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Accounting for growth in the Australian wine industry, 1987 to 2003

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CIES DISCUSSION PAPER 0029

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Accounting for growth in the Australian wine industry, 1987 to 2003

Abstract

A computable general equilibrium model of the Australian economy is used to account for the dramatic growth in Australia's wine industry between 1987 and 1999, and to project grape and wine volumes and prices to 2003. Export demand growth has made a major contribution to total output growth in premium wines, and accounts for most of the increase in the producer price of premium red wine. Domestic consumer preferences have shifted, mainly towards premium red wine, but there is also some evidence of growing demand for premium white wine since the mid-1990s. From the perspective of producers, productivity growth, while being less important than growth in or domestic demand, appears to have more than offset the negative effects on suppliers of wine consumer tax increases. From the domestic consumers' perspective, however, tax hikes have raised retail prices much more than productivity gains have lowered them. The high and sustained levels of profitability resulting from export demand growth have led to a massive supply response in Australia. Even so, by 2003 Australian wine output will still be less than 5 per cent of global production.

Keywords: wine trade, wine production, Australian wine industry

JEL codes: Q13, Q16, O56

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Accounting for growth in the Australian wine industry, 1987 and 2003

1. Introduction

Between 1987 and 1999, the volume of Australian wine production increased by over 70 per cent. The composition of output also altered substantially, with premium output trebling (red more that white) while non-premium output changed little. The present study makes two contributions: first, it uses available data and an economy-wide model to assess the relative contributions of various demand and supply factors to the rapid growth and structural changes in the wine industry since 1987; and second, it uses those results to obtain a projection of industry trends to 2003.[1] Specifically, the paper decomposes the effect on output and prices of wine of changes between 1987 and 1999 in (1) export demand for wine, (2) domestic demand for wine, (3) domestic wine taxes, (4) grape and wine industry productivity, (5) changes in the rest of the economy and (6) observed winegrape bearing area. This is done using a computable general equilibrium (CGE), 29-sector, two-region model of the economies of South Australia (where half the industry is located) and the rest of Australia. Known as FEDSA-WINE, it is a static model of Australia's economy in the ORANI family of models (Horridge, Parmenter and Pearson 1998; Madden 1995).

Drawing on insights from the historical growth accounting exercise, plus additional industry-specific information (most notably actual and intended winegrape plantings to 2000), we project the wine industry to 2003. This provides insights into where the Australian wine industry is headed as the new plantings reach maturity.

Past CGE studies focusing on the Australian wine industry include Meagher, Parmenter, Rimmer and Clements (1985) and CIE (1995b), both of which analyse the impacts of increasing consumption taxes on wine. We wish to examine more than just domestic demand issues, however, so we draw on the methodology of Dixon, Menon and Rimmer (2000).[2] This links the underlying theory of a CGE model with the available data. Since the focus here is on just the grape and wine industry, we are able to develop in one sense a simpler approach, utilising less data in a less elaborate CGE model with less disaggregation of non-wine sectors than the Dixon, Menon and Rimmer study, but in another sense more detail in that we allow for a degree of heterogeneity in the industry of focus. This is done by dividing both winegrapes and wine into three segments: premium red, premium white and non-premium.

An overview of our methodology is given in the next section. Then Section 3 presents the results of decomposition of the historical changes. The projection of the wine industry to 2003 is detailed in Section 4. The paper concludes in Section 5 with a summary of the findings.

2 Methodology

As explained in the appendix, the FEDSA-WINE model solves a system of equations involving variables for prices and quantities for a particular year, to which the database is updated from the base year during the simulation. The equations follow the standard competitive economic theory of CGE models. Different combinations of variables (called closures) can be included in the exogenous set to solve the model. The method

used for accounting for past growth involves running the model twice, doing first an historical simulation and then a decomposition simulation. The two runs require different combinations of exogenous variables. Table 1 summarises the categorization of key variables. Those that are exogenous in the historical simulation include observable variables for which data on historical changes are available. For each of the three wine types, we select as exogenous the following variables: household consumption, export volumes, and f.o.b. export prices. We also include producer prices for winegrapes and employment data for both winegrapes and wine. Observable macroeconomic variables (e.g., aggregate consumption) are also part of this set, even though such variables are normally endogenous in CGE simulations. To estimate unobservable variables in the historical simulation, or ones for which data are unreliable (notably disaggregated wine prices), the observable variables are shocked by the observed change.

