Terroir rising? Varietal and quality distinctiveness of Australia's wine regions

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Abstract

Australia's export-led growth in demand for commercial bottled wine was based in part on producer freedom (relative to Europeans) to blend wines across the full range of varieties and geographic regions, so as to be able to reproduce year after year a consistent style for each label. Over time, however, that has led some buyers in the 'Old World' to believe Australian winemakers do not respect or exploit regional differences in terroir or, worse still, that Australia is incapable of making high-quality, regionally distinct wines. This paper examines empirically the changing extent to which Australian wine regions do in fact vary in their choice of winegrape varieties and in the average quality of those winegrapes. Its new new quantitative indexes may also provide a base for simulating the potential impacts on different regions of climate change and of adaptive responses to it. The study focuses on 30 of Australia's winegrape regions and on the top 12 red and 10 white winegrape varieties that together account for all but 6 or 7 percent of Australia's winegrape crush.

JEL classification: D24, L66, Q13, Q15.
Keywords: wine economics, terroir, regional winegrape quality.

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1 Introduction

It has been argued that part of the reason Australia was able to contribute to and respond so successfully in the 1990s to the growth in demand for commercial bottled wine was because of its freedom (relative to European producers) to blend wines across the full range of varieties and geographic regions, so as to be able to reproduce year after year a consistent style for each label (Anderson 2003). Over time, however, that has led some buyers in the 'Old World' to believe Australian and other 'New World' winemakers do not respect or exploit regional differences in terroir or, worse still, that the 'New World' is incapable of making high-quality geographically distinct wines.

The purpose of this paper is to examine the changing extent to which Australian wine regions do in fact vary in their choice of winegrape varieties and in the average quality of those winegrapes. In doing so the study provides some new quantitative indexes that may be helpful for other purposes too, such as providing a base for simulating the potential impacts on different regions of new technologies such as those being produced to help growers adapt to climate change.

The study focuses on Australia's 26 biggest-producing winegrape regions (geographical indications or GIs) plus four newer cool-climate regions which together accounted in 2006 for 93 percent of the Australian winegrape crush (see Table 1), and on the top 12 red and 10 white winegrape varieties which together accounted in 2006 for 94 percent of Australia's winegrape crush (see Table 2). The 2006 rather than later vintages is shown because production was affected much more by drought, water shortages and other natural disasters in 2007 and 2008. And those 2006 crush numbers are compared with 2001 because it was the first year for which price and quantity data were compiled nationally by GI region and variety.

Five indexes are used to characterize wine regions according to their mix and qualities of grape varieties: a Regional Quality Index, a Varietal Quality Index, a Varietal Intensity Index, and two varietal-based Regional Similarity Indexes (based on varietal mix measured in terms of quantity and price).

The paper first defines these indexes. It then presents the empirical results for 2006, and draws out their differences with the 2001 results to show the extent to which varietal specialization and quality differentiation by region have increased over that period. The final section draws out some implications and discusses further applications of this research.

Table 1: Share of Australia's winegrape area and production and Regional Quality Index[a] by region, 2001 and 2006

(a) by GI

Code	Tem[a]	% of national winegrape area		% of national winegrape prodn. volume		% of national winegrape prodn. value		Regional Quality Index[b]		Region
		2001	2006	2001	2006	2001	2006	2001	2006	
RIV	VH	19.2	22.4	22.1	25.6	17.0	15.7	0.74	0.66	Riverland - SA
RIN	VH	11.0	12.2	11.0	13.6	6.2	10.0	0.57	0.66	Riverina - NSW
MDV	VH	14.9	14.3	14.1	12.3	9.5	8.0	0.81	0.63	Murray Darling - VIC
MDN	VH	5.3	6.0	5.2	6.7	3.5	4.8	0.81	0.63	Murray Darling - NSW
BAV	H	4.0	3.8	4.6	4.3	6.1	6.8	1.69	1.72	Barossa Valley - SA
PAD	W	2.4	3.1	2.8	3.5	4.2	3.4	1.84	1.56	Padthaway - SA
McL	H	3.0	2.9	3.4	3.4	7.4	6.2	2.03	2.01	McLaren Vale - SA
LAN	W	3.0	2.9	3.4	3.3	5.8	5.7	1.73	1.74	Langhorne Creek - SA
SWH	VH	2.3	2.8	2.2	2.4	1.5	1.6	0.81	0.61	Swan Hill - VIC
COO	W	2.6	2.0	3.0	2.3	7.1	2.5	2.05	1.56	Coonawarra - SA
CLV	H	1.5	1.9	1.8	2.2	2.6	3.4	1.74	2.01	Clare Valley - SA
MAR	W	2.9	3.4	1.7	1.6	2.6	3.4	1.86	2.79	Margaret River - WA
MUD	H	1.1	1.3	1.1	1.5	1.6	1.7	1.45	1.46	Mudgee - NSW
HUN	H	1.8	1.2	1.8	1.3	2.5	1.2	1.45	1.50	Hunter - NSW
ADH	C	1.0	1.1	1.1	1.2	2.5	3.1	1.95	2.44	Adelaide Hills - SA
COW	VH	1.2	1.0	1.2	1.1	1.1	0.9	1.30	1.29	Cowra - NSW
YAV	C	1.2	1.0	1.1	0.9	1.9	1.5	2.00	2.76	Yarra Valley - VIC
WRA	W	0.7	0.7	0.8	0.8	1.9	2.2	1.74	2.11	Wrattonbully - SA
GRS	W	1.7	1.5	1.0	0.7	1.3	1.3	1.80	2.32	Great Southern - WA
EDV	C	0.6	0.6	0.7	0.7	1.4	1.3	1.87	2.04	Eden Valley - SA
CUR	W	0.6	0.5	0.7	0.6	0.4	1.1	2.00	1.59	Currency Creek - SA
GOU	H	0.7	0.7	0.7	0.6	0.3	0.5	1.42	1.36	Goulburn Valley - VIC
ORA	W	0.6	0.5	0.6	0.6	1.0	0.6	1.69	1.51	Orange - NSW
RUG	H	0.4	0.5	0.4	0.4	0.6	0.7	1.15	1.25	Rutherglen - VIC
AVB	W	0.6	0.5	0.6	0.4	1.4	0.4	1.27	1.68	Alpine V/Beech. - VIC
SWA	VH	0.6	0.9	0.4	0.4	0.5	0.5	1.04	1.48	Swan District - WA
TAS	C	0.6	0.7	0.4	0.3	1.0	1.3	2.83	4.72	Tasmania - TAS
MtB	W	0.3	0.3	0.3	0.3	0.8	2.5	1.66	1.64	Mount Benson - SA
MOR	W	0.2	0.2	0.2	0.2	0.2	0.3	1.94	2.80	Mornington Pen. - VIC
CAN	W	0.0	0.1	0.0	0.1	0.1	0.2	1.75	3.04	Canberra District-NSW
		86.1	**90.9**	**88.4**	**93.3**	**94.0**	**92.8**	**1.00**	**1.00**	**AVERAGE of above**
								0.50	**0.87**	**Standard deviation**

