A Hedonic Price Function for Australian Premium Table Wine

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Abstract

Rosen's (1974) pure competition model for differentiated products provides the foundation for an estimated hedonic price function for Australian premium table wine. Six attribute groups are found to be statistically important in explaining deviations from average wine prices, i.e., quality, cellaring potential, grape variety/style, grape region, grape vintage and producer size. Interaction terms for the impact of grape demand/supply imbalances and prestigious variety/region combinations are also modelled. Results are generally consistent with a priori expectations, but for the negligible influence of various interaction terms. The consequent marketing implications for producers and consumers are finally described.

I Introduction

The Australian wine industry represents one of the few booming export success stories of recent history. Apart from a few studies on broad aggregate demand for wine (Clements and Selvanathan (1991)) and wine grape demand and supply projections (Proctor and Phillips (1991)) very little economic research has been completed on the industry. In particular, no systematic study has been undertaken to identify and determine market values for, the individual attributes which make up the product called 'premium table wine'.[1] The identification and market evaluation of wine attributes has important ramifications for longer-term investment decisions of producers, purchasing decisions of retailers and consumers and government policy directives for enhancing exports.

In this study the determination of market values for wine attributes is undertaken through the estimation of a hedonic price function, which relates the price of a bottle of wine to its various attributes. Hedonic price functions have been estimated for a variety of products ranging from residential housing and farming property values through to agricultural products and environmental goods. The principal theoretical foundation for hedonic price studies rests with Rosen's (1974) pure competition model for differentiated products. It is this foundation, of demand and supply for attributes interacting to determine implicit marginal market attribute prices which provides the basis for our study of the attributes contained in wine.

The next section provides a broad overview of the Australian wine industry identifying some key issues. Hedonic price functions in general and the appropriateness of the approach for Australian premium table wine are described in section III. The data set employed and the estimated function are outlined in section IV. Section V discusses the important marketing and policy implications of the analysis, while section VI concludes.

[1]One related study by Johnson, Ringham and Jurd (1991) used conjoint choice analysis to focus upon consumer attribute choice and market segmentation. Little emphasis it seems however, was given to the market determination of prices, which represents the focus of our study.

II The Australian Wine Industry

The Australian wine industry produces a vast array of products ranging from premium table wines through to bulk, cask and non-alcoholic wines.[2] During 1990-91, approximately 23% of all wine produced was packaged in bottle sizes of one litre or less (i.e., premium table wine). Trends indicate that sales of premium table wine are increasing (22% increase over 1985-6 to 1989-90) at the expense of cask wine (18% decline). Further, even though total wine sales have increased by only 1.9% (over 1985-6 to 1989-90), exports have increased by 285%. During 1990-91, exports made up 15% of total wine sales and in contrast to domestic sales, the majority of exports are premium table wine sales. Most industry commentators point out that given the prospect of relatively flat domestic demand for wine, the industry's future prosperity rests with the exporting of premium table wines. In fact, industry export targets have been set which seek to increase exports by nearly 500% over the current decade.

In 1990, over 500 wine making organisations existed in Australia, however, the seven largest conglomerate companies produced 66% of all total wine sales. Edwards and Spawton (1990) argue that the market exhibits elements of both oligopolistic and competitive pricing. That is, the larger firms tend to pursue pricing strategies very mindful of competitors' reactions while the smaller producers generally adjust quantities to maintain predetermined price levels. On the demand side it is clear that there are hundreds of thousands of wine consumers, however, research by McKinna (1987) indicates that significant preference differences exist between consumers with four types of consumer identifiable, i.e., connoisseurs (25% of all consumers), aspirational drinkers (51%), cask wine drinkers (14%) and new wine drinkers (10%).

As indicated previously, an enormous range of wine products are marketed in Australia, the main broad categories are: premium table, cask, bulk, fortified, sparkling, flavoured, carbonated and non-alocholic wines. In fact, over 10,000 dif-

[2] This background description of the industry is sourced from: Edwards and Spawton (1990), Proctor and Phillips (1991), Sutton (1991), Combe (1992) and the Australian Bureau of Statistics (1992).

ferent Australian wine products are available. Given the increasing preference for premium table wine, both domestically but especially by export markets, our focus rests with this category. Within the premium table wine category a vast range of wines are offered at various qualities and at a multitude of prices. In particular, wines mainly differ respect to the variety, location and vintage of grape(s) used, but also to a lesser extent, with respect to the production and maturation techniques employed.