In the decomposition simulation, we revert to a more typical CGE closure. For example, household wine consumption is now endogenous. We isolate the effect of the taste shifter (estimated in the historical simulation) for the three wine types from the other shocks used to project the model between the end-point years (1987 and 1999). This provides an estimate of the contribution of domestic taste changes to the historical changes in the wine market. Similarly, the observable wine tax shocks in isolation provide an estimate of the historical impact of wine tax changes on the industry. Changes in aggregate household consumption and in population also contribute to changes in wine consumption through general economic effects.

3. Results

The historical data

Table 2 shows historical data for the Australian wine industry for 1987 and 1999. At the macroeconomic level, income growth allowed Australia's aggregate real consumption of goods and services to rise 43 per cent (in mid-point terms[3]) over the 12-year period. But consumption of wine rose by less than 10 per cent, despite the income and aggregate expenditure growth. However, within the wine category, there has been a dramatic switch in consumption in Australia from non-premium to premium (especially red) wine. There has also been a boom in wine exports. Australia's exports of premium wine grew more than fifteen-fold between 1987 and 1999, with the share of production exported rising from less than 5 to more than 30 per cent. To accommodate a rapid increase in premium (especially export) demand, plantings of premium wine grapes trebled over that period, with an accompanying increase (albeit with a 3-5 year delay) in Australian premium wine production.

Export demand growth

Column 1 in Table 3 shows the effect of the estimated shift in the volume of export demand. In the modelled decomposition of the observed period, export demand growth explains almost all the increase in producer prices for premium red wine (30.5 out of 31.2 per cent) and about one fifth of total output growth (25.1 out of 122.6 per cent). This implies that the wine supply response was not sufficient by the end of the period, even after adding the increase in winegrape area shown in the 6th column, to dampen upward price pressures.

By contrast, for premium white wine, the output increase attributable to export demand growth was relatively larger and the price increases smaller than for red wine. White winegrape prices were relatively high at the beginning of the period, indicating that demand for the premium white segment started at a high point (Table 2). Note that the static CGE framework and use only of endpoint data do not explain the timing of the supply response, a point we discuss further in section 4.

A high proportion of Australian non-premium wine is sold domestically, with the rest exported, mostly to New Zealand. Though non-premium export demand grew in the historical period, exports remained a small proportion of total output. Export demand growth contributed only 3 per cent to non-premium output growth, despite an increase in export volume of 82 per cent (Table 3).

Domestic consumer tastes

Column 2 of Table 3 provides an estimate of changes in consumption attributable to changing preferences rather than price, income or population growth effects. In the period from 1987 to 1996, we observed a taste swing against all alcoholic beverages except premium red wine. Between 1996 and 1999, there was also a preference change towards premium white wine consumption, with the net result that changing domestic consumer preferences explained almost none of the overall change in premium white wine production between 1987 and 1999. Increasing domestic preferences for premium red wine explain a significant part of the segment's output growth in the twelve-year period (30 per cent out of total growth of 123 per cent). By reducing excess supply, this

effect had a negative impact on export growth (-19 per cent). Emerging evidence of the health benefits of moderate red wine consumption may explain much of the increase in demand for red wine. The main reason for the swing against white is that demand for white was already strong in 1987 at a time when interest in premium wines was growing, whereas the histamine scare had for a time stopped consumers from turning to red wine. The negative consumption and output contributions in column 2 of Table 3 for non-premium wine reflect the growing preferences of consumers towards premium wine.

Increased consumer taxes and franchise fees

The Commonwealth Government introduced a 10 per cent wholesale sales tax on wine in August 1984, which had increased to 31 per cent by August 1993, before settling at 26 per cent in July 1995 after several adjustments. In addition, there were modest increases in State Government franchise fees on retail alcohol sales. The impact of increased taxes on domestic consumption had only a moderate effect on exports: 2 per cent for red, 1 per cent for white, and less than 1 per cent for non-premium exports (column 3 of Table 3). This is because output is reduced by the increase in consumption taxes: with imperfect substitution between domestic and export sales, producers bear a small part of the burden of the tax. The rest is borne by domestic consumers, evident in declines in consumption of 8, 6 and 4 per cent for premium red, premium white and non-premium wines. For each, the increase in consumer price due to the ad valorem tax increase was around 10 per cent.

