine exported from the rest of Australia (Agrifood infonet 2012).

While export growth has been the major driver of growth in the national wine industry, this has not been the case for the wine industry in Western Australia (WA) as most wine produced in WA is sold on local and national markets (DAFWA, 2007). The current proportion of premium and commodity wine in WA's production is about 35:65. Although the WA wine industry mostly has a national and local focus, nonetheless as a supplier of high end premium wines in these and some international markets, the industry has been adversely affected by the emergence of greater international supplies and the rise in the value of the Australian dollar. The latter has meant that even domestic sales have been affected by wine imports, especially from New Zealand.²

² A producer rebate scheme for New Zealand producers means any of their wine sold in Australia provides them with an attractive margin.

To respond to its current structural challenges, the WA industry wants to shift its production focus even more towards premium wine production. To support this shift the industry is considering a few options; investing in promotion to stimulate demand for its premium wine or investing further in production research to increase the productivity of premium wine production. As yet no formal assessment of the economic merits of these investments has been undertaken. The focus of this paper is to provide such an assessment, and to estimate the impacts of these investment options on the value chains that underpin the WA wine industry.

Regarding investments in productivity-enhancing R&D, the resulting distribution of productivity gains among supply chains has been a topic of interest to economists and to industry players who contribute research funds for productivity gain (see for example, Freebairn *et al.*, 1982; Alston and Scobie, 1983; Holloway, 1989; Lemieux and Wohlgenant, 1989; Mullen *et al.*, 1989; Wohlgenant, 1993; Chung and Kaiser 1999; Zhao, 2002; and Zhao *et al.*, 2003). These studies typically conclude that results are highly sensitive to the assumptions about the nature of supply and demand curves, elasticities of substitution and the type of shift in supply curves generated by R&D.

Freebairn *et al.* (1982) used a single process commodity surplus model to evaluate the benefits from multistage production. They found that the more inelastic a sector's supply relative to other sectors, the larger were the research benefits to that sector. With zero elasticity of substitution, off-farm oriented research was found to be more worthwhile than farm oriented research. Alston and Scobie (1983) extended the study by relaxing the assumptions. They found that research on farm production was better than off farm research when the elasticity of substitution was not zero. If input substitution was not possible, each sector received an equal share of the benefit from the research in any sector, but when input substitution was possible, then the distribution of benefits was greater for the sector that was the primary focus of the research.

Some authors, such as Zhao (2003), include investment in promotion in their modelling of impacts. Zhao (2003), for example, estimated the distribution of aggregate returns from R&D and promotion in the Australian wine industry using an equilibrium displacement model (see other examples: Mullen *et al.*, 1982; Mullen *et al.*, 1989; Mounter *et al.*, 2007; Zhao *et al.*, 2003 & 2005; Zhao 2000 & 2002). Zhao (2003) found that gains from cost-reducing R&D mainly went to producers. Similarly producers benefited more from export promotion than from domestic promotion. These results held for a wide range of parameter values.

Understanding the relative returns and their distribution when facing a choice between investing in production or promotion activity is important when funds for such activities are scarce (Wohlgenant, 1993). In this paper we analyse the comparative advantage of investing in production *versus* promotion of premium wine. An interactive multimarket value chain model is constructed and is used to estimate the value-added by the wine industry to the WA economy. The impacts on the WA economy of alternative investment scenarios for the wine industry are compared, as well as the distribution of profits among sectors in the industry's value chain. This paper comprises four sections. Section 2 describes the model and its data sources. Results and discussion are presented in section 3, and conclusions are given in section 4.

2. Modelling approach

2.1 Model Structure

Figure 3 is a schematic outline of the value chain model for the WA wine industry. It describes the flows of input and output quantities of sectors in the industry's value chain. Each rectangle represents a key value-added³-generating sector in the industry; including wine grape growers, wine makers, wine wholesalers, wine retailers, and wine exporters. Due to data limitations we omitted a specific wine tourism sector which generates value-added from its services but we did include wine sales in hotels, and included restaurant and tourism activities as part of the retail sector. Sectors were classified as sectors being within the industry (identified by rectangles) or as being outside the industry (identified by ovals). These latter sectors may supply intermediate inputs or may purchase final products from sectors within the industry. We modelled the entire industry as producing only premium and commodity wines. This distinction allowed us to investigate separate impacts on the premium and commodity wine sub-sectors.

The model consists of accounting and interactive equations. The accounting equations capture the transaction values of wine grapes and wine products among the sectors within the industry, as well as those transactions between the sectors within the industry and those outside the industry. The accounting equations are grouped into production costs, revenues, and value-added for each sector within the industry and are expressed as follows:

$$(1) c_s = ipoi_s + ipwi_s + wet_s^c - wet_s^r$$

$$(2) r_s = opwi_s + opoi_s$$

$$(3) va_s = r_s - c_s [1 - (l_s + k_s + v_s)]$$

Equation (1) is the production cost which includes input from sectors outside the industry ($ipoi_s$) and input from sectors within the industry ($ipwi_s$). It also accounts for the Wine Equalisation Tax (WET) treatment in winemaking and wholesale sectors, where wet_s^c and wet_s^r is the WET charge and producer rebate⁴, respectively. Equation (2) is the revenue which includes value of outputs sold to sectors within the industry' ($opwi_s$) as intermediate goods and the value of outputs sold to sectors outside the industry' ($opoi_s$) as final sales. Equation (3) is the value-added which is the difference between revenues and costs excluding the costs of wages, interests and rent, where l_s , k_s , and v_s is the cost share of wages, interest and rent payments, respectively.