The major issue facing the industry now and in the future, appears to be the co-ordination of grape production volumes to satisfy the specific needs of the booming export market. Sutton (1991) describes the 1987-89 period as a clear case of excess demand for particular premium grape varieties leading to soaring prices. Historically, premium grape prices have been very volatile. It is clear that one cause of this price volatility stems from the inflexible nature of grape production with new vine plantings taking up to six years before commercial production levels are reached. The industry's concern for these grape supply demand imbalances is reflected by the Australian Grape and Wine Research Council commissioning of the Australian Bureau of Agricultural and Resource Economics to conduct a comprehensive surveyed based analysis of the current and future demand and supply of wine grapes, i.e., Proctor and Phillips (1991) and Abdalla, Kelly and Proctor (1991).

III Hedonic Price Functions

A hedonic price function relates the price a product to its various attributes/characteristics, the respective partial derivatives of the function represent implicit marginal attribute prices. Early examples of estimated functions include, Griliches (1961) and Fettig (1963). Rosen (1974) however, was the first to develop a formal theoretical justification for the existence of the hedonic price function. Rosen constructed a theory of competitive price determination for a market where products are differentiated in terms of their attributes.

In particular, Rosen suggests that consumers choose attribute levels to maximise utility by equating the given hedonic price function with a bid function (i.e., the maximum amount the consumer is willing to pay for attributes given fixed income and utility). Producers choose attribute levels to maximise profits by equating the given hedonic price function with an offer function (i.e., the minimum amount the producer is willing to accept for attributes given fixed profits). The hedonic price function is market determined after a competitive process where attribute market demand and supply are equated. Essentially, equilibrium is located at the gradient where bid functions are always tangential to offer functions. This common gradient traces out the hedonic price function as an envelope of a family of bid and offer functions.

To ensure that a variety of products with varying attribute mixes result from the theoretical construct, Rosen assumes that individual consumers and producers differ, with varying tastes and cost conditions. Even so, because the price function represents the envelope of an entire family of offer and bid functions each with individual consumer and producer traits, the envelope itself cannot identify those individual traits. Consequently, the hedonic price function is a function of product attributes alone, it is not a function of individual consumer and producer traits.

Beyond issues of theory, Rosen (1974) also describes a two-stage estimation procedure for the identification of marginal inverse demand and supply functions. The first stage requires the estimation of the hedonic price function. The second stage employs the implicit marginal attribute prices estimated in the first stage as instruments in marginal demand and supply price equations. Arguments in these equations include product attributes and individual consumer (for demand) and producer (for supply) traits.

More recent literature generally follows one of two streams, i.e., pure hedonic price function estimation or the more elaborate two stage estimation of inverse attribute demand/supply. Examples of the former include, Barnett (1985), Palmquist and Danielson (1989), Rasmussen and Zuehlke (1990) and Coelli et.al. (1991). Much of this literature in part, focuses upon the choice of the most appropriate hedonic price functional form. Examples of estimated inverse demand/supply functions include, Bartik (1987) and Clark and Cosgrove (1990). Much of this latter literature (see also Mendelsohn (1987) and Epple (1987) for non-empirical discussions) has pointed to limitations of the original Rosen two stage estimation framework and hence has proposed and employed suitable remedies. Given the wide ranging heterogeneity of individual consumers and producers of premium table wine, the costs associated with collecting a suitable data set describing individual agent traits are prohibitive. This is the principal reason for our focus upon hedonic price function estimation only.

Ideally, theoretical consistency should be maintained by deriving the price function's functional form from explicit consumer and producer choice theoretic programs, Epple (1987, p62) gives an example of such a derivation. Unfortunately, such closed form solutions will not be available for arbitrarily chosen demand and supply functions, and so a more general approach is needed. Rosen (1974) left the issue open by recommending the use of the best fitting form. For more recent discussion on functional forms, see Halvorsen and Pollakowski (1981) who recommend the quadratic Box-Cox form and Cassel and Mendelsohn (1985) and Cropper, Deck and McConnell (1988) who argue against the use of this general form.

Given this broad overview of hedonic price functions, the question of applicability to the Australian premium table wine market arises. The industry does produce many highly differentiated 'table wine' products with varying characteristics and prices. However, the question of the suitability of Rosen's pure competition equilibrium framework remains. Four specific issues need to be addressed: the flow of information; the barriers to entry and exit; the relative sizes of individual producers and consumers; and the likelihood of trading at market non-clearing prices.