Productivity changes

Within the database for 1996, the shares of labour, capital and agricultural land in Australia's GDP are 0.59, 0.40 and 0.01. Between 1987 and 1999, the increases in labour, capital and land inputs were 24, 58 and 0 per cent (ABS, 2000). Real GDP rose 50 per cent in this period, implying total factor productivity (TFP) growth of about 14 per cent for the economy overall. In the winegrape industry, changes in the bearing land area are known at a disaggregated level. For labour inputs, available data for both winegrapes and wine have been disaggregated by assuming that the premium segments are more labour-intensive than the non-premium segments. But changes in capital usage are unknown. These are estimated within the model, based on output growth, changes in the rate-of-return on capital (imposed to follow the direction of observed price changes) and imposed primary factor productivity growth. We use the economy-wide TFP calculation to ascribe productivity shocks, adjusting for differences between broad industry groups.[4]

The growing emphasis on quality in all stages of production in grape-growing and wine-making implies that measures of productivity may understate the impact of new technologies on the industry. For example, a grape grower may raise the unit costs of production through practices that increase the quality and price of output, possibly without a productivity improvement — or even a decline — in quantitative terms. This emphasis on quality differs from an earlier understanding propounded by the Senate Standing Committee on Trade and Commerce (1977), which stresses that with technological improvements, winemakers could produce wine from inferior grapes. Now, much of the aim of the industry is to maximise profits through raising the quality

of grapes. Nonetheless, mechanical harvesting and pruning are being used increasingly, not only in non-premium production but also in the 'commercial' or lower end of the premium spectrum, with a significant impact on quantifiable productivity. In particular, mechanisation and computerisation of irrigation have decreased the labour-intensity of winegrape production.

As for wineries, we can attribute much of the employment growth to an increasing proportion of premium in total wine production. Premium wine production per litre of output is substantially more labour-intensive than non-premium production. Winemakers, for example, pay most attention to premium produce even in wineries where the volume of non-premium wine is substantially greater than the premium volume.

Column 4 of Table 3 indicates an order of magnitude (based on the economy-wide estimate) rather than a more-precise estimate of the impact of productivity growth on wine producers and consumers. Productivity growth contributes proportionally more to export growth (28 per cent for red) than growth in domestic consumption (3 per cent for red). This reflects the effect of supply shifts along the relatively elastic export demand curves compared with less elastic domestic demand. Such growth also more than compensates for increases in consumer taxes on premium wine in the historical period, from the producers' perspective. However, the small consumer price declines arising from the productivity effect fall well short of compensating consumers for rising taxes in the period. The effect on premium wine output is proportionally larger than on non-premium wine. This is due to non-premium grapes being multi-purpose. That is,

increased productivity increases grape availability for use as table and dried grapes as well as increased inputs into non-premium wine production. In addition, the non-premium wine segment is less export oriented, so there is less scope for expansion through excess supply shifts along the relatively elastic export demand curve.

General economic growth and changes in other industries

In the historical simulation, the task is to fit observed data at the macroeconomic and at the industry level, beyond changes only in the wine industry. Observed macroeconomic data include GDP and primary factor endowments. The 5th column of Table 3 indicates the impact of changes in the economy not directly related to the wine industry. The column also includes the impact of productivity growth in non-wine industries and the observable change in the real exchange rate. To summarise, this indicates what would have happened to the wine industry without any wine industry-specific changes in the historical period.

General economic growth increases domestic consumption of each wine type through the expenditure effect. The expenditure effect is output increasing and export reducing. It is surprising therefore that this column makes a positive contribution to exports for white wine. This appears to be due to rising apparent rates of return on capital in non-wine industries. In isolation, this lowers the ratio of the rate of return in the wine industry to that in other industries, thereby inducing a capital inflow to wine and increasing its excess supply.

Observed changes in the bearing area of winegrapes

The 6th column in Table 3 shows the impact of changes in the winegrape bearing area between 1987 and 1999. As we expect, the outward supply shifts implied by increased bearing area for premium winegrapes raise output and the excess supply, while lowering producer and consumer prices. The price effect induces an increase in domestic consumption. This change in plantings comprises only part of the supply response of the winegrape segments, as they can still respond to changing prices via primary factor substitutability.