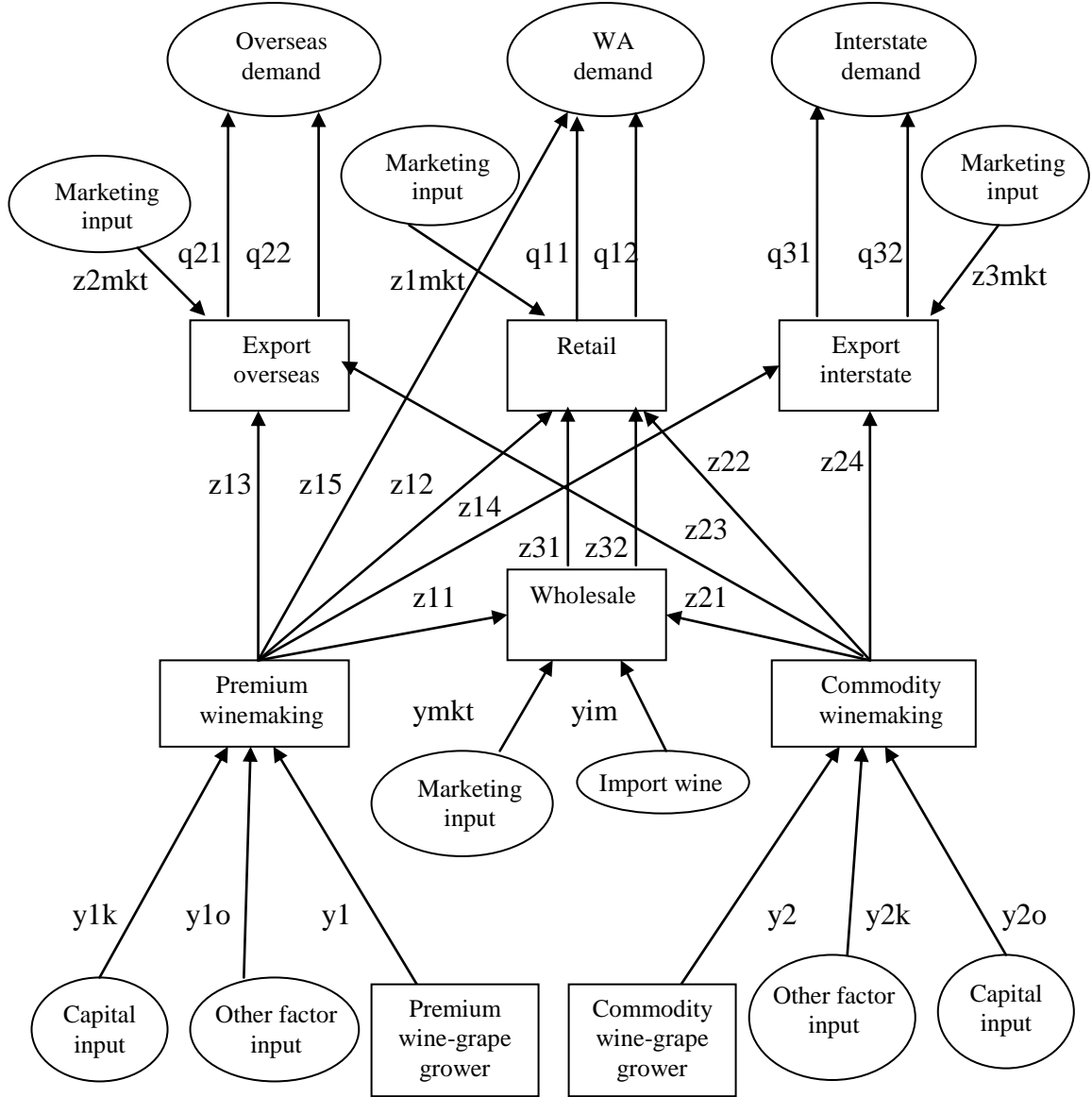
Turning to interactive equations, they provide response functions for sectors to adjust their revenue, production cost, and hence each sector's value added when there are external factor and policy shocks. The interactive equations consist of a set of demand and supply functions, and market equilibrium conditions. To derive this set of functions, we adopted the approach

³ Value added is the sum of profit, wages, interests and rent (Islam 1997)

⁴ Producer rebate scheme entitles wine producers to a rebate of 29% of the wholesale value of eligible domestic sales (Source: Guide to wine equalisation tax, Australian Taxation Office)

developed by Zhao (1999) and Zhao *et al.* (2003). They assume that all sectors in the supply chain are utility and profit maximisers and that the industry's technologies are characterised by constant returns to scale.

Figure 3. Schematic of the model.



As indicated earlier, the sectors outside the industry may supply intermediate inputs to or purchase final products from sectors within the industry. Accordingly x_s^{is} is the factor input supply and x_s^{od} is the output demand by sectors outside the industry. According to Zhao (1999) and Zhao *et al.* (2003), the factor- input supply and output demand are exogenous to the model and can be expressed in generic function form as follows:

$$(4) x_s^{is} = x_s^{is} (w_s^{is}; t_s^{is})$$

$$(5) x_s^{od} = x_s^{od} (w_s^{od}, w_{\#s}^{od}; n_s^{od})$$

Equation (4) shows that the supplies of factor input responds to its own price (w_s^{is}) and a supply shifter (t_s^{is}). This function is applied to the input supply of all sectors, such as import of wine, capital and marketing inputs, except for the supply of grapes. We assumed that the supply of commodity-wine grapes is subject to a cross price substitution for premium-wine grapes. This implies that the commodity wine-grape growers can shift some of their production to premium grape production and *vice versa*., in response to changes in the relative prices of the two types of grapes. Equation (5) is the demand function for either premium or commodity wines that applies to markets in WA, interstate and overseas. In this regard, the demand for premium wine (x_s^{od}) is a function of its own price (w_s^{od}) and price of commodity wine ($w_{\#s}^{od}$). This allows wine buyers to choose the wines in response to wine price changes. The demand shifter (n_s^{od}) is also included in the demand function to capture changes in demand due to promotion or increases in wine quality.

Input demand and output supply for sectors within the industry are endogenous to the model and are expressed in generic functional form as follows:

$$(6) x_s^{id} = x_s^{os} * c_s' (v_s^{id}, v_{\#s}^{id})$$

$$(7) x_s^{os} = x_s^{is} * r_s' (v_s^{is}, v_{\#s}^{is})$$

Equation (6) is the output-constrained input demand (x_s^{id}) that equals the unit of output (x_s^{os}) times its marginal cost $c_s' (v_s^{id}, v_{\#s}^{id})$. Equation (7) is the input-constrained output supply (x_s^{os}) that equals the unit of input times its marginal revenue. The input-constrained output supply was defined for sectors producing multiple outputs; such as the wholesale, retail and export sectors.⁵

$$(8) x_s^{id} (x_s^{id}, x_{\#s}^{id}) = x_s^{os} (x_s^{os}, x_{\#s}^{os})$$

$$(9) c_s^{ais} (v_s^{is}, v_{\#s}^{is}) = r_s^{aos} (v_s^{os}, v_{\#s}^{os})$$

Equations (8) and (9) are the quantity and value equilibrium conditions. Equation (8) ensures that aggregate input quantities are equal to aggregate output quantities. Equation (9) sets the unit costs incurred per unit of aggregate output to equate to the unit revenue earned per unit of aggregate input.