(b) By climate zone (percent)

Code	% of national winegrape area		% of national winegrape prodn. volume		% of national winegrape prodn. value	
	2001	2006	2001	2006	2001	2006
Very hot	55	60	56	62	39	41
Hot	13	12	15	14	21	21
Warm	15	16	14	14	27	24
Cool	3	3	3	3	7	7
Not included above	14	9	12	7	6	7
TOTAL	100	100	100	100	100	100

[a] Mean January temperature zone: VH=very hot (23.0 °C and above); H=hot (between 21.0 and 22.9 °C); W=warm (between 19.5 and 20.9 °C); and C=cool (less than 19.5 °C). This and other climate variables are shown in Appendix Table H.
[b] Average winegrape price in the region as a proportion of the average price nationally. When the VH region is excluded, the means in 2001 and 2006 are 1.32 and 1.55, and the standard deviations are 0.36 and 0.77, respectively.

Source: Author's calculations based on data available at www.awbc.com.au

2 Defining the indexes

Three sets of indexes are defined in turn in this section: two varietal/regional quality indexes, a varietal intensity index, and two varietal-based regional similarity indexes.

2.1 Regional and Varietal Quality Indexes

To capture differences in the wineries' perception of the quality of the grapes delivered, bearing in mind consumers' willingness to pay for their wines, use can be made of a number of price-based indexes.

The overall quality of all winegrapes in region i, as perceived by wineries in the light of consumer willingness to pay is indicated by the average winegrape price in that region, P_i, as a proportion of the national average winegrape price, P, across all varieties. Call that the *Regional Quality Index*, R_i, where

(1) $R_i = (P_i/P)$

The simplest index of quality of different varieties is the ratio of the national average price for variety m to the national average price of all winegrape varieties. Call that the *Varietal Quality Index*, Q_m, where

(2) $Q_m = (P_m/P)$.

Table 2: Shares of Australia's winegrape area and production and Varietal Quality Index,a by variety, 2001 and 2006

(a) Reds

Share (%) of national winegrape area		Share (%) of national winegrape prodn volume		Share (%) of national winegrape prodn value		Varietal Quality Index[a]		Red variety	Abbrev.
2001	2006	2001	2006	2001	2006	2001	2006		
22.4	24.7	22.4	23.7	28.8	27.9	1.24	1.18	Shiraz	Sh
19.1	17.5	17.9	15.4	23.7	16.5	1.26	1.09	Cabernet Sauv.	Ca
5.9	6.3	5.8	6.9	6.2	6.7	1.05	0.99	Merlot	Me
2.5	2.6	2.1	1.9	2.8	2.9	1.16	1.68	Pinot Noir	PN
0.6	0.9	0.4	1.5	1.6	1.6	1.00	0.74	Petit Verdot	PV
1.6	1.3	1.6	1.3	1.4	1.3	1.03	1.13	Grenache	Gr
1.9	0.9	2.2	1.5	0.4	0.9	0.72	0.53	Ruby Cabernet	RC
0.7	0.5	0.8	0.6	0.6	0.5	0.73	0.72	Mataro	Mt
0.3	0.3	0.2	0.3	0.2	0.3	1.01	0.91	Sangiovese	Sa
0.6	0.4	0.4	0.2	0.1	0.3	1.03	1.14	Cabernet Franc	CF
0.1	0.2	0.1	0.2	0.2	0.3	0.73	0.59	Durif	Du
0.3	0.2	0.3	0.2	0.4	0.2	0.84	1.12	Malbec	Ma
56.0	***55.7***	***54.4***	***53.7***	***66.5***	***59.3***	***1.17***	***1.09***	***Sub-total, above***	

(b) Whites

Share (%) of national winegrape area		Share (%) of national winegrape prodn volume		Share (%) of national winegrape prodn value		Varietal Quality Index[a]		White variety	Abbrev.
2001	2006	2001	2006	2001	2006	2001	2006		
13.2	17.9	17.6	22.3	17.9	20.6	0.98	0.96	Chardonnay	Ch
5.0	3.7	6.4	5.4	4.4	4.7	0.72	0.96	Semillon	Se
2.0	2.4	1.8	2.3	2.0	3.9	1.03	1.69	Sauvignon Blanc	SB
2.4	2.6	1.9	2.2	1.8	2.9	0.98	0.98	Riesling	Ri
1.4	1.7	2.8	4.2	1.2	2.1	0.43	0.53	Colombard	Co
1.0	1.0	0.9	1.1	0.8	0.9	0.87	0.93	Verdelho	Ve
0.0	0.4	n.a	0.3	0.1	0.9	n.a	1.59	Pinot Gris	PG
0.0	0.5	0.0	0.4	0.0	0.6	0.85	1.71	Viognier	Vi
0.4	0.5	0.3	0.6	0.5	0.5	0.66	0.94	Gurwitztraminer	Gu
0.6	0.4	1.0	0.6	0.2	0.5	0.49	0.87	Chenin Blanc	CB
26.0	***31.1***	***32.8***	***39.4***	***28.9***	***37.6***	***0.83***	***0.91***	***Sub-total, above***	
82.0	**86.8**	**87.2**	**94.1**	**95.4**	**96.9**	**1.00**	**1.00**	**TOTAL, above**	
						0.22	**0.36**	**Standard deviation**	