The flow of information about which wine consumers and producers must make decisions appears to be excellent. Recommended retail prices and the attributes of wine products (such as: grape variety, vintage and location used; cellaring potential and overall "quality") are published regularly in daily national newspapers and wine publications such as *Winestate*. It is clear that wine producers with appropriate training and the wealth of experience, are capable of appropriately assessing the information needed to make optimal decisions. On the other hand, many consumers (especially aspirational and new wine drinkers) might not be so proficient in evaluating intangible attributes and overall quality. However, as argued by Edwards and Mort (1991) the concept of "opinion leadership" as offered by expert wine tasters, whose views are widely published and accessible, circumvents the need for individual consumers to confidently and expertly assess intangible wine qualities.

There appear to be no significant barriers to entry and exit in the Australian wine industry. This is evidenced by the extreme range in the size of viable on-going producers, i.e., from a producer who produces only 25 cases per annum, to large conglomerates producing over 4 million cases per annum. Further, even though the time from vine planting to commercial grape production levels may take up to six years (which might be viewed as a significant barrier to entry) new entrants do and can overcome this revenue time delay barrier by purchasing grapes from established grape growers not contracted to specific wine producers.

It is clear that price taking behaviour is practised by wine consumers, the same cannot be said for producers. As indicated previously, even though over 500 producers exist, the size of producers varies enormously. Edwards and Spawton (1990) argue that even though no single producer acts as the obvious price leader some of the large producers act as oligopolists. Ideally, Rosen's theoretical framework should be modified to explicitly allow for varying degrees of price-making behaviour and then the consequences for the specification of hedonic price function rigourously determined. Even without such a foundation we suggest that the price function should explicitly incorporate individual producer size characteristics. That is, the price function is no longer the same for all producers but rather depends upon their individual size of operation. We shall make this modification in our study.

Unlike residential housing markets, for which hedonic price functions are often estimated, transaction costs associated with the trading of wine products are minimal and hence would appear not to significantly obstruct the attainment of market clearing prices. On the other hand, the variety specific demand/supply imbalances alluded to previously, may prohibit equilibrium trading. We argue however, that the disequilibrating impact of grape supply/demand imbalances may not directly flow through to the retail market. The following reasons support this claim. First, unprocessed grapes only make up part of the overall identity of the finished wine product. In fact, in terms of costs of production, Halliday (1990) suggests that for a small scale producer, the cost of grapes makes up only 25% of total production costs. Second, at any given time various vintages of a single variety are offered for sale. Thus, a significant excess demand experienced in one vintage for a particular grape variety may not be reflected by a higher current wine price if other vintages of the same grape variety (which do not suffer from a similar imbalance) are offered for sale at the same time. Effectively, unless a particular grape variety is in a chronic one-sided state of imbalance (which appears not to be the case, see Proctor and Phillips' (1991) projections) wine prices for a particular variety will probably not reflect year to year grape demand/supply imbalances.

In spite of these arguments the possibility of wine prices not reflecting equilibrium trades cannot be ruled out absolutely. To model such disequilibrium processes access to time series (to measure disequilibrium price changes) and individual producer and consumer characteristics (to measure the demand/supply imbalance) data sets would be needed. In the absence of such elaborate data, to account for possible disequilibrium effects we shall include various interaction terms between vintage and variety type. Thus if, for example, Chardonnay grape prices in 1987 reflected an excess demand circumstance then the corresponding interaction term in the price function should measure the impact on the associated bottle wine price.

The key issue in estimating a hedonic price function for Australian premium table wine is the accurate identification of relevant characteristics. Spawton (1991) helps in this identification by dividing the 'bundle of benefits' in a wine product into three groups. First, there exist core benefits, that is, the reason for choosing wine to other beverages, e.g., sparkling wine for celebration and table wine for food consumption. Second, there exist tangible benefits, for example, the bottle dress, style/blend, vintage, region, variety and branding. Third, there are the intangible benefits, for example, awards, outlets, endorsements, promotions, and image. Our focus rests with the latter two groups given the emphasis on wine prices only.

IV Data and Estimation Results

Potentially there exist many sources of data for premium table wine prices and their associated characteristics. Consumer wine guides which are readily and widely accessible are most appealing since these publications best align with the 'flow of information' requirement of pure competition. High profile and nationally accessible guides include, Halliday (1989), Bradley (1990), Shield and Meyer (1991), and the bi-monthly magazine *Winestate*. The attainment of data accuracy and consistency is particularly important for the intangible characteristic of overall quality. After extensive investigation the data set employed is that from Shield and Meyer (1991). This choice is made because of the availability of the following information: recommended retail prices; consistent quality ratings made by the same expert tasters which are distinct from value for money ratings; grape variety(s); location(s) of grapes; vintage of grapes; consistent cellaring potential recommendations; and over 1000 industry representative sampled wines. All other publications were deficient in at least two of these aspects.