The interactive equations are differentiated to allow their transformation to an equilibrium displacement form. This form is a linear equation system, with market elasticities as coefficients. The final structural model is 59 equations with 15 exogenous variables that can

⁵ Wineries are considered as single-output producing sectors, as they produce either premium or commodity wine but their products are sold at different prices.

represent exogenous shocks to supply and demand conditions at various parts of the production and marketing chain (see Appendix 1 for details).

2.1 Model Data

Data from various sources were used to estimate the 2010-11 value added of the WA wine industry. The quantities of wine grapes and wine production are derived from ABS (2012). A report (Wine Australia 2011) on price dispersion within the Australian wine industry was used to derive the average price of premium and commodity wine-grapes, while the average prices of premium and commodity wines and production costs for each sector in the supply chain were estimated through industry consultation. The quantity and value of imports and exports of wine from WA were extracted from the Agrifood Infonet database (DAFWA, 2012), while data related to interstate supply was supplied by the WA Liquor Licensing Authority. The flow of products between different sectors in the supply chain was mainly estimated from WA Liquor Licensing Authority data.⁶ WET was calculated at different selling points as either 29% of the wholesale value of wine or the half price retailing method whichever was applicable. The benefits of the producer rebate scheme were also included, using an assumption that 70% of the industry is eligible for the WET rebate, considering the small size of individual operations. Table 1 is a summary of data used in this study for the base-line scenario.

⁶ Wherever data was not available, various assumptions were used. For example, the wholesale sector was assumed to import wine from overseas. Also wine retailing was assumed to comprise cellar door and mail order sales, bottle sales in restaurants taverns and pubs; and additional per glass sales in restaurants, taverns and pubs.

Table 1. Data used for base-line estimation

Commodity wine-grape grower		Premium wine-grape grower		Commodity Winery		Premium Winery		Wholesale		Retail		Export Interstate		Export Overseas	
y2=	42,887 t	y1=	23,093 t	z21=	9,572 000L	z11=	4,003 000L	z31=	5,546 000L	q11=	6,987 000L	q31=	5,259 000L	q21=	2,747 000L
v2=	775 \$/t	v1=	1,402 \$/t	w 21=	5.8 \$/L	w 11=	9.3 \$/L	w 31=	23.5 \$/L	p11=	37.4 \$/L	p31=	12.7 \$/L	p21=	7.8 \$/L
				z22=	5,160 000L	z12=	1,441 000L	z32=	9,572 000L	q12=	14,732 000L	q32=	10,764 000L	q22=	4,416 000L
				w 22=	10.8 \$/L	w 12=	18.6 \$/L	w 32=	12.0 \$/L	p12=	13.3 \$/L	p32=	8.7 \$/L	p22=	3.1 \$/L
				z23=	4,416 000L	z13=	2,747 000L	yim=	1,543 000L						
				w 23=	2.0 \$/L	w 13=	6.1 \$/L	vim=	9.3 \$/L						
				z24=	10,764 000L	z14=	5,259 000L								
				w 24=	5.8 \$/L	w 14=	9.3 \$/L								
						z15=	2,562 000L								
						w 15=	29.0 \$/L								
l=	15%	l=	15%	l=	9%	l=	17%	l=	4%	l=	8%	l=	9%	l=	6%
k=	5%	k=	5%	k=	1%	k=	5%	k=	3%	k=	4%	k=	1%	k=	2%
v=	1%	v=	1%	v=	1%	v=	2%	v=	1%	v=	2%	v=	1%	v=	1%
				y2k*v2k/cost2=	18%	y1k*v1k/cost1=	20%	ym*vm/cost3=	11%	z1m*u1m/cost4=	16%	z3m*u3m/cost5=	12%	z2m*u2m/cost6=	21%
				y2o*v2o/cost2=	39%	z1o*v1o/cost1=	41%								

Parameters used in our model are similar to Zhao *et al.* (2003). Over all, a price elasticity demand for commodity wine is more elastic than that of premium wine, while the demand in the export market is more elastic than in the domestic market. See Table 2 for a summary of elasticities used in this study.

Table 2. Elasticities used in the model

	Commodity Winery	Premium Winery	Wholesale	Retail	Export Eastern States	Export Overseas
*Price elasticity demand						
<i>Premium: own-price</i>		-0.8			-0.5	-5
<i>cross-price</i>					0.11	0.71
<i>Commodity: own-price</i>					-0.9	-7
<i>cross-price</i>					0.32	0.3
*Output Transformation Elasticity	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
*Input Substitution Elasticity	0.1	0.1	0.1	0.1	0.1	0.1
*Input Supply Elasticity						
premium-wine grape own-price		0.8				
premium-wine grape cross-price		-0.3				
commodity-wine grape own-price	0.8					
commodity-wine grape cross-price	-0.3					
<i>marketing input own-price</i>				2	2	2
<i>wine import own-price</i>				2		
<i>capital input own-price</i>	0.8	0.8				

3. Results and Discussion

3.1 The base-line scenario

Value chain accounting software (Xayavong and Islam, 2010) was used to estimate the current or base-line contribution of the WA wine industry to the WA economy. The results are presented in Table 3.

Table 3. Baseline scenario (using 2010/11 production data).