There are two reasons why we have presented the effects of changes in the bearing area in a separate column. First, part of the motivation for decomposition was to assist in projecting future industry outputs (see Section 4 below). Plantings in a given year plus the year's bearing area allow us to obtain a relatively accurate projection of the bearing area several years into the future. Second, explaining the decision to invest in a vineyard may require more than the standard theory embedded in (even dynamic) CGE models.

A critical issue concerns the timing of vineyard investments in response to a change in market signals. The premium red segment started the period emerging from a time of great pessimism, in which the South Australian and Commonwealth governments introduced a short-lived vine-pull scheme to encourage disinvestment in grape growing. Except for price falls in the recessive early 1990s, premium red winegrape producers rose throughout the past dozen years. We calculate that based on the new plantings of 1998 and 1999, the bearing area of premium red winegrapes will double between 1999

and 2003 (having almost doubled between 1996 and 1999). By contrast, growth in the bearing area of white winegrapes has been and will continue to 2003 to be only very gradual.

Viticulture's substantial fixed costs imply considerable supply irreversibility. Winegrape growing is extremely capital intensive, with an investment required per hectare currently of at least $A30,000 plus the costs of land and water rights. Also, there is a lag of at least three years before there is a positive cash flow. During several years of high and rising prices, as occurred in the late 1990s, growers may be able to recoup new investments quickly. After recovering those sunk costs, many growers would be able to maintain profitability in the event of a sharp fall in winegrape prices. Therefore, while a sustained boom in the wine industry has led to rapid plantings of vineyards, a subsequent fall in grape prices is unlikely to lead to a rapid reduction in production.[5]

4 Projecting to 2003

We have projected FEDSA-WINE into the future and examine how different scenarios may impact on expected growth. This entails the use of macroeconomic projections plus the forecast increase in bearing area of the winegrape segments of the model (Table 4). We also impose primary factor productivity growth on both winegrapes and wines (and on the non-wine industries in the model). And we assume that export demand growth and domestic taste changes continue, based approximately on shocks estimated in the historical simulation (Table 4).

The base case projection from 1999 to 2003

The base projection, including the GST tax reforms (discussed in Wittwer and Anderson, 2000) but excluding the recent currency devaluation (considered separately below), has domestic premium red wine consumption increasing from 63 Ml (megalitres) in 1999 to 92 Ml in 2003 (Table 2). In the same period, premium white wine consumption increases from 70 Ml to 88 Ml, and non-premium wine consumption decreases from 241 Ml to 240 Ml. The expenditure effect and increased preferences for premium wine add to the effect of falls in consumer prices. Population growth and falling prices almost offset the effect of the projected taste swing against non-premium consumption.

Production of premium red wine is projected to double between 1999 and 2003, with slower yet still substantial growth in white wine production. Due to this increase, the export supply of premium wine is projected to escalate in this period. Premium red wine exports increase from 88 Ml in 1999 to 254 Ml in 2003, premium white wine exports from 83 Ml to 149 Ml, and non-premium exports from 46 Ml to 76 Ml.

A real depreciation of the Australian dollar

In the wake of the East Asian financial crisis in the late 1990s, the Australian dollar appreciated against East Asian currencies but depreciated in real terms against other major currencies. In the first ten months of 2000, the domestic currency devalued sharply against the US dollar. Sustained changes in the real exchange rate will alter outcomes, particularly for export-oriented industries including premium red and white

wine. Relative to the 2003 base projection, which assumes no change in the exchange rate from 1999, a real devaluation that reduces aggregate consumption raises wine output and increases exports, with a decrease in domestic wine consumption (final column of Table 2). Multipurpose grapes are diverted from winemaking to direct exports as table grapes, explaining the small output reduction for non-premium wine. Winegrape prices rise slightly along with the costs of production. During the present phase of rapid expansion in the wine industry, any real depreciation will favour wine export growth slightly. The converse effect would result from any recovery of the Australian dollar's real exchange rate to pre-Asian crisis levels.

