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A HEDONIC PRICE FUNCTION FOR AUSTRALIAN PREMIUM TABLE WINE*

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A hedonic price function, relating the price of Australian wine to its attributes, is estimated. 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. Various interaction terms between these variables and the impact of the year of marketing are also modelled. The consequent marketing implications for producers and consumers are discussed.

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 purpose of the paper is to fill this void. The identification and market evaluation of wine attributes have 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. The principal theoretical foundation for hedonic price studies rests with Rosen's (1974) pure competition model for differentiated products. That is, market de-

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

mand and supply for attributes interact to determine implicit marginal market attribute prices.

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 then described. Next the data set employed and the estimated function are outlined. This is followed by a discussion of the important marketing and policy implications of the analysis.

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 per cent of all wine produced was packaged in bottle sizes of one litre or less as premium table wine. Trends, over 1985-6 to 1989-90, indicate that sales of premium table wine are increasing (22 per cent increase) at the expense of cask wine (18 per cent decline). Further, even though total wine sales have increased by only 1.9 per cent, exports have increased by 285 per cent. During 1990-91, exports made up 15 per cent of total wine sales. 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 per cent over the current decade.

In 1990, while there were over 500 wine making organisations in Australia, the seven largest conglomerate companies produced 66 per cent of 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 mindful of competitors' reactions while the smaller producers generally adjust quantities in response to market determined price levels. On the demand side research by McKinna (1987) indicates significant differences in preferences between consumers, with four types of consumer identifiable, i.e., connoisseurs (25 per cent of all consumers), aspirational drinkers (51 per cent), cask wine drinkers (14 per cent) and new wine drinkers (10 per cent).

The main marketed Australian wine categories are: premium table, cask, bulk, fortified, sparkling, flavoured, carbonated and non-alcoholic wines. In fact, over 10,000 different Australian wine products are available. Given the increasing preference for premium table wine, on domestic but more especially on export markets, our focus rests with this category. Within the premium table wine category a vast range of wines is offered at various qualities and prices. In particular, wines mainly differ

[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).

with 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. To help the industry better understand these grape demand and supply imbalances, a comprehensive survey-based analysis of the current and future demand and supply of wine grapes has recently been completed by Proctor and Phillips (1991) and Abdalla, Kelly and Proctor (1991).

Specifying Hedonic Price Functions for Wine

The theory and practice of hedonic price functions are well-known to agricultural economists: see for example, Waugh (1928), Fettig (1963), Rosen (1974), Coelli *et al.* (1991) and Williams *et al.* (1993). A hedonic price function relates the price of a product to its various attributes or characteristics. Essentially any variable which influences consumers' utilities or producers' costs is a candidate for inclusion in the function. In other words the function is not limited to 'pure quality' factors. If the attribute is continuously measurable (quantitative) then the respective partial derivative of the function represents the implicit marginal attribute price. If the attribute is not continuously measurable (qualitative) then a displacement of the consumption or production possibility frontier occurs, and a clear theoretical interpretation for the function remains (see Edmonds Jr., 1984, pp 80-1). In this latter case partial derivatives are not defined but estimates measure the impact of the presence of the attribute represented by the variable. Most hedonic functions use a combination of both quantitative and qualitative variables (see for example Coelli *et al.*, 1991 and Williams *et al.*, 1993).

To the best of our knowledge the only published 'economic' study of hedonic pricing for grapes or wine is that by Golan and Shalit (1993). They develop a hedonic quality index for Israeli grapes and then a hedonic price function for Californian wines. Their hedonic quality index relates a tasting grade to various 'technical' aspects of grapes such as the level of sugar, grape variety, types and levels of acid, date of harvest, region of source and grape weight. The price function for wine relates the price of Californian wine to the quality index developed in the first stage and dummy variables for grape variety.

The standard Rosen (1974) theoretical framework assumes that consumers' bid functions are always tangential to producers' offer functions at the equilibrium hedonic price gradient. Given the competitive market structure assumption, the hedonic price function is a function of product attributes alone; it is not a function of individual consumer and producer traits. The question arises of the suitability of Rosen's pure competition equilibrium framework for the Australian retail premium table market. 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 on which wine consumers and producers must make decisions appears to be adequate. 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*. As such, information is readily accessible to both consumers and producers. It is clear that wine producers with appropriate training and a 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) may not be so proficient in evaluating intangible attributes and overall quality. However, as argued by Edwards and Mort (1991), the 'opinion leadership' 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 insurmountable barriers to entry and exit in the Australian wine industry. Even though the initial capital outlay needed to construct a winery may be substantial, the existence of over 500 on-going producers of varying size implies relative freedom of entry and exit in the industry. The presence of favourable negative gearing tax arrangements ensures the existence and continued entry of small producers whose operations might otherwise not be economically viable.