	Commodity wine-grape Grower	Premium wine-grape Grower	Commodity Winery	Premium Winery	Wholesale	Retail	Export Eastern States	Export Overseas	Total
Base-line result									
Unit: Million \$A									
WET charge			16.2	19.6	71.2				
WET rebate			34.6	40.2					
Input from sectors within industry	0	0	33.2	32.4	92.9	328	111.5	25.7	623.7
Input from sectors outside industry	30.2	24.6	78.4	80.4	32.9	53.3	16.5	7.6	323.9
Total Input	30.2	24.6	93.2	92.1	197	381.3	127.9	33.4	979.7
Output to sectors within industry	0	0	182.6	129.9	245.5	0	0	0	558
Output to sectors outside industry	33.2	32.4	0	74.3	0	457.3	159.9	35.1	792.2
Total Output	33.2	32.4	182.6	204.2	245.5	457.3	159.9	35.1	1350.2
Profit	3	7.8	89.4	112.1	48.5	76	32	1.7	370.5
Value Added	9.3	13	104.8	143.9	64.3	129.4	44.8	4.4	513.9

In 2010/11, total grape production was 65,980 tonnes in the WA wine industry and was worth \$792.2 million at the point of final sale. The wine industry used inputs worth \$323.9 million from non-wine industries for the production, processing and marketing of their products. These input purchases constitute the indirect contribution of the wine industry to the WA economy. The total value-added of the industry is estimated at \$513.9 million, which includes profit of \$370 million. Wine-grape growers add a value of \$22.3 million, and as their wines pass through different sectors until being sold in the retail and export markets, adding further value of \$491.6 million to the WA economy. Of the \$491.6 million post-farm value-added, the winery sector is the largest contributor (\$248.7 million), while the export sector is the smallest (\$4.4 million), and the wholesale and retail (local and national) sectors contribute \$174.2 million.

3.2. Promotion and productivity enhancement scenarios

Three scenarios are considered. The first scenario considers an increase in the demand for premium wine from the overseas market that is attributed to effective export promotion. The second scenario considers an increase in the demand for premium wine in the interstate and overseas markets that also is attributed to effective promotion in these markets. This second scenario enables the relative importance of promotion in the different markets, export versus interstate, to be assessed. The third scenario examines an increase in the production of premium wine grapes triggered by effective production research.

Table 4 shows the simulation results for the first scenario, a 5 per cent increase in export demand for premium wine from WA, which is modelled as an increase of around 137,000 litres of premium wine sold on export markets.

Table 4. Difference between the baseline results and those for a 5 percent increase in overseas exports of premium wine, generated by marketing promotion (scenario one)

	Commodity wine-grape Grower	Premium wine-grape Grower	Commodity Winery	Premium Winery	Wholesale	Retail	Export Eastern States	Export Overseas	Total
Increase in premium wine export by 5%									
Unit: Million \$AU									
WET charge			0.1	0.1	0.2				
WET rebate			0.1	0.1					
Input from sectors within industry	0	0	0.3	0.4	0.4	1	0.5	1.2	3.8
Input from sectors outside industry	0.3	0.3	0.7	0.7	0	-0.1	-0.1	0.4	2.2
Total Input	0.3	0.3	0.9	1.1	0.6	0.9	0.5	1.5	6.1
Output to sectors within industry	0	0	1.2	1.3	0.6	0	0	0	3.1
Output to sectors outside industry	0.3	0.4	0	0.3	0	0.9	0.7	3.3	5.9
Total Output	0.3	0.4	1.2	1.6	0.6	0.9	0.7	3.3	9
Profit	0	0.1	0.4	0.5	0.1	0	0.2	1.8	3.1
Value Added	0.1	0.1	0.4	0.7	0.1	0.1	0.3	1.9	3.7

The beneficial outcomes of the first scenario can be summarised as follows:

- The value of the industry increases by \$5.9m, led by a major increase of \$3.3 million from overseas exports.
- The value-added by the industry increases by \$3.7 million.

The overseas export sector is the main source of the increase in value-added (\$1.9 million) followed by premium wineries that generate an additional value-added of \$0.7 million.

Table 5. Difference between the baseline results and those for a 5 percent increase in domestic and export demand of premium wine, generated by marketing promotion (scenario two)

	Commodity wine-grape Grower	Premium wine-grape Grower	Commodity Winery	Premium Winery	Wholesale	Retail	Export Eastern States	Export Overseas	Total
Premium wine increase by 5% in all markets									
Unit: Million \$A									
WET charge			0.0	0.1	0.2				
WET rebate			0.1	0.1					
Input from sectors within industry	0	0	0.1	0.1	0.3	0.8	0.3	0.3	1.9
Input from sectors outside industry	0.1	0.1	0.2	0.3	0.1	0	0	0.1	0.9
Total Input	0.1	0.1	0.3	0.5	0.5	0.8	0.3	0.3	2.9
Output to sectors within industry	0	0	0.6	0.5	0.6	0	0	0	1.7
Output to sectors outside industry	0.1	0.1	0	0.6	0	0.8	0.5	0.6	2.7
Total Output	0.1	0.1	0.6	1.1	0.6	0.8	0.5	0.6	4.4
Profit	0	0	0.3	0.6	0	0	0.1	0.4	1.4
Value Added	0	0	0.3	0.8	0	0.1	0.1	0.4	1.7

Table 5 shows the simulation results for the second scenario which is also modelled as a 137,000 litres increase in the demand for WA premium wine, but this increase is equally distributed across all four main selling outlets; cellar door and mail order sales, local retail sales, interstate sales and overseas export.

The benefits from the second scenario can be summarised as follows:

- The value of the WA wine industry increases by \$2.7 million, with the retail sector registering the largest increase in value by \$0.8 million.

- The industry's value-added increases by \$1.7 million.
- The greatest change in value-added of \$0.8 million is for wineries producing premium wines.

Table 6 shows the simulation results for the third scenario that is modelled by a 5 per cent rightwards shift of the supply curve for premium wine-grapes.