Even though there is significant discounting of prices by some of the larger retailers, we shall employ recommended retail prices (RRP) for the following reasons. First, discounting is not wide spread or consistent throughout all outlets. In particular, at any given time the larger retailers tend to discount different lines to those discounted by their competitors, while local hotel bottle shops often do not discount at all. Second, RRP align better with the perfect flow of information assumption since they are published widely in wine guides, while discount prices appear somewhat spasmodically in advertising leaflets and newspapers. Third, some wine producers strategically set their prices with full knowledge (of wholesale and retail mark-ups,..etc.) of the consequent RRP, but without knowledge of what discounting might or might not take place. Thus, RRP align more closely with Rosen's notion of a producer's offer function.

The availability of data largely dictates what characteristics can be used as regressors in the hedonic price function. Even so, the most important and most accurately measurable characteristics seemed to have been identified.[3] In terms of tangible 'objective' characteristics, dummy (binary) variables allow us to quantify, grape variety, the region from which grapes were sourced, vintage of harvest and size of producer. Because producer size is difficult to measure accurately then broad groupings (i.e., small, medium,..etc.) measured by dummy variables are employed. Recall producer size is included to allow for possible 'price making' strategies, but also might be viewed as measuring the characteristic of 'exclusiveness', that is, some consumers desire particular wines from small producers because of their limited availability, rarity and 'trendiness.'

Two intangible 'subjective' characteristics are quantified, overall quality and cellaring potential. Dummy variables are used again. For quality, given that only six discrete ratings are available, the use of a single continuous variable rather than a series of dummies will unnecessarily impose a restrictive specific structure. Dummy variables based on broad groupings are used for cellaring potential given the approximate nature of such recommendations.[4]

[3]Unique characteristics resulting from the employed production and maturation techniques which might be considered important, have been omitted due to expected high degrees of collinearity with other characteristics and data unavailability. That is, production and maturation techniques are generally grape variety/style specific (i.e., most red wines are matured in oak, brandy spirit is added to vintage port) and it is expected that the measurable variety/style characteristic will adequately reflect such techniques. Moreover, attributes such as the winemaker's skill, use of new oak, quality of grapes, ...etc., should be captured by an overall quality rating. Further, it is clear that some characteristics are simply "unmeasurable", for example, how does one accurately and consistently measure the attractiveness of the wine bottle's label?

[4]Some of the sample data were omitted because of ambiguous information, i.e., producer, grape region, grape variety could not be clearly identified. Further, because of our focus is on vintage wines, then all non-vintage wines were omitted. These omissions led to a final sample size of 797 (750ml equivalent) wines available during 1991. All basic data is taken from Shield and Meyer (1991). Halliday (1989) is principally used to identify wine regions and producer sizes.

Given the emphasis on dummy independent variables, the issue of choosing a control (or base) group for each of the six characteristics arises. With such a large number (and exclusive use) of dummy variables, this choice takes on some particular interpretation importance. Rather than omitting a control group we employ the approach advocated by Suits (1984) and Kennedy (1986), which permits explicit estimation of coefficients for all dummy variables. Estimated coefficients are interpreted as deviations from the average of the dependent variable. This modification only alters the interpretation of coefficients, that is, all summary statistics, residuals, diagnostic tests, ..etc., are equivalent to those generated by the conventional control group approach.[5]

Our choice of functional form is limited, given the exclusive use of independent dummy variables. We shall contrast the two most popular forms, linear and log-linear.[6] For the independent variables, flexibility can only be gained through the use of interaction terms. As alluded to previously, interaction terms (between vintage and variety) are examined for modelling possible year-to-year 'disequilibrium' grape

[5]Consider a simple two dummy variable model: $Y = \beta_0+\beta_1 D_1+\beta_2 D_2$ $(where\ D_1+D_2=1)$ to illustrate the mechanics of the Kennedy (1986) approach. Sum over all observations and then divide both sides of this equation by the sample size N $\Rightarrow$ $\bar{Y} = \beta_0+\beta_1 P_1+\beta_2 P_2$, *where* P_1 *and* P_2 are the proportion of non-zeros in D_1 *and* D_2 respectively. If the restriction $\beta_1 P_1 + \beta_2 P_2 = 0$ is imposed then the least squares estimate of the intercept becomes $\hat{\beta}_0 = \bar{Y}$ and so $\hat{\beta}_1$ and $\hat{\beta}_2$ should be interpreted as deviations from the average value of the dependent variable. Rather than employ Suit's (1984) computational approach we suggest the following simpler alternative. The stated restriction can be re-written as $\beta_1 = -\beta_2(P_2/P_1)$ this can be substituted into the original equation and rearranged to get: $Y = \beta_0 + \beta_2(D_2 - (P_2/P_1)D_1)$ OLS applied here provides $\hat{\beta}_2$. Symmetrically, substituting $\beta_2 = -\beta_1(P_1/P_2)$ leads to $Y = \beta_0 + \beta_1(D_1 - (P_1/P_2)D_2)$ and hence $\hat{\beta}_1$. In sum, two appropriately defined regressions permit the estimation of all coefficients and standard errors.