It is clear that price-taking behaviour is practised by wine consumers. The same cannot be said for producers. Even though there are over 500 producers, the size of producers varies enormously. Edwards and Spawton (1990) argue that no single producer acts as the obvious price leader but 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 the consequences for the specification of hedonic price functions rigorously determined. Such a theoretical modification is beyond the scope of this study.

Even without a rigorous theoretical foundation to account for elements of non-competitiveness in the price function, we suggest that the 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. This incorporation of individual market agent characteristics to account for degrees of imperfect competition is also a feature of many other hedonic price studies. For example, Brorsen, Grant and Rister (1984) include the number of market bidders in their hedonic price model for U.S. rough rice; Parker and Zilberman (1993) include a dummy variable to measure the impact of a particularly large producer on the hedonic prices of Californian peaches; while Parker (1993) estimates different hedonic price functions (also for

Californian peaches) for different selling outlets, i.e., chain, independent and produce stores.

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 and supply imbalances alluded to previously may prohibit equilibrium trading. We argue, however, that the disequilibrating impact of grape supply and 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 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 per cent 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 does not appear to occur, see Proctor and Phillips' (1991) projections) wine prices for a particular variety will probably not reflect year to year grape demand and 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 individual producer and consumer characteristics to reflect the demand and 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 condition, the corresponding interaction term in the price function should measure the impact on the associated bottle wine price.

Estimation of Hedonic Price Functions for Australian Wine

Data

Potentially there are many sources of data for premium table wine prices and their associated characteristics. Since our focus rests with the retail wine market, technical quality grape attributes such as the level of sugar and acid in grapes, which are used in Golan and Shalit (1993), are not employed. Such grape attributes are of primary interest to grapegrowers and winemakers, but are not important for the wine consumer. That is, given that the vast majority of wine consumers do not have access to information on the technical qualities of grapes, these cannot impact significantly on retail wine prices from the demand side of the market. To this extent our choice of data set should be determined by the data's accessibility to the wine consuming public at large. This requirement stems from the 'flow of information' assumption of Rosen's hedonic price model.

The best candidates for our data source are high profile and nationally accessible consumer wine guides such as: Halliday (1989), Bradley (1990), Shield and Meyer (1991 and 1992) and the bi-monthly magazine *Winestate*. After extensive investigation, the data set employed is that from Shield and Meyer (1991 and 1992).[3] 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; location of grapes; vintage of grapes; consistent cellaring potential recommendations; and over 1600 industry representative sample wines. All other publications were deficient in at least two of these aspects.[4]

Even though there is significant discounting of prices by some of the larger retailers, we employ recommended retail prices (RRP) for the following reasons. First, discounting is not widespread 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 and winery cellar door sales 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 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.[5]

[3] 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 our focus is on vintage wines, then all non-vintage wines were omitted. These omissions led to a final sample size of 1604 (750ml equivalent) wines, 797 marketed in 1991 and 807 marketed in 1992. All basic data are taken from Shield and Meyer (1991 and 1992). Halliday (1989) and the *Australian and New Zealand Wine Industry Directory* (1992) are used to identify wine regions and producer sizes.

[4] As part of the investigation into the most appropriate data set, a hedonic price function was also estimated for data sourced from the *Winestate* magazine. Data from 1988-1990 covering 2033 wines were employed. The results were deficient in one major respect, the wine quality measure employed. A rating of 3, 4 or 5 stars is awarded to each wine. The narrowness of this scale led to insignificant degrees of variability for the quality measure, i.e., over 70 per cent of wines were awarded 3 stars. Further, the inconsistency of different tasters' evaluations and the incorporation of 'value for money' considerations in the quality measure produced unexpected estimates for the dummy variables measuring the impact of wine quality. In particular, a wine awarded the highest rating of five stars was estimated to have a negative impact (from the average price) on prices. Given the use of multiple regression techniques in estimating the function, the misspecification produced by this measure biases all the remaining estimates for the other attributes in the function.