Table 6. Difference between the baseline results and those for a 5 percent increase in the production of premium grapes (scenario three)

	Commodity wine-grape Grower	Premium wine-grape Grower	Commodity Winery	Premium Winery	Wholesale	Retail	Export Eastern States	Export Overseas	Total
Increase in supply of premium wine-grape by 5%									
Unit: Million \$A									
WET charge			-0.1	0.1	0.1				
WET rebate			0.0	0.1					
Input from sectors within industry	0	0	-0.1	0.9	0	0.2	0.1	-0.2	0.9
Input from sectors outside industry	-0.1	0.7	-0.3	-0.6	0	0	-0.1	-0.1	-0.5
Total Input	-0.1	0.7	-0.5	0.4	0.1	0.2	0.1	-0.4	0.5
Output to sectors within industry	0	0	-0.9	0.9	0.2	0	0	0	0.2
Output to sectors outside industry	-0.1	0.9	0	0.3	0	0.2	0.3	-0.8	0.8
Total Output	-0.1	0.9	-0.9	1.2	0.2	0.2	0.3	-0.8	1
Profit	0	0.2	-0.4	0.8	0.1	0.1	0.2	-0.4	0.6
Value Added	0	0.3	-0.5	0.9	0.1	0.1	0.2	-0.5	0.6

If production research for premium wine-grapes induces a 5% increase in supply, the economic impact on the WA economy would be as follows:

- The value of the WA wine industry increases by \$0.8 million.
- The industry's value-added increases by \$0.6 million.
- Wineries producing premium wines as well as premium wine grape growers increase their value-added by \$0.9 million and \$0.3 million respectively.
- However, a decline in value-added of \$0.5 million occurs firstly in wineries producing commodity wines and secondly, in the overseas export sector. The decline in the value-added by commodity wineries is due a shift in grape production away from commodity to premium wine, while the overseas export sector experiences an oversupply of wine that, without any promotional activities, leads to price competition that erodes profits. In the domestic market there is some displacement of commodity wine, so the same effect is not evident.

Overall, the modelling results suggest that promotional activities solely in overseas markets may generate the greatest economic benefits. By contrast, when the increase in demand is distributed between domestic and overseas markets, the returns are not as great. Similarly, production research that increases production of premium wine grapes generates additional value-added, but the size of the increase is less than that generated through promotional activity.

An important caveat to these findings is that although the estimation of benefits associated with each scenario may properly represent outcomes, nonetheless the analysis does not specify the costs of the promotion and production research activity that generate the same 5 per cent increase in premium wine grape production. In other words, although the magnitude of benefits differs between the three scenarios, the costs of the promotional and research

activity that generate similar production impacts is not stated. The decision about which scenario is worth investing in will depend on those costs. The differences in benefits however, do imply firstly that if the same effect for the same expenditure is possible for promotion and production research then the promotion activity will be preferred provided its costs are less the magnitude of benefits generated. Secondly, it does imply that the greater benefits from promotion, especially promotion to stimulate overseas demand for premium WA wines, would justify greater expenditure on promotion relative to that on production research. Another weakness in production research, unlike direct promotion, is that often production research findings are readily transferable to other regions, often with small transfer costs. In time producers in these other regions then also benefit and they erode the comparative advantage initially enjoyed by the WA premium wine grape growers.

4. Conclusions

The Australian wine industry, like some southern and northern hemisphere counterparts, experienced boom conditions throughout the 1990s and into the 2000s, but in recent years has experienced problems with global oversupply and a strong Australian dollar. Some premium wine regions in Australia, like the Margaret River region in Western Australia (WA) now face structural adjustment pressures.

This paper examines some structural choices facing the WA wine industry. Should the industry invest in more promotion on overseas markets? Or should the industry invest in production research that lifts the productivity of premium wine grape production? To address these questions this paper uses interactive multimarket value chain modelling to estimate firstly the base-line value-added by the WA wine industry to the WA economy. Then economic impacts of alternative investment scenarios for the wine industry are estimated and compared, and the distribution of profits among sectors in the industry's value chain are outlined.

Three investment scenarios are examined. The first scenario considers an increase in the demand for premium WA wine from the overseas market that is attributed to effective export promotion. The second scenario considers an increase in the demand for premium WA wine in interstate and overseas markets that also is attributed to effective promotion in these markets. This second scenario enables the relative importance of promotion in the different markets, export versus interstate, to be assessed. The third scenario examines an increase in the production of premium WA wine grapes that is triggered by effective production research.

The results from interactive multimarket value chain modelling indicate that promotional activity in overseas markets may generate the greatest economic benefits for the WA wine industry. By contrast, promotional activity in national and overseas markets to stimulate demand that generates an increase in premium wine grape production in WA leads to a lesser increase in value-added. Similarly, production research that increases production of premium wine grapes generates additional value-added, but the increase is less than that generated through promotional activity.

This study's findings show that different investment activities, although each triggering an increase in premium grape production, do differently benefit participants in the industry's value chain and that the aggregate value-added of these benefits also can be different. Hence, industry development is affected by the focus of the industry investment. In this case, promotion activity on export markets generates the greatest benefits.

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Appendix 1. Model specification; a listing of equations, variables and parameter values

1. Retail sector

1.1. WA demand for wine:

- (1) $Ez15 = \varepsilon_{z15,u1} * (Eu1 - Nz15)$
- (2) $Eq11 = \varepsilon_{q11,p11} * (Ep11 - Nq11) + \varepsilon_{q11,p12} * (Ep12 - Nq12)$
- (3) $Eq12 = \varepsilon_{q12,p11} * (Ep11 - Nq11) + \varepsilon_{q12,p12} * (Ep12 - Nq12)$

1.2. Market equilibrium conditions:

- (4) $\kappa_{z12}Ez12 + \kappa_{z31}Ez31 + \kappa_{z22}Ez22 + \kappa_{z32}Ez32 + \kappa_{z1mkt}Ez1mkt = \lambda_{q11}Eq11 + \lambda_{q12}Eq12$
- (5) $\kappa_{z12}Eu1 + \kappa_{z31}Eu31 + \kappa_{z22}Eu2 + \kappa_{z32}Eu32 + \kappa_{z1mkt}Eu1mkt = \lambda_{q11}Ep11 + \lambda_{q12}Ep12$

1.3. Input-constrained output supply of retail sector:

- (6) $Eq11 = -\lambda_{q12}\tau_{q11,q12} * Ep11 + \lambda_{q12}\tau_{q11,q12} * Ep12 + Ezrt$
- (7) $Eq12 = \lambda_{q11}\tau_{q11,q12} * Ep11 - \lambda_{q12}\tau_{q11,q12} * Ep12 + Ezrt$