[a] National average price for variety as proportion of national average price of all varieties.
Source: Author's calculations based on data available at www.awbc.com.au

2.2 Varietal Intensity Index

Define f_{im} as the area of plantings of grape variety m as a proportion of the total grape plantings in region i such that these shares fall between zero and one and sum to one (i.e., there are a total of M different grape varieties across the nation, and $0 \leq \quad f_{im} \quad \leq 1$ and $\Sigma_m \quad f_{im} = 1$). For the nation as a whole, f_m is the area of plantings of grape variety m as a proportion of the total national grape plantings, and $0 \leq \quad f_m \quad \leq 1$ and $\Sigma_m \quad f_m = 1$. Then the Varietal Intensity Index, V_{im} for variety m in region i is:

(3) $V_{im} = f_{im}/f_m$.

This quantity-based index could also be generated for grape production by a region's growers, or for a region's grapes crushed by wineries.[2] While area data will show changes earliest and not be subject to year-to-year fluctuations due to weather-related seasonal differences across regions, production data are more likely to have matching price data. Since in Australia the latter is the case, we use production rather than area data below.

2.3 Regional Similarity Indexes

To define indexes of similarity between regions, we borrow and adapt an approach introduced by Jaffe (1986)—see also Griliches (1979)—and used subsequently by Jaffe (1989) and others including Alston, Norton and Pardey (1998) to measure inter-firm or inter-industry or inter-regional technology spillover potential.

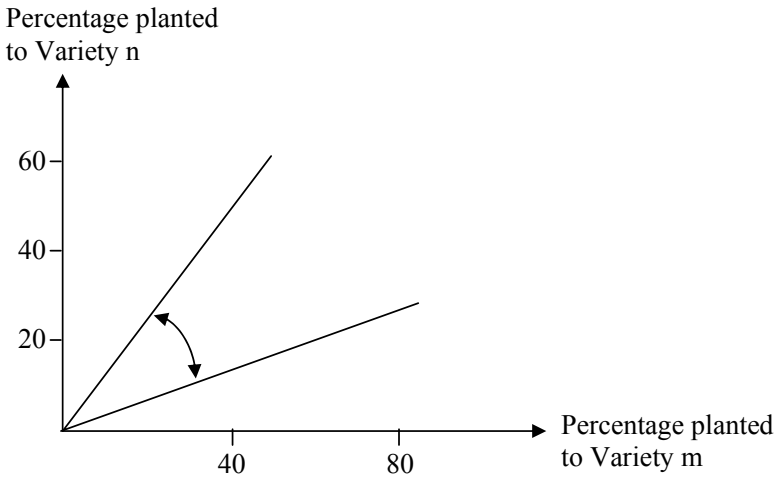
We could use agro-ecological characteristics in the different regions (as used in a different context by Wood and Anderson 2005) to define their "closeness" to one another viticulturally, in the same way that Jaffe (1989) used characteristics of the patents obtained by firms to define a measure of technological closeness among firms. Various agro-ecological characteristics of viticulture might be used for this purpose, such as measures of climate (temperature mean, maximum and variability; rainfall mean and distribution; sunshine; humidity; windiness; etc.), geological characteristics of the soil, topography of the land, and so on, drawing on the work of Gladstones (1992) and others. Here we use measures of the mix of grape varieties planted or harvested, a form of revealed preference or judgement by vignerons about what is best to grow. That judgement is affected by not only terroir but also past and present economic considerations, including current expectations about future price trends plus the sunk cost that would be involved in grafting new varieties onto existing rootstocks.

The previously defined vector of grape varietal shares $f_i = (f_{i1}, \ldots, f_{iM})$ locates region $i$in M-dimensional space. Noting that proximity is defined by the direction in which the f-vectors are pointing, but not necessarily their length, Jaffe (1989) proposed a measure called the angular separation of the vectors which is equal to the cosine of the angle between them. If there were just two varieties, m and n, and region i had 80 percent of its total vine area planted to variety m whereas only 40 percent of region j was planted to variety m, then their index of regional similarity is the cosine of the arrowed angle between the two vectors

[2]It is important to ensure winery crush data refer to the region of origin of the grapes rather then the region in which the winery is located, given that some grapes are processed outside the region in which they are grown.

shown in Figure 1.

Figure 1: Angular separation between two regions, each growing two grape varieties



When there are M varieties, this measure is defined as:

(4) $\omega_{ij} = \frac{\sum_{m=1}^{M} f_{im} f_{jm}}{\left(\sum_{m=1}^{M} f_{im}^2\right)^{1/2} \left(\sum_{m=1}^{M} f_{jm}^2\right)^{1/2}}$,

where again f_{im} is the area of plantings of grape variety m as a proportion of the total grape plantings in region i such that these proportions fall between zero and one and sum to one (i.e., there are a total of M different grape varieties across the nation, and $0 \leq f_{im} \leq 1$ and $\Sigma_m \ f_{im} = 1$). This allows us to indicate the degree of varietal mix "similarity" of any pair of regions. One can also generate it for each region relative to the average of the nation's N regions, call it ω.

In short, ω_{ij}measures the degree of overlap of f_i and f_j. The numerator of equation (4) will be large when i's and j's varietal mixes are very similar. The denominator normalizes the measure to be unity when f_i and f_j are identical. Hence, ω_{ij} will be zero for pairs of regions with no overlap in their grape varietal mix, and one for pairs of regions with an identical varietal mix. For the in-between cases, $0 < \omega_{ij} < 1$. It is conceptually similar to a correlation coefficient. Like a correlation coefficient, it is completely symmetric in that $\omega_{ij} = \omega_{ji}$ and $\omega_{ii} = 1$. Thus the results can be summarized in a symmetric matrix with values of 1 on the diagonal, plus a vector that reports the index for each region relative to the national varietal mix.