[5] Unsuccessful attempts were made to construct some measure of discount prices for use in the hedonic function. To produce a reliable measure, prices and quantities for

The availability of data largely dictates what characteristics can be used as regressors in the hedonic price function. Even so, it is likely that the most important and most accurately measurable characteristics have been selected.[6] 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, broad groupings (e.g., small, medium, *etc.*) are represented by dummy variables.[7] 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. As with the producer size variable, even though both variables are measured quantitatively, a series of dummy variables are employed. For quality, Shield and Meyer (1991 and 1992) assess 'objectively' the overall quality of each wine by using the international show judging system (a modified Davis scale) which scores each wine out of 20 points: 3 for colour, 7 for nose and 10 for palate. The score out of 20 is then scaled to a score out of 5 from which one of six ratings is reported. It is important to note that Shield and Meyer also present a 'value for money' measure. This implies that the quality measure presented is independent of the monetary value of the wine and as such is a measure of quality only. Given that only six discrete quality ratings are available, the use of a single continuous variable rather than a series of

individual wines from all major retailers would be required. Larger retailers do not maintain historical records of prices charged and at best were only able to produce incomplete newspaper advertising material. In any case, individual wine quantities sold by retailers are and will remain highly confidential, as they represent information of significant commercial value to competing retailers.

6 Spawton (1991) describes some of these attributes from a marketing perspective. 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 (e.g., 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?

7 The use of a series of dummy variables rather than a single continuous variable for producer size has some advantages. First, large measurement errors in the variable will have less of a misspecification impact if dummies are employed. Second, a series of dummies represents a more general specification (permitting non-linear impacts) of which a single continuous variable represents a special case. Note that the use of several dummy variables to represent a single variable is also a feature of other hedonic price studies (see for examle, Coelli *et al.*, 1991).

dummies would unnecessarily impose a restrictive specific structure. Dummy variables based on broad groupings are used for cellaring potential given the approximate nature of such recommendations.

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 assumes particular 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.[8]

Functional Form

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 (only the log of the dependent variable can be taken). 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 price differences. Further, certain wines from particular regions using particular varieties have historically gained prestige and notoriety, e.g., Coonawarra Cabernet Sauvignon. For similar reasons, interactions between vintage and region are also modelled. The approach suggested by Halliday (1991) is used to identify the possibly important region/variety interactions. Finally, to recognise the potential variability due to the year of marketing, the intercept and slope coefficients associated with all the basic characteristics are permitted to differ between 1991 and 1992.

[8] Consider a simple two dummy variable model: $Y = \beta_0 + \beta_1 D_1 + \beta_2 D_2 + u$ (where $D_1 + D_2 = I$) 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 the equation rearranged to yield: $Y = \beta_0 + \beta_2 [D_2 - (P_2/P_1)D_1] + u$. The application of OLS provides $\hat{\beta}_2$. Symmetrically, substituting $\beta_2 = -\beta_1(P_1/P_2)$ leads to $Y = \beta_0 + \beta_1[D_1 - (P_1/P_2)D_2] + u$ and hence $\hat{\beta}_1$. In sum, two appropriately defined regressions permit the estimation of all coefficients and standard errors.

In summary, the general form of the estimated hedonic price function is:

> Price of Wine (RRP) = f (quality rating, cellaring potential, grape variety, grape region, grape vintage, producer size, year of marketing, region*variety, vintage*variety, vintage*region, interactions between year of marketing and all other attributes)

Results

Initially, standard tests (e.g., used in SHAZAM, White *et al.*, 1990, p 94) for both the linear and log-linear forms indicated significant degrees of heteroscedasticity. Given that it was difficult to identify the specific form of heteroscedasticity, 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.[9] Results presented in Table 1 indicate overwhelming support for the log-linear model over the linear model. That is, at the conventional 5 per cent level of significance, the RESET(2) test strongly rejects the linear model, but fails to reject the log-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, as the null hypothesis of no misspecification error cannot be rejected at conventional levels of significance. The summary statistics for the log-linear model presented in Table 1, indicate a reasonably good level of overall predictive performance. Finally, for completeness, summary statistics for the linear model are also presented in Table 1.[10]

[9] 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.

[10] Initially, a significant degree of multicollinearity was identified for both functional forms. In developing the preferred specification three explicit actions were taken to reduce the consequences of multicollinearity. First, a data source with a large number of observations was employed. Second, some variables within the broad attribute groupings of grape variety and grape region were combined (e.g., combining all other straight white varietals) to reduce the number of individual regressors. Third, interaction terms were only included if significant at a 10 per cent level.