1.4. Output constrained input demand of retail sector

- (8) $Ez1mkt = -\left(\kappa_{z12}\sigma_{z1mkt,z12} + \kappa_{z31}\sigma_{z1mkt,z31} + \kappa_{z32}\sigma_{z1mkt,z32} + \kappa_{z22}\sigma_{z1mkt,z22}\right) * Eu1mkt$
 $+ \kappa_{z12}\sigma_{z1mkt,z12} * Eu1 + \kappa_{z32}\sigma_{z1mkt,z32} * Eu32 + \kappa_{z31}\sigma_{z1mkt,z31} * Eu31$
 $+ \kappa_{z22}\sigma_{z1mkt,z22} * Eu2 + Eq1$
- (9) $Ez12 = -\left(\kappa_{z1mkt}\sigma_{z12,z1mkt} + \kappa_{z31}\sigma_{z12,z31} + \kappa_{z32}\sigma_{z12,z32} + \kappa_{z22}\sigma_{z12,z22}\right) * Eu1$
 $+ \kappa_{z1mkt}\sigma_{z12,z1mkt} * Eu1mkt + \kappa_{z31}\sigma_{z12,z31} * Eu31 + \kappa_{z32}\sigma_{z12,z32} * Eu32$
 $+ \kappa_{z22}\sigma_{z12,z22} * Eu2 + Eq1$
- (10) $Ez31 = -\left(\kappa_{z12}\sigma_{z31,z12} + \kappa_{z1mkt}\sigma_{z31,z1mkt} + \kappa_{z32}\sigma_{z31,z32} + \kappa_{z22}\sigma_{z31,z22}\right) * Eu31$
 $+ \kappa_{z12}\sigma_{z31,z12} * Eu1 + \kappa_{z1mkt}\sigma_{z31,z1mkt} * Eu1mkt + \kappa_{z32}\sigma_{z31,z32} * Eu32$
 $+ \kappa_{z22}\sigma_{z31,z22} * Eu2 + Eq1$
- (11) $Ez32 = -\left(\kappa_{z12}\sigma_{z32,z12} + \kappa_{z1mkt}\sigma_{z32,z1mkt} + \kappa_{z31}\sigma_{z32,z31} + \kappa_{z22}\sigma_{z32,z22}\right) * Eu32$
 $+ \kappa_{z12}\sigma_{z32,z12} * Eu1 + \kappa_{z1mkt}\sigma_{z32,z1mkt} * Eu1mkt + \kappa_{z31}\sigma_{z32,z31} * Eu31$
 $+ \kappa_{z22}\sigma_{z32,z22} * Eu2 + Eq1$
- (12) $Ez22 = -\left(\kappa_{z12}\sigma_{z22,z12} + \kappa_{z31}\sigma_{z22,z31} + \kappa_{z32}\sigma_{z22,z32} + \kappa_{z1mkt}\sigma_{z22,z1mkt}\right) * Eu2$
 $+ \kappa_{z12}\sigma_{z22,z12} * Eu1 + \kappa_{z31}\sigma_{z22,z31} * Eu31 + \kappa_{z32}\sigma_{z22,z32} * Eu32$
 $+ \kappa_{z1mkt}\sigma_{z22,z1mkt} * Eu1mkt + Eq1$

1.5. Factor supply for retail sector

- (13) $Ez1mkt = \eta_{z1mkt,u1mkt} * (Eu1mkt - Tz1mkt)$

2. Overseas export sector

2.1. Overseas demand for WA wine:

- (14) $Eq21 = \varepsilon_{q21,p21} * (Ep21 - Nq21) + \varepsilon_{q21,p22} * (Ep22 - Nq22)$
- (15) $Eq22 = \varepsilon_{q22,p21} * (Ep21 - Nq21) + \varepsilon_{q22,p22} * (Ep22 - Nq22)$

2.2. Market equilibrium conditions:

- (16) $\kappa_{z13}Ez13 + \kappa_{z23}Ez23 + \kappa_{z2mkt}Ez2mkt = \lambda_{q21}Eq21 + \lambda_{q22}Eq22$

$$(17) \kappa_{z13}Eu1 + \kappa_{z23}Eu2 + \kappa_{z2mkt}Ezu2mkt = \lambda_{q21}Ep21 + \lambda_{q22}Ep22$$

2.3. Input-constrained output supply of overseas export sector:

$$(18) Eq21 = -\lambda_{q22}\tau_{q21,q22} * Ep21 + \lambda_{q22}\tau_{q21,q22} * Ep22 + Ezoe$$

$$(19) Eq22 = \lambda_{q21}\tau_{q21,q22} * Ep21 - \lambda_{q21}\tau_{q21,q22} * Ep22 + Ezoe$$

2.4. Output constrained input demand of overseas export sector

$$(20) Ez2mkt = -(\kappa_{z13}\sigma_{z2mkt,z13} + \kappa_{z23}\sigma_{z2mkt,z23}) * Eu2mkt + \kappa_{z13}\sigma_{z2mkt,z13} * Eu1 \\ + \kappa_{z23}\sigma_{z2mkt,z23} * Eu2 + Eq2$$

$$(21) Ez13 = -(\kappa_{z2mkt}\sigma_{z13,z2mkt} + \kappa_{z23}\sigma_{z13,z23}) * Eu1 + \kappa_{z2mkt}\sigma_{z13,z2mkt} * Eu2mkt \\ + \kappa_{z23}\sigma_{z13,z23} * Eu2 + Eq2$$

$$(22) Ez23 = -(\kappa_{z13}\sigma_{z23,z13} + \kappa_{z2mkt}\sigma_{z23,z2mkt}) * Eu2 + \kappa_{z13}\sigma_{z23,z13} * Eu1 \\ + \kappa_{z2mkt}\sigma_{z23,z2mkt} * Eu2mkt + Eq2$$

2.5. Factor supply for overseas export sector

$$(23) Ez2mkt = \eta_{z2mkt,u2mkt} * (Eu2mkt - Tz2mkt)$$

3. Interstate export sector

3.1. Interstate demand for WA wine:

$$(24) Eq31 = \varepsilon_{q31,p31} * (Ep31 - Nq31) + \varepsilon_{q31,p32} * (Ep32 - Nq32)$$

$$(25) Eq32 = \varepsilon_{q32,p31} * (Ep31 - Nq31) + \varepsilon_{q32,p32} * (Ep32 - Nq32)$$

3.2. Market equilibrium conditions:

$$(26) \kappa_{z14}Ez14 + \kappa_{z24}Ez24 + \kappa_{z3mkt}Ez3mkt = \lambda_{q31}Eq31 + \lambda_{q32}Eq32$$

$$(27) \kappa_{z14}Eu1 + \kappa_{z24}Eu2 + \kappa_{z3mkt}Ezu3mkt = \lambda_{q31}Ep31 + \lambda_{q32}Ep32$$