This index can also be generated for a region's grapes crushed by wineries – and that is what is used below for Australia.

3 Empirical results

We begin with the two quality indexes, then report the regional intensity indexes before turning to the regional similarity indexes.

3.1 Regional and Varietal Quality Indexes

That Australian winegrape regions vary substantially in terms of average winegrape quality is clear from estimates of the Regional Quality Index, defined as the average winegrape price in a region across all varieties as a proportion of that average price nationally. Winegrapes in 2006 from the warm irrigated regions of the Riverland, Riverina, Murray Darling, Swan Hill, Cowra and Swan Valley, which comprise 60 percent of the national crush volume, received on average just under two-thirds of the national average price, whereas all other 23 regions received on average between 30 and 380 percent above the national average price that vintage (Table 1). Indeed 11 of those 23 other regions enjoyed an average price of more than twice the overall national average. The distribution of prices for regions other than the five hottest ones is illustrated in Figure A.1, which shows the thin tail of the right side of that distribution – a tail that has shifted substantially to the right between 2001 and 2006, indicating an increase in the average quality range across regions. This shift is reflected in the increase in the standard deviation of Regional Quality Index across regions, from 0.50 to 0.87 over that six-year period. It is also reflected in the fact that of the 18 regions whose Regional Quality Index rose over the 2001 to 2006 period, two-thirds of them had an index value of greater than 1.7 in 2006.

The average price of each variety nationally also covers quite a range. The two most-common red varieties (shiraz and cabernet sauvignon) and the most common white (chardonnay) together accounted for 58 percent of the volume of national winegrape production in 2001 and 61 percent in 2006, suggesting that economic factors play a non-trivial role in varietal selection in addition to terroir. But note from Table 2 that by 2006 four other red varieties received an average price above that for Cabernet Sauvignon and four other whites had an average price above that for chardonnay. The standard deviation of that Varietal Quality Index across varieties increased from 0.22 to 0.36 between 2001 and 2006, indicating an increase in the average quality range across varieties.

3.2 Varietal Intensity Index

The extent to which winegrape regions vary in terms of the mix of varieties they produce is captured by the Varietal Intensity Index, as it is the share of each variety in a region's production as a ratio of that variety's share of national production. That index ranges from zero to more than 40 (Table 3), being higher for the cool-climate and lesser varieties.

Table 3: Ranking of varieties according to Varietal Intensity Index,[a] by Australian GI region, 2001 and 2006

(a) 2001

Adelaide Hills	9.29	PN	5.43	SB	3.70	Vi	2.53	Sa	1.48	Me	1.32	Ch
Alpine Valley/Beechworth	6.01	Du	3.98	PN	3.43	Ma	3.14	Me	2.88	SB	1.84	CF
Barossa Valley	5.40	Vi	3.55	Gr	2.75	Ri	1.96	Se	1.90	CF	1.71	CB
Canberra District	15.57	Vi	5.69	PN	5.22	Ri	2.71	Gu	2.28	SB	1.39	CF
Clare Valley	7.70	Ri	3.09	Ma	1.98	CF	1.82	Sa	1.36	Gu	1.36	Sh
Coonawarra	2.91	CF	2.60	Ca	2.30	Ma	2.19	Ri	1.87	PN	1.06	Sh
Cowra	7.55	CF	4.73	Ve	2.48	Ma	2.39	Ch	1.43	Se	1.42	SB
Currency Creek	5.99	Gr	4.11	Gu	2.09	Ca	1.63	CB	1.37	Sh	1.12	SB
Eden Valley	13.11	Ri	8.61	Gu	8.20	Vi	2.71	PN	1.18	SB	1.14	Ch
Goulburn Valley	9.32	Vi	3.15	Ri	2.89	SB	2.01	CF	1.41	Ch	1.21	Ma
Great Southern	4.28	SB	4.09	Ri	3.49	Ve	3.14	CF	2.41	Ma	1.63	PN
Hunter	10.11	Ve	4.05	Gu	2.99	Se	2.45	Ch	1.53	Vi	1.01	CF
Langhorne Creek	5.85	Sa	2.97	Ma	2.31	Ca	1.74	Ve	1.61	PV	1.47	Sh
Margaret River	6.70	SB	2.56	CF	2.41	Se	2.40	CB	1.62	Ve	1.60	Ma
McLaren Vale	3.71	Gr	3.41	Vi	2.52	CF	1.68	Sh	1.30	SB	1.29	Sa
Mornington Peninsula	17.49	PN	2.85	SB	2.28	Vi	1.88	Ch	0.69	Gu	0.51	CF
Mount Benson	8.76	SB	2.62	PN	2.56	CF	2.02	Me	1.64	Ca	1.15	PV
Mudgee	2.90	Sa	1.59	Se	1.48	CF	1.48	Sh	1.42	Ca	1.37	SB
Murray Darling - NSW	2.01	Vi	1.59	Co	1.40	Me	1.20	Ch	1.13	RC	0.83	Ca
Murray Darling - VIC	1.94	Co	1.38	RC	1.30	Sa	1.20	Me	1.19	Ch	0.79	Se
Orange	2.91	SB	2.04	Me	1.84	Ve	1.41	Sh	1.37	Ca	1.21	CF
Padthaway	3.70	Ri	2.20	Gu	2.15	Vi	2.14	PN	1.95	CF	1.65	Ch
Riverina	6.51	Du	3.87	Gu	3.32	Se	2.28	RC	1.86	Co	1.84	Ve
Riverland	2.85	PV	2.81	Mt	2.06	Gr	1.72	CB	1.71	RC	1.60	Co
Rutherglen	41.25	Du	3.39	Sa	1.72	Ma	1.70	Sh	1.08	CF	1.06	CB
Swan District	29.88	CB	11.75	Ve	8.36	Gr	2.60	Vi	1.97	Gu	1.02	Se
Swan Hill (VIC)	1.62	RC	1.56	CB	1.35	Co	1.12	Mt	0.81	Ri	0.80	Sh
Tasmania	17.84	PN	3.18	Ri	2.87	SB	2.87	Gu	2.17	Ch	1.79	CF
Wrattonbully	2.95	Ca	2.06	SB	1.89	Me	1.62	PV	1.45	PN	0.97	Sh
Yarra Valley	11.36	PN	4.62	SB	1.87	Ch	1.35	CF	1.01	Ca	0.98	Me