TABLE 1
Ramsey RESET Specification Tests[(a)] and Summary Statistics

Functional Form			P Values
Log-Linear	RESET(2) = 3.022	~ F(1,1508)	0.082
	RESET(3) = 1.564	~ F(2,1507)	0.103
	RESET(4) = 1.061	~ F(3,1506)	0.303
	$R^2 = 0.6075$	$\bar{R}^2 = 0.5830$	
	$\bar{Y} = 2.5862$	$\hat{\sigma} = 0.2247$	
	N = 1604	D.F. = 1509	
Linear	RESET(2) = 126.8	~ F(1,1508)	< 0.00001
	$R^2 = 0.5718$	$\bar{R}^2 = 0.5452$	
	$\bar{Y} = 14.161$	$\hat{\sigma} = 3.9172$	

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

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.[11] Consider the broad groupings in turn. There appears to be a direct relation between quality ratings and price, with extremes of a 14.9 per cent reduction from average price for modest wines and a 17.9 per cent increase for very rare wines. Average prices are most typical of extremely good wines. Similarly, cellaring potential has a direct relation with price. At the extremes a drink-now wine produces a 13.4 per cent reduction from average price and an over-10-years wine a 53.1 per cent increase. Average wine prices are most typical of the cellaring potential classification, $2 < X \leq 4$ years.

[11] Note that because of the existence of many interaction terms, the 'total' relative impact of a particular attribute may be a complex function of other attributes. For example, the relative impact of Rhine Riesling depends upon its region (Adelaide Hills) and vintage (1992). To ease interpretation, the figures in parentheses in the 'percentage impact' column of Table 2 measure the total relative impact for the attribute evaluated at the sample means of the data, e.g., Rhine Riesling = –7.6 – 12.3 [Mean (Adelaide Hills)] – 23.5 [Mean (1992 Vintage)] = –7.6 –12.3 (0.061) – 23.5 (0.007) = –8.5.

TABLE 2
Hedonic Price Log-linear Model Estimates

Variable	Coefficient	T Ratio[(a)]	Percentage Impact[(b)]	Sample Mean[(c)]
Constant	2.586*	475.2		14.16
Wine Quality Ratings				
Modest (2.5)	–0.159*	–2.29	–14.9	0.002
Good (3.0)	–0.131*	–9.37	–12.3	0.147
Very good (3.5)	–0.039*	–4.42	–3.8	0.278
Extremely good (4.0)	0.004	0.57	0.4	0.352
Brilliant (4.5)	0.108*	6.83	11.4	0.137
Very rare (5.0)	0.165*	6.56	17.9	0.084
Cellaring Potential (X = Average age of range)				
Drink now	–0.143*	–5.22	–13.4	0.115
0 < X ≤ 2 years	–0.081*	–3.91	–7.8	0.340
2 < X ≤ 4 years	–0.020	–0.92	–2.0	0.346
4 < X ≤ 6 years	0.078*	3.05	8.1	0.147
6 < X ≤ 10 years	0.169*	4.28	18.3	0.047
X > 10 years	0.436*	3.12	53.1	0.005
Grape Variety/Style				
Chardonnay	–0.084	–1.00	–8.4 (19.2)	0.187
Rhine Riesling	–0.079*	–3.07	–7.6 (–8.5)	0.097
Sauvignon Blanc	0.071*	2.57	7.3	0.046
Semillon	–0.069*	–2.38	–6.3	0.054
Sweet White	0.198*	3.94	21.7 (27.4)	0.022
Dry White Blends	–0.014	–0.48	–1.4	0.035
Other Straight White Varietals	–0.043	–1.40	–4.3	0.038
Cabernet Sauvignon	0.046	1.60	4.7 (6.3)	0.141
Pinot Noir	0.203*	6.41	22.4 (24.3)	0.054
Shiraz	–0.043	–1.60	–4.2 (–2.9)	0.147
Cabernet Sauvignon / Merlot	0.090*	3.05	9.4 (9.0)	0.041
Cabernet Sauvignon / Shiraz	–0.055	–1.22	–5.4	0.022
Other Reds (Blends & Varietals)	0.039	1.21	3.9	0.064
Light Reds	–0.152*	–3.14	–14.2	0.014
Vintage Port	–0.349*	–4.85	–29.6 (–25.7)	0.011
Sparkling Wine	0.440*	9.62	55.1	0.026
Grape Region				
Hunter Valley	–0.009	–0.51	–0.9 (–1.5)	0.103
M.I.A.	–0.430*	–5.59	–35.1 (–32.4)	0.011
Other N.S.W. Districts	–0.167*	–4.70	–15.4	0.018