3.3. Input-constrained output supply of interstate export sector:

$$(28) Eq31 = -\lambda_{q32}\tau_{q31,q32} * Ep31 + \lambda_{q32}\tau_{q31,q32} * Ep32 + Ezie$$

$$(29) Eq32 = \lambda_{q31}\tau_{q31,q32} * Ep31 - \lambda_{q31}\tau_{q31,q32} * Ep32 + Ezie$$

3.4. Output constrained input demand of interstate export sector

$$(30) Ez3mkt = -(\kappa_{z14}\sigma_{z3mkt,z14} + \kappa_{z24}\sigma_{z3mkt,z24}) * Eu3mkt + \kappa_{z14}\sigma_{z3mkt,z14} * Eu1 \\ + \kappa_{z24}\sigma_{z3mkt,z24} * Eu2 + Eq3$$

$$(31) Ez14 = -(\kappa_{z3mkt}\sigma_{z14,z3mkt} + \kappa_{z24}\sigma_{z14,z24}) * Eu1 + \kappa_{z3mkt}\sigma_{z14,z3mkt} * Eu3mkt \\ + \kappa_{z24}\sigma_{z14,z24} * Eu2 + Eq3$$

$$(32) Ez24 = -(\kappa_{z14}\sigma_{z24,z14} + \kappa_{z3mkt}\sigma_{z24,z3mkt}) * Eu2 + \kappa_{z14}\sigma_{z24,z14} * Eu1 \\ + \kappa_{z3mkt}\sigma_{z24,z3mkt} * Eu3mkt + Eq3$$

3.5. Factor supply for interstate export sector

$$(33) Ez3mkt = \eta_{z3mkt,u3mkt} * (Eu3mkt - Tz3mkt)$$

4. Wholesale sector

4.1. Market equilibrium conditions:

$$(34) \kappa_{ymkt} Eymkt + \kappa_{yim} Eyim + \kappa_{z11} Ez11 + \kappa_{z21} Ez21 = \lambda_{z31} Ez31 + \lambda_{z32} Ez32$$

$$(35) \kappa_{ymkt} Evmkt + \kappa_{yim} Evim + \kappa_{z11} Eu1 + \kappa_{z21} Eu2 = \lambda_{z31} Eu31 + \lambda_{z32} Eu32$$

4.2. Input-constraint output supply of wholesale sector

$$(36) Ez31 = -\lambda_{z32} \tau_{z31,z32} * Eu31 + \lambda_{z32} \tau_{z31,z32} * Eu32 + Ey3$$

$$(37) Ez32 = \lambda_{z31} \tau_{z31,z32} * Eu31 - \lambda_{z31} \tau_{z31,z32} * Eu32 + Ey3$$

4.3. Output constrained input demand of wholesale sector

$$(38) Eymkt = -\left(\kappa_{yim} \sigma_{ymkt,yim} + \kappa_{z11} \sigma_{ymkt,z11} + \kappa_{z21} \sigma_{ymkt,z21}\right) * Evmkt + \kappa_{yim} \sigma_{ymkt,yim} * Evim \\ + \kappa_{z11} \sigma_{ymkt,z11} * Eu1 + \kappa_{z21} \sigma_{ymkt,z21} * Eu2 + Ez3$$

$$(39) Eyim = -\left(\kappa_{ymkt} \sigma_{yim,ymkt} + \kappa_{z11} \sigma_{yim,z11} + \kappa_{z21} \sigma_{yim,z21}\right) * Evim + \kappa_{ymkt} \sigma_{yim,ymkt} * Evmkt \\ + \kappa_{z11} \sigma_{yim,z11} * Eu1 + \kappa_{z21} \sigma_{yim,z21} * Eu2 + Ez3$$

$$(40) Ez11 = -\left(\kappa_{yim} \sigma_{z11,yim} + \kappa_{ymkt} \sigma_{z11,ymkt} + \kappa_{z21} \sigma_{z11,z21}\right) * Eu1 + \kappa_{yim} \sigma_{z11,yim} * Evim \\ + \kappa_{ymkt} \sigma_{z11,ymkt} * Evmkt + \kappa_{z21} \sigma_{z11,z21} * Eu2 + Ez3$$

$$(41) Ez21 = -\left(\kappa_{yim} \sigma_{z21,yim} + \kappa_{z11} \sigma_{z21,z11} + \kappa_{ymkt} \sigma_{z21,ymkt}\right) * Eu2 + \kappa_{yim} \sigma_{z21,yim} * Evim \\ + \kappa_{z11} \sigma_{z21,z11} * Eu1 + \kappa_{ymkt} \sigma_{z21,ymkt} * Evmkt + Ez3$$

4.4. Factor supply for wholesale sector

$$(42) Eymkt = \eta_{ymkt,vmkt} * (Evmkt - Tymkt)$$

$$(43) Eyim = \eta_{yim,vim} * (Evim - Tyim)$$

5. Premium winemaking sector

5.1. Market clearing condition

$$(44) Ez1 = \mu_{11} * Ez11 + \mu_{12} * Ez12 + \mu_{13} * Ez13 + \mu_{14} * Ez14 + \mu_{15} * Ez15$$

$$(45) Eu1 = \kappa_{y1k} * Ev1k + \kappa_{y1o} * Ev1o + \kappa_{y1} * Ev1$$

5.2. Output constrained input demand of premium winery sector

$$(46) Ey1k = -\left(\kappa_{y1o} \sigma_{y1k,y1o} + \kappa_{y1} \sigma_{y1k,y1}\right) * Ev1k + \kappa_{y1o} \sigma_{y1k,y1o} * Ev1o \\ + \kappa_{y1} \sigma_{y1k,y1} * Ev1 + Ez1$$

$$(47) Ey1o = -\left(\kappa_{y1k} \sigma_{y1o,y1k} + \kappa_{y1} \sigma_{y1o,y1}\right) * Ev1o + \kappa_{y1k} \sigma_{y1o,y1k} * Ev1k \\ + \kappa_{y1} \sigma_{y1o,y1} * Ev1 + Ez1$$

$$(48) Ey1 = -\left(\kappa_{y1o} \sigma_{y1,y1o} + \kappa_{y1k} \sigma_{y1,y1k}\right) * Ev1 + \kappa_{y1o} \sigma_{y1,y1o} * Ev1o \\ + \kappa_{y1k} \sigma_{y1,y1k} * Ev1k + Ez1$$