Table 3 (cont.): Ranking of varieties according to Varietal Intensity Index,[a] by Australian GI region, 2001 and 2006

(b) 2006

Adelaide Hills	7.11	PN	7.02	SB	4.95	PG	2.37	Vi	1.69	Sa	1.51	Ri
Alpine V/Beechworth	6.10	PG	5.66	Sa	4.58	Me	4.22	Vi	3.26	PN	2.55	SB
Barossa Valley	4.93	Gr	2.62	Ri	1.95	Se	1.87	Mt	1.73	Sh	1.66	Vi
Canberra District	5.57	Ri	4.55	Sa	3.81	PN	3.58	CF	3.30	Vi	3.16	SB
Clare Valley	6.91	Ma	6.73	Ri	2.13	Sa	1.50	Sh	1.40	Ca	1.31	CF
Coonawarra	3.81	CF	2.92	Ca	1.48	Ri	1.39	PN	1.12	SB	1.08	Me
Cowra	6.15	CF	3.98	Ve	3.32	Ma	2.27	Ch	1.49	Se	1.31	SB
Currency Creek	2.22	Ca	1.58	Sh	1.53	Gr	1.52	SB	1.41	Gu	1.36	Me
Eden Valley	10.59	Ri	5.48	PG	2.71	Vi	1.68	Ma	1.44	PN	1.30	Gu
Goulburn Valley	5.38	Sa	5.36	Vi	2.37	SB	1.79	Ve	1.62	Sh	1.58	CF
Great Southern	7.90	SB	4.67	Ri	2.90	Ma	2.45	CF	1.99	Se	1.45	Ve
Hunter	10.30	Ve	3.69	Se	2.30	Gu	1.59	Ch	0.82	Sh	0.70	SB
Langhorne Creek	2.58	Ma	2.21	Gr	2.12	Ca	1.59	Sa	1.56	Vi	1.41	Sh
Margaret River	6.89	SB	6.55	CB	3.27	CF	2.97	Se	2.19	Ma	1.75	Ve
McLaren Vale	5.31	Gr	1.93	CF	1.89	Sh	1.88	Sa	1.85	Vi	1.08	Ca
Mornington Peninsula	33.41	PG	20.20	PN	1.78	Vi	1.30	Ch	1.21	SB	1.16	CF
Mount Benson	3.11	SB	2.91	CF	1.74	PN	1.62	Me	1.58	Ca	1.45	PG
Mudgee	3.77	Gu	3.61	Sa	1.57	Me	1.37	Se	1.32	Ca	1.31	Sh
Murray Darling - NSW	1.79	Vi	1.66	Me	1.58	Co	1.44	Ch	0.93	Ca	0.89	RC
Murray Darling - VIC	1.68	Sa	1.67	Co	1.45	Ch	1.13	Me	0.85	Ca	0.84	RC
Orange	2.60	PG	2.40	CF	2.22	SB	2.01	Me	1.46	Ca	1.21	Ri
Padthaway	7.08	Ma	5.08	CF	2.68	Ri	2.17	PG	2.04	Mt	1.55	PN
Riverina	5.17	Du	3.10	Gu	2.96	RC	2.95	Se	2.40	PG	2.03	Ve
Riverland	2.41	PV	2.18	Mt	1.71	Co	1.44	RC	1.44	CB	1.37	Gr
Rutherglen	33.53	Du	4.81	PG	2.88	Sa	2.37	Vi	1.71	Sh	1.39	Gu
Swan District	46.70	CB	12.01	Ve	4.27	Gr	1.44	CF	1.18	Ma	0.78	Ri
Swan Hill (VIC)	1.52	CB	1.32	Sa	1.25	Co	1.17	Vi	1.15	Mt	1.13	Ve
Tasmania	22.91	PN	11.08	PG	4.51	Ri	3.28	SB	1.22	Ch	0.89	Gu
Wrattonbully	2.96	Ca	2.11	Ma	1.89	Me	1.34	Sh	1.10	PN	0.61	Vi
Yarra Valley	12.37	PN	2.72	SB	2.39	Vi	1.68	CF	1.48	PG	1.34	Ch

[a] Defined as the share of each variety in the region's production as a ratio of that variety's share of national production

Source: Author's calculations (see Appendix Table A for full details) based on data from www.awbc.com.au

For shiraz the top two regions in 2006 are Barossa Valley and McLaren Vale, for cabernet sauvignon they are Wrattonbully and Coonawarra, and for pinot noir they are Tasmania and Mornington Peninsula. Among the whites that index is highest for riesling in Eden Valley and Clare Valley, for semillon in the Hunter and Margaret River, and for sauvignon blanc in Great Southern and the Adelaide Hills. According to the standard deviation of those index values (whose mean value is unity by definition), between 2001 and 2006 the extent of their dispersion

has increased for 7 and decreased for 4 of the 12 red varieties (Table 4). The growth in varietal specialization of regions is reflected in Figure A.2 which shows the growing varietal intensity indexes for an illustrative sample of four varieties and selected regions.