5 Conclusion

In our analysis of the 1990s exceptional growth phase of the wine industry, we find using a static CGE model that expanding export growth explains a significant proportion of that output growth and, for the premium red segment, most of the observed price increase in the period from 1987 to 1999. With accelerated winegrape plantings in the late 1990s and expanding wine manufacturing capacity, the industry will rely increasingly on export sales over the next decade. A sustained depreciation of the Australian dollar will assist producers during the rapid expansion phase. Our modeling suggests only a modest fall in winegrape prices with expanding export supply by 2003. But for producer prices to remain firm, Australia's producers will need to continue successful export promotion as the wine export supply of other countries grows — an obvious area for further modeling development and analysis.

Appendix: Details of the methodology used in the decomposition analysis

FEDSA-WINE solves a system of equations of the following form:

$$F(X) = 0 \tag{1}$$

where

F is an m-vector of differentiable equations, and

X is an n-vector of variables for year t, $n > m$.

X includes variables for prices and quantities in year t, to which the database is updated from the base year during the simulation. The m equations follow the economic theory of CGE models, including supplies and demands reflecting utility- and profit-maximising behaviour, with supplies equalling demands, and perfectly competitive prices set equal to unit costs. Different closures or combinations of $n–m$ variables can be included in the exogenous set to solve the model. The method used for historical accounting involves running the model twice, doing first a historical simulation and then a decomposition simulation. To solve the model, we use version 7.0 of GEMPACK to decompose the shocks of large change simulations (Harrison, Horridge and Pearson 1999). The two runs require different combinations of exogenous variables. We can have four versions of X (as in Table 1):

X(HD), X(H'D), X(HD') and *X(H'D')*

where

H is exogenous and *H'* endogenous in the historical closure and

D is exogenous and *D'* endogenous in the decomposition closure.

X(HD'), for example, refers to variables exogenous in the historical simulation and endogenous in the decomposition simulation. This set includes observable variables for which data on historical changes are available. For each of the three wine types, we select as exogenous the following variables: household consumption, export volumes, and f.o.b. export prices. We also include producer prices for winegrapes and employment data for both winegrapes and wine. Observable macroeconomic variables (e.g., aggregate consumption) are also part of the *X(HD')* set. This set thus includes variables that are normally endogenous in CGE simulations. To estimate unobservable variables, the observable variables are made exogenous in the historical simulation and shocked by the observed change. The unobservable variables have an economic interpretation. By making aggregate consumption exogenous, for example, we obtain an estimate of the change in the average propensity to consume between the two end points (1987 and 1999) of the historical simulation.[6] Table 1 summarises the categorization of key variables.

ABS publishes only a single price index for wine, and other surveys tend not to have representative expenditure weights for disaggregated wine types. Hence, wine prices are part of the *X(H'D')* set. Variables with a large influence on disaggregated retail wine prices (p_i) include available winegrape prices (winegrapes account for about 25 per cent of wine production costs, Winemakers' Federation of Australia, personal communication) and tax shifters. Household demands for non-wine commodities are assumed in FEDSA-WINE to respond almost entirely to expenditure effects (induced by the imposed change in aggregate consumption) and price effects. Such data are available but they would add little to our understanding of changes in the wine industry.

X(HD) includes observable changes in wine import tariff and consumer tax rates, c.i.f. import prices for wine, and population. CGE models generally are not used to explain these variables. This set also includes imposed primary factor productivity growth, as changes in capital stocks are not available to complete the picture of primary factor usage for winegrapes and wine.

To illustrate the use of the historical and decomposition simulations of the period 1987 to 1999 in this study, we consider a general function (i.e., not defining the functional form) for household demand within a CGE model:

$$x_i = (p_i, p_j, c, a_i, q) \tag{2}$$

In percentage change terms, x_i and p_i denote the domestic consumption quantity and price of household good i, p_j is the price of other goods ($i \neq j$), c is aggregate household consumption, a_i denote household preferences and q is population. For each of the three wine types in the database, x_i is observable and in the set *X(HD')*: it is exogenous in the historical run and endogenous in the decomposition run. Other observable variables include aggregate consumption, population growth and tax rates. The retail price p, as discussed above, is endogenous in all simulations. The unobservable residual a_i is in the set *X(H'D)*, and hence endogenous in the historical simulation: it provides an estimate of the taste change for each wine type.