[6]We shall not employ the general Box-Cox transformation to the dependent variable for reasons alluded to by Cropper, Deek and McConnell (1988) and Rasmussen and Zuehlke (1990) and others. For example, the transformation results in hedonic price estimates which are difficult to interpret and when attributes are unobserved and replaced by proxies the transformation leads to less reliable predictions than simpler forms.

price differences. Further, certain wines from particular regions using particular varieties have historically gained prestige and notoriety, e.g., Coonawarra Cabernet Sauvignon. Halliday (1991) is principally used to identify these possibly important region/variety interactions. Scope for further meaningful interactions seems limited.

Initially, both the linear and log-linear forms exhibited significant degrees of heteroscedasticity as evidenced by a standard set of (SHAZAM) tests. Given that the specific form of heteroscedasticity was difficult to identify White's (1980) heteroscedastic consistent covariance matrix was used for further analysis. Parameter estimates and summary statistics are still appropriately based on least squares estimates. To discriminate between the linear and log-linear forms, Ramsey's RESET(2) specification error test was employed.[7] Results presented in table 1, indicate overwhelming support for the log-linear model over the linear model. To further check the adequacy of the log-linear model RESET(3) and RESET(4) tests were also applied. Again results in table 1 point to no serious problems. Finally, the summary statistics for the log-linear model presented in table 1, indicate a reasonably good level of overall predictive performance.

The estimated hedonic price function is presented in table 2. Given the exclusive use of dichotomous variables partial derivatives are not defined and thus the estimates do not represent conventional implicit attribute prices. Instead, the estimates measure the relative impact, from the average price, of the presence of the attribute represented by the variable. Consider the broad groupings in turn. There appears to be a direct relation between quality ratings and price, with extremes of a 25.2% reduction from average price for modest wines and a 17.6% increase for very rare wines. The dividing average wine price line falls between a very good wine and an extremely good wine. Five of the six quality ratings have a statistically significant impact (at a 5% level) from the average price. Similarly, cellaring potential has a direct relation with price. At the extremes a drink now wine produces a 9.5% reduc-

[7] Even though RESET(2) was designed as a specification error test, Godfrey, McAleer and McKenzie (1988) show that this test has good size and high power properties for discriminating between linear and log-linear forms under both normality and various types of non-normality.

Table 1: Hedonic Price Model Diagnostics and Statistics

Ramsey RESET Specification Tests[a]	
Log-Linear	P Values
RESET(2) $= 0.223 \sim F(1,713)$	0.637
RESET(3) $= 0.244 \sim F(2,712)$	0.784
RESET(4) $= 0.205 \sim F(3,711)$	0.893
Linear	
RESET(2) $= 20.217 \sim F(1,713)$	0.00001
mmary Statistics	
Log-Linear	
$R^2 = 0.6162$	$\bar{R}^2 = 0.5721$
$N = 797$	$D.F. = 714$
$\bar{Y} = 2.5889$	$\hat{\sigma} = 0.2348$

(a) RESET tests are based upon White's (1980) heteroscedasticity consistent covariance matrix.

tion from average price and an over 10 years wine a 45.8% increase. Average wine prices seem to fall between the cellaring potential classifications $0 < X \leq 2$ *years* and $2 < X \leq 4$ *years*. Four of the six measures of cellaring potential are statistically significant.

The main impacts of grape variety/style are increases of: 51.5% for sparkling wine, 44.4% for Botrytis and 20.5% for Pinot Noir; and reductions of: 23.4% for Vintage Port, 15.5% for Rhine Riesling and 14.4% for Cabernet Sauvignon/Shiraz. These extreme impacts are as expected. Premium sparkling wine requires specialised production techniques, Botrytis whites require favourable grape growing conditions and Pinot Noir is a 'trendy' variety. The three most significant price reductions occur with old fashion varieties/styles. Varieties most typical of average prices appear to be Sauvignon Blanc, Cabernet Sauvignon and other red blends. Eleven of the nineteen grape varieties are statistically significant from the average price.