5.3. Factor supply for premium winery sector

$$(49) Ey1k = \eta_{y1k,v1k} * (Ev1k - Ty1k)$$

$$(50) Ey1o = \eta_{y1o,v1o} * (Ev1o - Ty1o)$$

$$(51) Ey1 = \eta_{y1,v1} * (Ev1 - Ty1) + \eta_{y1,v2} * (Ev2 - Ty2)$$

6. Commodity winemaking sector

6.1. Market clearing conditions

$$(52) Ez2 = \mu_{21} * Ez21 + \mu_{22} * Ez22 + \mu_{23} * Ez23 + \mu_{24} * Ez24$$

$$(53) Eu2 = \kappa_{y2k} * Ev2k + \kappa_{y2o} * Ev2o + \kappa_{y2} * Ev2$$

6.2. Output constrained input demand of non-premium winemaking sector

$$(54) Ey2k = -(\kappa_{y2}\sigma_{y2k,y2} + \kappa_{y2o}\sigma_{y2k,y2o}) * Ev2k + \kappa_{y2}\sigma_{y2k,y2} * Ev2 \\ + \kappa_{y2o}\sigma_{y2k,y2o} * Ev2o + Ez2$$

$$(55) Ey2o = -(\kappa_{y2}\sigma_{y2o,y2} + \kappa_{y2k}\sigma_{y2o,y2k}) * Ev2o + \kappa_{y2}\sigma_{y2o,y2} * Ev2 \\ + \kappa_{y2k}\sigma_{y2o,y2k} * Ev2k + Ez2$$

$$(56) Ey2 = -(\kappa_{y2k}\sigma_{y2,y2k} + \kappa_{y2o}\sigma_{y2,z2o}) * Ev2 \\ + \kappa_{y2k}\sigma_{y2,y2k} * Ev2k + \kappa_{y2o}\sigma_{y2,z2o} * Ev2o + Ez2$$

6.3. Factor supply to non-premium winemaking sector

$$(57) Ey2 = \eta_{y2,v1} * (Ev1 - Ty1) + \eta_{y2,v2} * (Ev2 - Ty2)$$

$$(58) Ey2k = \eta_{y2k,v2k} * (Ev2k - Ty2k)$$

$$(59) Ey2o = \eta_{y2o,v2o} * (Ev2o - Ty2o)$$

Endogenous Variables

q1: aggregate quantity of wine sale at retail market

q11, p11: quantity & price of premium wine sale at retail market

q12, p12: quantity & price of non-premium wine sale at retail market

q2: aggregate quantity of wine sale at oversea export market

q21, p21: quantity & price of premium wine sale at oversea export market

q22, p22: quantity & price of non-premium wine sale at oversea export market

q3: aggregate quantity of wine sale at interstate export market

q31, p31: quantity & price of premium wine sale at interstate export market

q32, p32: quantity & price of non-premium wine sale at interstate export market

z1, u1: aggregate quantity & average price of premium wine sale at winery sector

z11: quantity of premium wine purchased by wholesale from winery

z12: quantity of premium wine purchased by retail sector from winery

z13: quantity of premium wine for export oversea

z14: quantity of premium wine for export to other states

z15: quantity of premium wine sale to cellar door

z2, u2: aggregate quantity & average price of non-premium wine sale at winery sector

z21: quantity of non-premium wine purchased by wholesale from winery

z22: quantity of non-premium wine purchased by retail sector from winery

z23: quantity of non-premium wine for export oversea

z24: quantity of non-premium wine for export to other states

z3: aggregate quantity of wine sale at wholesale market

z31, u31: quantity and price of premium wine purchased by retail from wholesale

z32, u32: quantity and price of non-premium wine purchased by retail from wholesale

z1mkt, u1mkt: quantity and aggregate marketing cost of retail market

z2mkt, u2mkt: total wine quantity and aggregate marketing cost of oversea export market

z3mkt, u3mkt: total wine quantity and aggregate marketing cost of interstate export market

zrt: aggregate input of retail market

zoe: aggregate input of oversea export market

zie: aggregate input of interstate export market

ymkt, vmkt: quantity and average marketing cost of wholesale market

yim, vim: quantity and price of import wine by wholesale market

y3: aggregate input of wholesale market
 y1k, v1k: quantity and price of capital of premium-winemaking market
 y1o, v1o: quantity and price of other factor input of premium-winemaking market
 y1, v1: quantity and price of wine-grape purchased by premium-winemaking market
 y2k, v2k: quantity and price of capital of non-premium-winemaking market
 y2o, v2o: quantity and price of other factor input of non-premium-winemaking market
 y2, v2: quantity and price of wine-grape purchased by non-premium-winemaking market

Exogenous Variables

nz15: shifting demand
 nq11: Change in WA demand for premium wine
 nq12: Change in WA demand for non-premium wine
 tz1mkt: Change in factor supply to retail sector
 nq21: Change in overseas export demand for premium wine
 nq22: Change in overseas export demand for non-premium wine
 tz2mkt: Change in factor supply to overseas export sector
 nq31: Change in interstate export demand for premium wine
 nq32: Change in interstate export demand for non-premium wine
 tz3mkt: Change in factor supply to interstate export sector
 tymkt: Change in factor supply to wholesale sector
 tyim: Change in import supply to wholesale sector
 ty1k: Change in capital expenditure to premium winemaking sector
 ty1o: Change in other factor supply to premium winemaking sector
 ty1: Change in supply of premium wine grape
 ty2: Change in supply of non-premium wine grape
 ty2k: Change in capital expenditure to non-premium winemaking sector
 ty2o: Change in other factor supply to non-premium winemaking sector

Parameters

$\eta_{i,j}$: Supply elasticity of commodity i with respect to price j .
 $\varepsilon_{i,j}$: Demand elasticity of input for commodity i with respect to price j .
 $\sigma_{i,j}$: Substitution elasticity of input between commodities i and j .
 $\kappa_{i,j}$: Cost shares of inputs
 $\lambda_{i,j}$: Revenue shares
 $\mu_{i,j}$: Quantity shares