Table 4: Standard deviation of Varietal Intensity Indexes[a] of Australian GI regions, by variety, 2001 and 2006

	2001	**2006**
Shiraz	0.45	0.47
Cabernet Sauv.	0.51	0.69
Merlot	0.65	0.80
Pinot Noir	4.97	5.66
Ruby Cabernet	0.65	0.62
Petit Verdot	0.64	0.48
Grenache	2.02	1.47
Mataro	0.64	0.64
Sangiovese	1.33	1.60
Durif	7.68	6.14
Cabernet Franc	1.48	1.55
Malbec	1.47	1.81
Chardonnay	0.59	0.46
Semillon	0.88	0.97
Colombard	2.16	2.05
Sauvignon Blanc	2.90	2.41
Riesling	0.65	0.58
Verdelho	2.86	2.81
Chenin Blanc	5.60	8.53
Gurwitztraminer	1.95	0.95
Viognier	3.16	1.32
Pinot Gris	n.a.	6.33

[a] Defined as the share of each variety in the region's production as a ratio of that variety's share of national production

Source: Author's calculations (see Appendix Table A for full details) based on data from www.awbc.com.au

3.3 Regional Similarity Indexes

The degree of similarity of each region's varietal mix with the overall national varietal mix is shown in the Regional Similarity Index numbers based on winegrape crush reported in Table 5. The mean went down in almost two-thirds of the regions between 2001 and 2006, although the unweighted national average of those regional means fell only slightly. That means there has been a slightly increasing diversity

of regions relative to the national average, which is evident also from the slightly broader distribution of those numbers in 2006 as compared with 2001, depicted in Figure A.3 (which excludes the five large hot zone regions).

Table 5: Index of Regional Similarity of each Australian GI region relative to the national average, and share of national winegrape production,[a] 2001 and 2006

	Quantity-based Regional Similarity Index				Share of vol. of national crush, 2006 (percent)
	Mean		Standard deviation		
	2001	2006	2001	2006	
Adelaide Hills	0.78	0.80	0.13	0.13	1.2
Alpine V/Beechworth	0.86	0.74	0.12	0.12	0.4
Barossa Valley	0.92	0.87	0.18	0.20	4.3
Canberra District	0.92	0.91	0.11	0.13	0.1
Clare Valley	0.93	0.86	0.18	0.21	2.2
Coonawarra	0.85	0.79	0.20	0.19	2.3
Cowra	0.85	0.84	0.14	0.16	1.1
Currency Creek	0.88	0.86	0.21	0.22	0.6
Eden Valley	0.80	0.84	0.13	0.15	0.7
Goulburn Valley	0.96	0.92	0.14	0.19	0.6
Great Southern	0.96	0.83	0.14	0.12	0.7
Hunter	0.74	0.82	0.16	0.16	1.3
Langhorne Creek	0.89	0.90	0.21	0.19	3.3
Margaret River	0.90	0.83	0.14	0.14	1.6
McLaren Vale	0.95	0.88	0.18	0.20	3.4
Mornington Peninsula	0.51	0.51	0.20	0.18	0.2
Mount Benson	0.86	0.93	0.17	0.18	0.3
Mudgee	0.98	0.97	0.18	0.17	1.5
Murray Darling NSW[b]	0.96	0.95	0.13	0.14	6.7
Murray Darling VIC[b]	0.94	0.93	0.12	0.14	12.3
Orange	0.96	0.96	0.18	0.15	0.6
Padthaway	0.96	0.98	0.12	0.13	3.5
Riverina	0.86	0.87	0.14	0.14	13.6
Riverland	0.98	0.99	0.16	0.14	25.6
Rutherglen	0.86	0.80	0.21	0.22	0.4
Swan District	0.48	0.55	0.09	0.08	0.4
Swan Hill VIC[b]	0.96	0.98	0.17	0.14	2.4
Tasmania	0.45	0.39	0.22	0.20	0.3
Wrattonbully	0.78	0.77	0.22	0.22	0.8
Yarra Valley	0.71	0.79	0.16	0.13	0.9
Unweighted average -- all	**0.848**	**0.835**	**0.161**	**0.162**	
-- all excluding the 5 large Very Hot regions	**0.830**	**0.814**	**0.165**	**0.167**	

[a] Coefficient of correlation between the Regional Similarity Index and share of national crush is 0.35

[b] The Murray Darling/Swan Hill district average is shown for each of these regions

Source: Author's calculations based on data from www.awbc.com.au

Table 5 also reports also the standard deviation of the Regional Similarity Index for each region vis-à-vis each other region. The standard deviation went up between 2001 and 2006 for almost two-thirds of the regions. Even though the unweighted national average of those regional standard deviations increased only slightly, this nonetheless provides further evidence that Australia's wine regions

are becoming more distinct from each other over time. The three most-similar regions to each of the regions in 2001 and 2006 is shown in Table 6.

4 Implications of results and areas for further research

In summary, these empirical data suggest that the distinctiveness of Australia's wine regions, at least in terms of grape quality and varietal mix, has indeed intensified over the six vintages since 2001. The extent of those changes may be even more marked if area data were used; and if the numbers were calculated for each year one could see the time path of adjustment. Further research is currently under way to see if this phenomenon is also showing up in data for other New World wine-producing countries.

Apart from the way it is used here, the Regional Similarity Index also can be calculated using climate and other biophysical characteristics of regions. Such indexes could be used to provide a basis for gauging the inter-regional spillover potential for other regions of new technologies developed in any particular region. Were such indexes to be calculated for other countries, international spillover possibilities also could be identified.

A matching of biophysical characteristics of regions need not only be across space, however. An even more promising application would be to include temperature and other relevant weather variables – variables that are likely to alter with global warming – and to re-calculate those index values with what those variables are expected to be in several decades time under particular climate change scenarios (Anderson 2008). Matching the projected weather characteristics of a region in, say, 2050 with those of today's regions could give an idea of how the variety mix of that region may change over the next half-century.