Table 2: **Hedonic Price Log-linear Model Estimates**

Variable	Coefficient	T Ratio[a]	Percentage Imapct[b]	Sample Mean[c]
Constant	2.589*	328.82		14.26
<u>Quality Ratings</u>				
A modest wine (2.5 rating)	-0.289*	-4.98	-25.2	0.003
A good wine (3.0 rating)	-0.110*	-6.02	-10.4	0.179
A very good wine (3.5 rating)	-0.026*	-2.04	-2.6	0.287
An extremely good wine (4 rating)	0.017	1.52	1.7	0.360
A brilliant wine (4.5 rating)	0.106*	3.52	11.1	0.102
A very rare wine (5 rating)	0.163*	4.01	17.6	0.069
<u>Cellaring Potential</u>				
X: Average age of range				
Drink Now	-0.100*	-4.37	-9.5	0.203
$0 < X \leq 2$ *years*	-0.015	-1.73	-1.5	0.476
$2 < X \leq 4$ *years*	0.047*	2.74	4.8	0.236
$4 < X \leq 6$ *years*	0.141*	3.98	15.1	0.054
$6 < X \leq 10$ *years*	0.274*	4.05	31.2	0.029
Over 10 years	0.409	1.62	45.8	0.003
<u>Grape Variety/Style</u>				
Chardonnay	0.109*	6.48	11.5	0.192
Rhine Riesling	-0.168*	-6.36	-15.5	0.092
Sauvignon Blanc	0.007	0.19	0.6	0.046
Semillon	-0.122*	-4.40	-11.5	0.059
Chardonnay/Semillon	-0.052	-1.49	-5.1	0 013
Botrytis (White)	0.370*	5.47	44.4	0.013
Other Sweet Whites	0.098	0.58	8.7	0.004
Dry White Blends	-0.079	-1.95	-7.7	0.021

Table 2: Continued

Variable	Coefficient	T Ratio[a]	Percentage Imapct[b]	Sample Mean[c]
Other Straight White Varietals	-0.074	-1.74	-7.2	0.038
Cabernet Sauvignon	0.010	0.39	1.0	0.134
Pinot Noir	0.187*	5.23	20.5	0.054
Shiraz	-0.103*	-4.23	-9.8	0.149
Cabernet Sauvignon/Merlot	0.087*	3.25	9.1	0.045
Cabernet Sauvignon/Shiraz	-0.154*	-2.51	-14.4	0.026
Other Red Blends	-0.020	-0.48	-2.1	0.044
Other Straight Red Varietals	0.117	1.54	12.1	0.015
Light Reds	-0.131*	-2.77	-12.4	0.016
Vintage Port	-0.263*	-3.21	-23.4	0.014
Sparkling Wine	0.415*	7.13	51.2	0.025
Grape Region				
Lower Hunter Valley	-0.012	-0.52	-1.2	0.103
Upper Hunter Valley	-0.010	-0.19	-1.1	0.020
Mudgee	-0.151*	-3.05	-14.1	0.010
Other N.S.W. Districts	-0.245*	-2.83	-22.0	0.011
Hilltops (NSW)	0.008	0.14	0.6	0.005
M.I.A.	-0.430*	-2.89	-35.7	0.010
North East Victoria	-0.059	-1.41	-5.8	0.051
Bendigo and District	0.049	0.67	4.7	0.016
Southern and Central Victoria	0.125	0.99	12.4	0.004
Mornington Penisula	0.255*	8.05	29.0	0.039
Geelong	0.120*	2.10	12.6	0.010
Gippsland	0.119	0.52	9.7	0.004
Great Western and District	0.052	0.91	5.2	0.025
Yarra Valley	0.205*	5.40	22.7	0.045
Pyrenees	0.022	0.53	2.1	0.031

Table 2: Continued

Variable	Coefficient	T Ratio[(a)]	Percentage Imapct[(b)]	Sample Mean[(c)]
North Goulburn River	-0.250*	-5.61	-22.2	0.006
Central Goulburn Valley	0.056	1.67	5.7	0.041
Macedon	0.165*	2.55	17.7	0.010
Murray River	-0.342*	-2.38	-29.7	0.003
Adelaide Metropolitan Area	-0.056	-1.14	-5.6	0.006
Riverland	-0.377*	-3.84	-31.7	0.011
Barrossa Valley	-0.131*	-5.19	-12.3	0.103
Southern Vales	-0.143*	-5.84	-13.4	0.102
Langhorne Creek	-0.009	-0.13	-1.1	0.011
Coonawarra	0.032	0.86	3.2	0.075
Clare Valley	-0.059	-1.52	-5.8	0.061
Adelaide Hills	0.142*	3.84	15.2	0.061
Padthaway	0.036	0.51	3.4	0.013
Lower Great Southern Area (WA)	0.123*	3.22	13.0	0.023
Margaret River	0.148*	3.19	15.8	0.026
South West Coastal Plain (WA)	0.069	0.72	6.7	0.008
Swan Valley	0.025	0.52	2.4	0.010
Canberra	0.101*	2.87	10.6	0.005
Tasmaina	0.166*	4.30	18.0	0.020
New Zealand	0.052	1.29	5.3	0.019
Grape Vintage				
1970	2.155*	24.88	759.6	0.001
1975	1.663*	16.92	425.0	0.001
1980	0.693*	7.68	99.2	0.001
1982	0.312*	2.24	35.3	0.004
1983	0.345*	6.16	41.0	0.006
1984	0.324*	3.28	37.6	0.006