In the decomposition simulation, x_i is endogenous. We isolate the effect of the taste shifter a_i (estimated in the historical simulation) for the three wine types from the other shocks used to project the model between the end points. This provides an estimate of

the contribution of domestic taste changes to the historical changes in the wine market. Similarly, the observable wine tax shocks in isolation provide an estimate of the historical impact of wine tax changes on the industry. And *c*, through the expenditure effect, and *q*, contribute to changes in wine consumption through general economic effects.

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Table 1 Selected variables in the historical and decomposition closures

Exogenous in historical simulation, endogenous in decomposition simulation (components of *X(HD')*)	**Endogenous in historical simulation, exogenous in decomposition (corresponding components of *X(H'D)*)**
Wine consumption	Shifts in household preferences, wine
Producer prices, winegrapes	Markups on costs, winegrapes
Wine export volumes and f.o.b prices	Shifts in foreign demand and domestic supply functions, wine
Employment, winegrapes and wine	Capital/labour bias in technical change, winegrapes and wine
Aggregate consumption	Shift in average propensity to consume
Exogenous in both historical and decomposition simulations (components of *X(HD)*)	**Endogenous in both historical and decomposition simulations (components of *X(H'D')*)**
Tax and tariff rates	Producer prices, except winegrapes
Population	Consumer prices, wine and other commodities
Winegrape bearing area	Capital stocks, all industries
Primary factor saving technical change	Demands for intermediate inputs (including margins services)
Rates-of-return on capital	

Table 2 Growth in the Australian winegrape and wine industries, 1987 to 2003

	1987	1999	mid-point % change [a]	2003[d] (1)	mid-point % change '99-'03	2003[e] (2)
	Historical			Projected		
Population (total, millions)	16.3	19.0	15.3	19.2	1.0	19.2
Real aggregate consumption ($bn)[b]	220.7	340.1	42.6	383.3	22.5	377.0
Domestic consumption (Ml)						
Premium red wine	22.4	62.5	94.5	92.2	38.4	88.8
Premium white wine	46.2	69.9	40.8	87.8	22.7	85.3
Non-premium wine	270.7	240.7	-11.7	240.0	-0.3	236.6
Wine, total	**339.3**	**372.6**	9.4	**420.0**	**12.0**	**410.6**
Production (Ml)						
Premium red wine	64.9	270.5	122.6	587.6	73.9	590.0
Premium white wine	94.5	242.1	87.7	383.3	45.1	386.7
Non-premium wine	330.2	339.6	2.8	359.4	5.7	356.1
Wine, total	**489.6**	**852.2**	54.0	**1330.2**	**43.8**	**1332.8**
Wine exports (Ml)						
Premium red wine	4.6	87.8	180.1	254.2	97.3	263.3
Premium white wine	5.4	82.6	175.5	149.1	57.4	153.2
Non-premium wine	14.0	45.7	106.2	75.9	49.6	76.1
Wine, total	**24.0**	**215.5**	159.9	**479.2**	**75.9**	**492.6**
Winegrape prices ($/tonne)[b]						
Premium red grapes	653	1,437	75.0	1,213	-16.8	1,219
Premium white grapes	874	813	-7.2	798	-1.9	802
Non-premium grapes	290	402	32.4	373	-7.5	376
C'wealth and state consumer taxes	19%	41%	..	48%	..	48%
Retail prices ($/litre)						
Premium red wine	9.54	13.11	31.5	12.59	-4.1	12.59
Premium white wine	10.00	11.46	13.6	11.36	-0.9	11.29
Non-premium wine	3.17	3.71	15.6	3.65	-1.5	3.59
Wine stocks (Ml)						
Premium red wine	155	580	115.6	1,253	73.4	1,265
Premium white wine	205	350	52.3	601	52.8	608
Non-premium wine	170	160	-6.1	140	-13.3	143
Area of bearing winegrapes ('000 ha)						
Premium red grapes	9.4	41.3	125.8	63.1	10.4	63.1
Premium white grapes	10.9	28.4	89.1	32.5	3.4	32.5
Non-premium grapes	14.9	14.8	-0.7	16.4	2.6	16.4
Self-sufficiency ratio[c] (%)						
Premium red wine	111	234	..	358	..	412
Premium white wine	107	212	..	257	..	288
Non-premium wine	103	112	..	121	..	130

Notes: (a) Mid-point % change = $200(Z_f - Z_i)/(Z_f + Z_i)$ where Z_f and Z_i are the final and initial values of Z.
(b) All values are real, in 1995-96 dollars.