Table 6: Each GI region's six most-similar regions in Australia, production-based Regional Similarity Index, 2001 and 2006

(a) 2001

Adelaide Hills	0.97	Yarra Valley	0.90	Alpine V/B'worth	0.89	Mornington Penin.
Alpine V/B'worth	0.91	MD- NSW	0.90	MD - VIC	0.90	Adelaide Hills
Barossa Valley	0.97	McLaren Vale	0.95	Mudgee	0.94	Clare Valley
Canberra District	0.96	Padthaway	0.94	Great Southern	0.94	Goulburn Valley
Clare Valley	0.95	Great Southern	0.94	Barossa Valley	0.94	McLaren Vale
Coonawarra	0.98	Wrattonbully	0.98	Langhorne Creek	0.95	Currency Creek
Cowra	0.96	Hunter	0.91	MD - VIC	0.91	Padthaway
Currency Creek	0.98	Langhorne Cr.	0.95	Coonawarra	0.93	Wrattonbully
Eden Valley	0.91	Clare Valley	0.91	Canberra District	0.87	Padthaway
Goulburn Valley	0.98	Padthaway	0.96	Great Southern	0.95	MD- NSW
Great Southern	0.96	Goulburn Valley	0.96	Orange	0.95	Mudgee
Hunter	0.96	Cowra	0.84	MD - VIC	0.80	Padthaway
Langhorne Creek	0.98	Currency Creek	0.98	Coonawarra	0.95	Wrattonbully
Margaret River	0.93	Great Southern	0.91	Mount Benson	0.91	Mudgee
McLaren Vale	0.97	Barossa Valley	0.97	Mudgee	0.97	Riverland
Mornington Penin	0.99	Tasmania	0.93	Yarra Valley	0.89	Adelaide Hills
Mount Benson	0.91	Orange	0.91	Margaret River	0.91	Great Southern
Mudgee	0.98	Orange	0.97	McLaren Vale	0.96	Riverland
MD - NSW	0.98	MD - VIC	0.96	Padthaway	0.95	Goulburn Valley
MD - VIC	0.98	MD- NSW	0.94	Padthaway	0.91	Cowra
Orange	0.98	Mudgee	0.96	McLaren Vale	0.96	Great Southern
Padthaway	0.98	Goulburn Valley	0.96	Canberra District	0.96	MD- NSW
Riverina	0.88	Barossa Valley	0.85	Swan Hill VIC	0.85	Mudgee
Riverland	0.99	Swan Hill VIC	0.97	McLaren Vale	0.96	Mudgee
Rutherglen	0.96	McLaren Vale	0.93	Barossa Valley	0.92	Swan Hill VIC
Swan District	0.53	Barossa Valley	0.51	Swan Hill VIC	0.50	Riverland
Swan Hill (VIC)	0.99	Riverland	0.96	McLaren Vale	0.95	Mudgee
Tasmania	0.99	Mornington Pen.	0.91	Yarra Valley	0.85	Adelaide Hills
Wrattonbully	0.98	Coonawarra	0.95	Langhorne Creek	0.93	Currency Creek
Yarra Valley	0.97	Adelaide Hills	0.93	Mornington Penin.	0.91	Tasmania

Table 6 (cont.): Each GI region's six most-similar regions in Australia, production-based Regional Similarity Index, 2001 and 2006

(b) 2006

Adelaide Hills	0.93	Yarra Valley	0.87	Great Southern	0.83	MD - VIC
Alpine V/B'worth	0.82	Orange	0.80	MD - NSW	0.79	Adelaide Hills
Barossa Valley	0.98	McLaren Vale	0.95	Goulburn Valley	0.94	Rutherglen
Canberra District	0.94	Eden Valley	0.93	Clare Valley	0.93	Mudgee
Clare Valley	0.94	Barossa Valley	0.94	Goulburn Valley	0.93	Currency Creek
Coonawarra	0.98	Wrattonbully	0.95	Langhorne Creek	0.94	Currency Creek
Cowra	0.95	MD - VIC	0.93	Hunter	0.92	MD - NSW
Currency Creek	0.99	Langhorne Cr.	0.97	Mount Benson	0.97	Wrattonbully
Eden Valley	0.94	Canberra Dist.	0.93	Clare Valley	0.86	Padthaway
Goulburn Valley	0.98	McLaren Vale	0.96	Mudgee	0.95	Mount Benson
Great Southern	0.94	Margaret River	0.89	Canberra District	0.87	Adelaide Hills
Hunter	0.93	Cowra	0.90	Riverina	0.86	MD - VIC
Langhorne Creek	0.99	Currency Cr.	0.97	Mount Benson	0.96	Wrattonbully
Margaret River	0.94	Great Southern	0.87	Mount Benson	0.85	Mudgee
McLaren Vale	0.98	Goulburn Val.	0.98	Barossa Valley	0.97	Rutherglen
Mornington Penin	0.96	Tasmania	0.90	Yarra Valley	0.77	Adelaide Hills
Mount Benson	0.98	Mudgee	0.97	Orange	0.97	Currency Creek
Mudgee	0.98	Mount Benson	0.98	Orange	0.96	Goulburn Valley
MD - NSW	0.99	MD - VIC	0.97	Swan Hill (VIC)	0.96	Riverland
MD - VIC	0.99	MD - NSW	0.97	Swan Hill (VIC)	0.95	Riverland
Orange	0.98	Mudgee	0.97	Mount Benson	0.97	Padthaway
Padthaway	0.97	Orange	0.96	Riverland	0.96	Mudgee
Riverina	0.91	Riverland	0.90	Swan Hill (VIC)	0.90	Hunter
Riverland	0.98	Swan Hill	0.96	Padthaway	0.96	MD - NSW
Rutherglen	0.97	McLaren Vale	0.94	Goulburn Valley	0.94	Barossa Valley
Swan District	0.55	Swan Hill	0.54	Riverland	0.54	Hunter
Swan Hill (VIC)	0.98	Riverland	0.97	MD - NSW	0.97	MD - VIC
Tasmania	0.96	Mornington P.	0.84	Yarra Valley	0.74	Adelaide Hills
Wrattonbully	0.98	Coonawarra	0.97	Currency Creek	0.96	Langhorne Creek
Yarra Valley	0.93	Adelaide Hills	0.90	Mornington P.	0.84	Tasmania