Table 2: Continued

Variable	Coefficient	T Ratio[a]	Percentage Imapct[b]	Sample Mean[c]
1985	0.29	1.75	31.8	0.013
1986	0.349*	5.25	41.5	0.020
1987	0.074	1.92	7.6	0.073
1988	-0.014	-0.60	-1.4	0.203
1989	-0.001	-0.06	-0.1	0.287
1990	-0.063*	-4.60	-6.1	0.366
1991	-0.086	-1.59	-8.4	0.018
Producer Size				
X: number of cases p.a.				
$0 < X \leq 2,000$ (Very Small)	0.052*	2.41	5.3	0.146
$2,000 < X \leq 5,000$ (Small)	0.082*	4.47	8.5	0.152
$5,000 < X \leq 20,000$ (Medium)	0.043*	3.21	4.4	0.272
$20,000 < X \leq 100,000$ (Large)	-0.021	-0.87	-2.1	0.149
Over 100,000 (Very Large)	-0.102*	-6.33	-9.7	0.281
Interaction Terms				
Yarra Valley Pinot Noir	-0.182*	-3.35	-16.8	0.014
Margaret River Cabernet Sauvignon	0.155	1.33	16.0	0.006
M.I.A. Botrytis White	1.227*	7.03	235.9	0.001
Pinot Noir 1986	0.529*	5.77	69.0	0.001
Pinot Noir 1989	0.114	1.47	11.7	0.014
Pinot Noir 1990	-0.081*	-2.14	-7.8	0.028

* Denotes significance at a 5% level
(a) T-ratios are based upon White's heteroscedastic consistent co-variance matrix
(b) Consistent estimates of the percentage average impact of the dummy variable on price as measured by: $100[exp(\hat{\beta} - 0.5\widehat{var}(\hat{\beta})) - 1]$, see Kennedy (1981) and Derrick (1984).
(c) The sample mean for the untransformed price is given for the constant, all other means represent the proportion of wines in the total sample with these characteristics.

The main impacts of grape region are increases of: 29.0% for Mornington Penisula, 22.7% for Yarra Valley and 18.0% for Tasmaina; these regions represent small scale cool climate grape production areas. The main reductions are: 35.7% M.I.A., 31.7% Riverland and 29.7% Murray River; these regions represent large scale water-irrigated grape production areas. Regions most typical of average prices are: Lower and Upper Hunter Valley and the Hilltops region of N.S.W. Seventeen of the thirty-five grape regions are statistically significant.

The older the vintage the higher the price is the general finding of the grape vintage dummies. This result reflects the time value of money and costs of storage. The extremes are an increase of 759.6% for the 1970 vintage and a reduction of 8.4% for the 1991 vintage. Average wine prices tend to be reflected by the 1988 and 1989 vintages. Eight of the thirteen vintages are statistically significant.

The smaller the producer size the higher the price is the general finding of the producer size variables. This is indicative of the trendiness of smaller producers and/or the lower costs of production associated with larger producers leading to their ability to set prices and under-cut competitors. The extremes are a 8.5% increase for 'small producers' and a 9.7% reduction for 'very large producers.' Average wine prices are most typical of 'large producers.' Four of the five producer size variables are statistically significant.

After extensive investigation only six interaction terms proved to have any degree of statistical significance, i.e., absolute t-ratios greater than unity.[8] Three variety/region interactions proved useful. On first appearances the sign of the Yarra Valley Pinot Noir interaction might appear strange. Recall however, these interactions measure impacts in addition to the single variety and single region impacts, for Yarra Valley (+22.7%), for Pinot Noir (+20.5%). In this light and given that Pinot Noir is now (relatively) extensively grown in the Yarra Valley, then the result is un-

[8]For the variety/region interaction other terms tried unsuccessfully included: Coonawarra Cabernet Sauvignon, Hunter Valley Semillon, Barrossa Valley Shiraz and Clare Valley Rhine Riesling. For the variety/vintage interaction other terms tried unsuccessfully included: vintages of Chardonnay, Cabernet Sauvignon/Merlot and Sauvignon Blanc.

derstandable. Of the 'disequilibrium' vintage/variety interactions only vintages of Pinot Noir proved to be important. These estimates probably reflect the increasing availability of Pinot Noir grapes over time.