(c) Self-sufficiency ratio = (Q-ΔS)/C, where Q is production, ΔS gross addition to stocks and C consumption.
(d) Including GST and Wine Equalisation Tax.
(e) Including a real depreciation relative to the base case.
Sources: ABS (1999); *Treasury Model of the Australian Economy*, Catalogue No. 1364.0; Australian Wine and Brandy Corporation, unpublished data.

Table 3 Decomposition of wine industry changes, 1987 to 1999

	Export demand growth (1)	Domestic consumer tastes (2)	Consumer tax changes (3)	Productivity (4)	Economic growth (5)	Winegrape area (6)	Total
Premium red wine			mid-point % change				
Output	25.1	30.1	-4.6	11.3	26.2	34.5	122.6
Producer price	30.5	2.6	-0.7	-5.6	15.5	-11.2	31.2
Consumer price	17.1	1.5	9.3	-3.1	13.3	-6.5	31.5
Domestic consumption	-15.4	61.6	-7.9	2.8	46.9	6.5	94.5
Export volume	114.2	-18.5	2.1	28.4	-38.3	92.2	180.1
Premium white wine							
Output	31.7	0.4	-4.0	10.9	31.6	17.2	87.8
Producer price	4.6	-0.2	-0.5	-5.6	6.2	-7.0	-2.4
Consumer price	2.6	-0.1	10.4	-3.2	7.9	-4.1	13.6
Domestic consumption	-1.5	3.4	-6.3	2.0	40.8	2.6	41.0
Export volume	104.4	-2.1	1.3	27.6	-1.4	45.7	175.5
Non-premium wine							
Output	3.2	-32.7	-3.3	1.8	34.9	0.2	4.0
Producer price	2.8	-0.6	-0.2	-4.6	6.0	-0.5	2.9
Consumer price	1.8	-0.4	10.8	-3.0	6.7	-0.3	15.6
Domestic consumption	-0.6	-38.4	-3.6	1.0	30.5	0.1	-11.1
Export volume	82.4	2.3	0.3	15.1	4.4	1.7	106.2

Source: Authors' FEDSA-WINE decomposition.

Table 4 Changes to productivity, wine export demand and domestic wine preferences (mid-point % per annum)

Primary factor productivity growth	1987 to 1999	1999 to 2003
Winegrapes	1.0	1.6
Wine	1.2	0.9
Export demand growth		
Red premium wine	*16.0*	12.3
White premium wine	*13.7*	10.0
Non-premium wine	*11.9*	8.3
Domestic taste change		
Red premium wine	*5.4*	4.5
White premium wine	*0.1*	2.4
Non-premium wine	*-3.2*	-2.6

Sources: Italicised numbers estimated in the historical simulation.

[1] Apart from being useful in its own right, we wanted to project forward the database so as to analyse the impacts of the GST and associated wine tax changes in July 2000 on the wine industry as of the early part of the present decade rather than the middle of the past decade (Wittwer and Anderson 2000).

[2] Earlier demand studies of the Australian wine industry include Tsolakis, Reithmuller and Watts (1983), Clements and Johnson (1984), Clements and Selvanathan (1991), Oczkowski (1994), CIE (1995a) and Clements, Yang and Zheng (1997). Earlier Australian CGE historical/decomposition simulation studies include Dixon, Malakellis and Rimmer (1997), Parmenter, Meagher and Higgs (1994) and Dixon et al. (2000).

[3] All changes are expressed in mid-point percentages, using the formula given in footnote a to Table 2. Mid-points are used as some key indicators, notably exports, have experienced rapid growth from low base levels in 1987.

[4] Consistent with the estimates of Dixon et al. (2000), greater shocks are imposed on mining and agriculture than other industries. The estimates of Knopke, Strappazzon and Mullen (1995) of agricultural productivity growth also imply higher growth than the economy-wide average for Australia. This is similar to the finding for many countries (Martin and Mitra 1999).

[5] A formal framework for examining the investment decision of winegrape growers in the 1990s is the real options theory elaborated by Dixit and Pindyck (1994).

[6] In simulating, we divided the time period into two, from 1996 back to 1987, and from 1996 to 1999. For brevity, we report the 12 years from 1987 to 1999 as one time period for most variables.

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