Source: Author's calculations based on data from www.awbc.com.au

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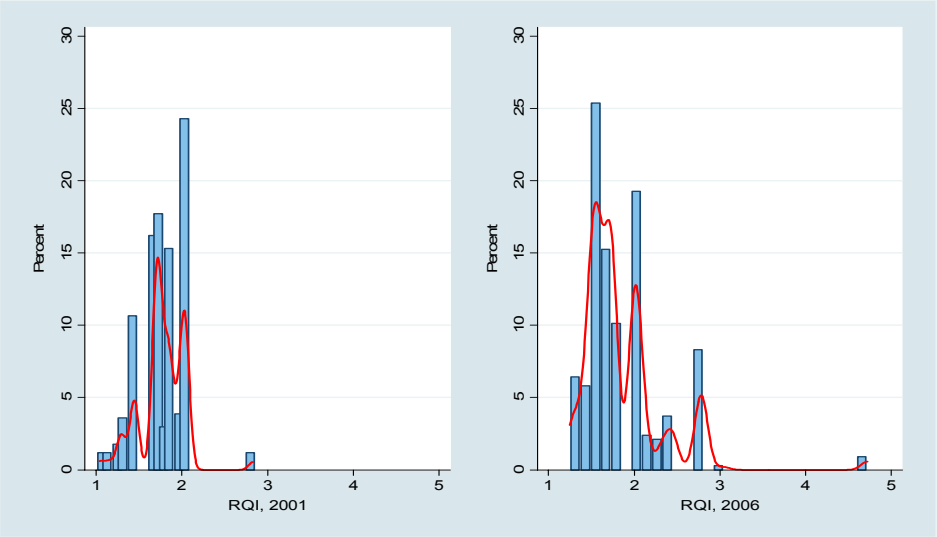
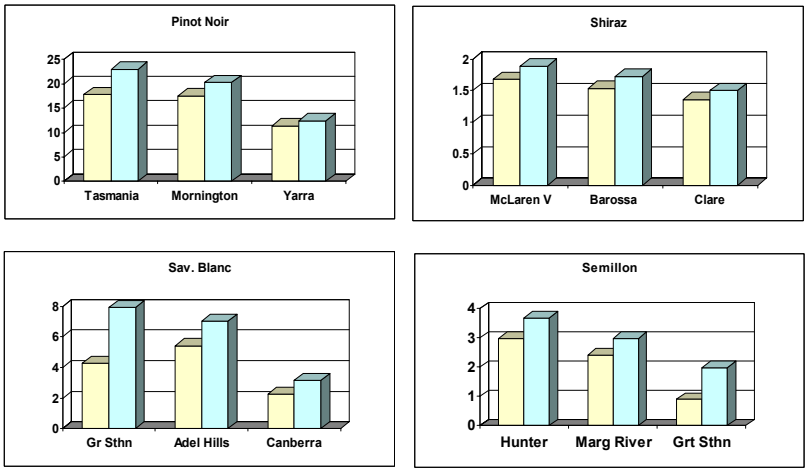
Appendix 1: Figures

Figure A.1: Regional[a] Quality Index, Australia winegrape production, 2001 and 2006



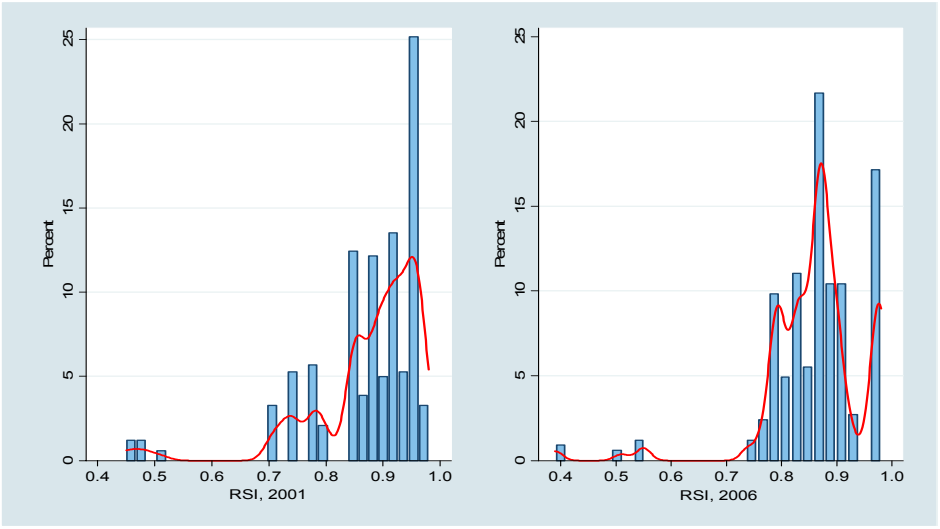
[a] Distribution of the index across all regions in Table 1 except the 5 warm-climate ones of Riverland SA, Riverina NSW, Murray Darling VIC, Murray Darling NSW and Swan Hill VIC. In 2006 these excluded regions accounted for 61 percent of national production and their average regional quality index (RQI) is 0.79 in 2001 and 0.66 in 2006. All other regions have an RQI above 1 and their weighted average RQI is 1.85 in 2001 and 1.80 in 2006. The line drawn through the distribution is a Gaussian Kernel Function. Source: Author's calculations based on Table 1.

Figure A.2: Varietal Intensity Index for selected varieties and regions in Australia, 2001 (left) and 2006 (right)



[a] Distribution of the index across all regions in Table 3 except the 5 large Very Hot ones of Riverland SA, Riverina NSW, Murray Darling VIC, Murray Darling NSW and Swan Hill VIC. Source: Author's calculations based on Table 3 and Appendix table A

Figure A.3: Regional[a] Similarity Index, Australia winegrape production, 2001 and 2006



[a] Distribution of the index across all regions in Table 5 except the 5 large Very Hot ones of Riverland SA, Riverina NSW, Murray Darling VIC, Murray Darling NSW and Swan Hill VIC. In 2006 these excluded regions accounted for 61% of national production. The line drawn through the distribution is a Gaussian Kernel Function. Source: Author's calculations based on Table 5.