North–East Victoria	–0.032	–1.20	–3.2	0.048
Mornington Peninsula	0.199*	7.71	22.0	0.034
Geelong	0.042	0.65	4.1	0.011
Great Western & Pyrenees	0.005	0.22	0.5	0.054
Yarra Valley	0.163*	4.69	17.6 (13.2)	0.048
Central & North Goulburn Valley	–0.043	–1.42	–4.3	0.036
Macedon	0.069	1.91	7.1	0.016
Murray River	–0.353*	–5.17	–29.9	0.007
Other Victorian Districts	–0.018	–0.42	–1.9	0.022
Riverland	–0.326*	–4.27	–28.0	0.011
Barossa Valley	–0.104*	–4.55	–9.9 (–13.2)	0.089
Southern Vales	–0.135*	–7.98	–12.6	0.117
Coonawarra & Padthaway	0.130*	3.19	13.8 (2.6)	0.094
Clare Valley	–0.081*	–3.03	–7.8 (–7.9)	0.064
Adelaide Hills	0.112*	3.72	11.8 (10.6)	0.061
Other S.A. Districts	–0.084	–1.81	–8.2	0.017
Lower Great Southern Area (WA)	0.086*	4.63	9.0	0.041
Margaret River	0.172*	5.74	18.7	0.032
Other W.A. Districts	0.029	0.97	2.9	0.019
Canberra	0.026	0.94	2.6	0.014
Tasmania	0.199*	5.15	21.9	0.019
New Zealand	0.028	0.96	2.8	0.014
Grape Vintage				
1970	2.159*	24.81	763.0	0.001
1975	1.655*	17.62	421.0	0.001
1976	1.657*	18.02	422.1	0.001
1979	0.538*	14.96	71.1	0.001
1980	0.610*	8.69	83.6	0.001
1982	0.341*	2.58	39.4	0.003
1983	0.345*	3.72	40.6	0.004
1984	0.443*	5.98	55.3 (50.5)	0.005
1985	0.224*	2.17	26.8 (35.3)	0.009
1986	0.411*	5.51	50.4 (53.9)	0.017
1987	0.100*	3.03	10.5 (25.6)	0.050
1988	0.008	0.42	0.8 (4.2)	0.147
1989	0.029	1.92	2.9 (6.5)	0.232
1990	–0.051*	–5.00	–5.0 (–1.8)	0.338
1991	–0.078*	–4.77	–7.5 (–4.3)	0.183
1992	0.024	0.25	2.0 (–0.3)	0.007
Producer Size (X = number of cases p.a.)				
$0 < X \leq 2{,}000$ (Very Small)	0.064*	4.18	6.6	0.147
$2{,}000 < X \leq 5{,}000$ (Small)	0.088*	6.53	9.2	0.143
$5{,}000 < X \leq 20{,}000$ (Medium)	0.036*	4.06	3.7	0.284
$20{,}000 < X \leq 100{,}000$ (Large)	–0.032	–1.94	–3.2	0.139
$100{,}000 < X$ (Very Large)	–0.097*	–8.50	–9.3	0.287
Year Marketed				
1991	0.024*	2.87	2.4 (2.9)	0.497
1992	–0.023*	–2.87	–2.3(–2.3)	0.503