V Marketing and Policy Implications

The estimated hedonic price function provides consumers and producers alike with a wealth of important wine marketing information. For consumers (and hence retailers) 'bargains' might be identified by comparing the price of a prospective wine purchase with the 'average market' price as estimated by the hedonic price function.[9] Further, the function contains a wealth of educational wine information, such as, which regions and varieties are most price 'prestigious'. This information will serve to further educate the wine consuming public.

For producers the function provides important information upon which longer-term investment decisions may be made. To warrant resources to be re-directed into attaining a particular attribute, a comparison of the benefits and costs associated with acquiring that attribute must be made. The estimated average benefits have been estimated by the hedonic price function. For example, moving from a 'good wine' (-10.4%) to a 'very rare wine' (+17.6%), at sample mean prices, translates to a $3.99 [(0.176 - - 0.104)*$14.26] increase in price, all other things constant. This benefit should be compared to the costs of improving quality (i.e., using better quality grapes, using new oak, employing better wine-making skills,..etc.) to determine whether an effort should be made to achieve this attribute.

The use of regression analysis in the estimation of the hedonic price function implies that the estimated benefits stemming from the attributes hold only in the *ceteris paribus* sense. For small price-taking producers, re-directing resources into the more desirable attributes should not significantly effect the estimated market

[9] To reduce the small sample bias in predicting raw prices from the log-linear model, scale predictions by $exp(\hat{\sigma}^2/2)$, see Dadkah (1984). That is, form predictions using: $exp(\widehat{lnPrice}) * 1.02795$.

determined benefits. Thus planning can be undertaken with some certainty. Given their relatively large size in the market place, this is not the case for the large conglomerate producers. For example, grape prices have historically been subject to volatile movements, in part, due to changes in grape availability directly brought about by the requirements of large wine producers. Complex strategies need determination here, which explicitly allow for the effects their quantity changes and the reaction of rivals, may have on prices. Issues are complicated further by a six year lead time between vine planting and commercial production levels. These complexities are illustrated by Pinot Noir and Chardonnay, which despite having some of the largest (1991) estimated positive wine price impacts, are also projected to be in significant grape excess supply over the period 1992/3 to 1993/4, see Proctor and Phillips (1991, p19). Thus, reacting to favourable attribute prices now may have unexpected consequences in subsequent years.

The estimated hedonic price function may also have important policy implications. If the government wishes to further enhance exports then specific incentives (i.e., tax concessions, marketing promotions,..etc.) should be directed to those wines with the most desirable attributes as identified. However, given that our function has been estimated using Australian prices and hence tastes and preferences, then directives for overseas markets should be taken with caution. Ideally, a similar function needs identification for each potentially important overseas market.

VI Concluding Comments

A hedonic price function has been estimated for Australian premium table wine. Six broad attribute groupings were found to statistically important in explaining price deviations from average prices, i.e., quality, cellaring potential, grape variety/style, grape region, grape vintage and producer size. Only a few interactions between these groups were identified as important.

The results on the subjective attributes (quality and cellaring potential) confirm the usefulness of the particular data set chosen. The results on grape region and variety/style generally align with a prior expectations, however, more observations for each of the large number of grape regions are probably needed to gain greater precision for estimates. The estimates on grape vintage provide a clear indication of the values of holding back wines from the market place. The producer size variable indicates that prices are clearly influenced by the size of a producer's operation and as such the market is not characterised by pure competition.

Interactions between some of the attribute groupings were found to be of little importance. In part, the lack of a sufficient number of sampled wines for each potentially important grouping explains some of this estimation imprecision. The variety/vintage interaction employed to capture grape demand/supply imbalances proved to be particularly disappointing given the industry's concern for the associated grape price volatility. However, we have alluded to many reasons why such grape price volatility may not surface as price volatility for finished wine products.

The few reservations of the analysis which have been identified could potentially be remedied by greater data availability. Conceptually however, adequate degrees of consistency may be very difficult to maintain for such larger data sets. That is, the important subjective attributes of quality and cellaring potential depend crucially upon the wine tasters' consistency in wine evaluation. The ratings and recommendations from larger cross-section data sets and comparisons over time between annual tastings, will definitely be subject to greater degrees of evaluation inconsistency.

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