Region / Variety				
Adelaide Hills Rhine Riesling	–0.130*	–2.90	–12.3	0.014
Barossa Valley Shiraz	0.138*	2.16	14.6	0.021
M.I.A. Sweet White	0.852*	2.45	120.7	0.001
Vintage / Variety				
1986 Pinot Noir	0.765*	8.29	114.0	0.001
1985 Chardonnay	0.389*	2.48	45.7	0.001
1987 Chardonnay	0.483*	2.97	60.0	0.001
1988 Chardonnay	0.233*	2.04	25.4	0.012
1989 Chardonnay	0.268*	2.50	30.0	0.033
1990 Chardonnay	0.249*	2.40	27.6	0.089
1991 Chardonnay	0.210*	1.98	22.7	0.047
1989 Cabernet Sauvignon	0.066	1.79	6.8	0.050
1992 Rhine Riesling	–0.262*	–2.55	–23.5	0.001
Vintage / Region				
1989 Coonawarra & Padthaway	–0.200*	–3.24	–18.3	0.026
1990 Coonawarra & Padthaway	–0.155*	–2.67	–14.5	0.026
1991 Coonawarra & Padthaway	–0.114	–1.92	–10.9	0.011
1984 Hunter Valley	–0.421*	–5.25	–34.6	0.001
1986 Hunter Valley	–0.292*	–2.56	–25.8	0.007
1988 Barossa Valley	–0.164*	–3.01	–15.3	0.019
1989 Barossa Valley	–0.148*	–2.98	–13.9	0.018
1984 Clare Valley	–0.211	–1.80	–19.6	0.001
1990 Yarra Valley	–0.137*	–2.80	–12.9	0.021
Year Marketed/Variety and Vintage				
1991 Sweet White	0.167*	2.65	17.9	0.008
1991 Cabernet Sauvignon/ Merlot	0.047*	2.35	4.8	0.022
1991 Vintage Port	0.101*	2.55	10.5	0.007
1991 Vintage 1987	–0.046*	–2.17	–4.5	0.036
1992 Sweet White	–0.094*	–2.65	–9.0	0.014
1992 Cabernet Sauvignon/ Merlot	–0.056*	–2.35	–5.5	0.019
1992 Vintage Port	–0.158*	–2.55	–14.8	0.004
1992 Vintage 1987	0.117*	2.17	12.2	0.014

* Significant at the 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: $100[exp(\hat{\beta} - 0.5\hat{var}(\hat{\beta})) - 1]$ (see Kennedy, 1981 and Derrick, 1984). The figures in parentheses represent the 'total' relative impact of the attribute by recognising the impact of associated interaction terms see footnote 11.

(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.

Grape varieties/styles which have the greatest impact on price are increases (from the average price) of: 55.1 per cent for sparkling wine, 27.4 per cent for sweet white and 24.3 per cent for Pinot Noir; and reductions of: 25.7 per cent for Vintage Port, 14.2 per cent for light reds and 8.5 per cent for Rhine Riesling. These extreme impacts are as expected. Premium sparkling wine requires specialised production techniques, premium sweet 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 dry white blends.

The main impacts on price of grape region are increases of: 22.0 per cent for Mornington Peninsula, 21.9 per cent for Tasmania and 18.7 per cent for Margaret River; these regions represent small scale cool climate grape production areas. The main reductions are: 32.4 per cent M.I.A., 29.9 per cent Murray River and 28.0 per cent Riverland; these regions represent large-scale irrigated grape production areas. Regions most typical of average prices are: Hunter Valley and the Great Western and Pyrenees.

The coefficients of the grape vintage dummies indicate that the older the vintage the higher the price. This result reflects the time value of money and costs of storage. The extremes are an increase of 763.0 per cent for the 1970 vintage and a reduction of 4.3 per cent for the 1991 vintage. Average wine prices tend to be reflected by the 1990 and 1992 vintages.

The coefficients of the producer size variable show producer size to be inversely related to price. 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 9.2 per cent increase for 'small producers' and a 9.3 per cent reduction for 'very large producers.' Average wine prices are most typical of 'medium and large producers'.

To maintain manageability, interaction terms were only included in the price function if they were significant at levels of 10 per cent or less. This criterion led to the inclusion of three region/variety, nine vintage/variety and nine vintage/region interaction terms. The vintage/variety interactions demonstrate, among other things, the impact of Chardonnay grape demand and supply imbalances on wine prices. In general, it appears that these disequilibrium impacts are diminishing over time. The vintage/region interactions indicate that only poor regional vintages result in prices significantly different from average, given that all the identified interactions were negative. These results and those on vintage alone (e.g., 1986 has a larger impact than all the 1982 to 1985 vintages) indicate that outstanding vintages have only an overall, rather than a regional, positive impact on wine price.

Finally, results on the impact of the year of wine marketing indicate that, on average, 1991 prices were greater than 1992 prices. Only four specific 'slope' terms were found to be additionally significantly different between the two years of marketing.[12]

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.[13] To practically implement this recommendation consumers would need to identify all the attributes of their prospective purchase. If the wine is one of the extensive range of wines evaluated in the annual Shield and Meyer guide then no difficulties arise. If the wine is not listed, there should still be no problem in identifying the wine's 'objective' attributes. However, identifying the quality rating and cellaring potential measures appears to be more problematic. Consumers could make use of the extensive number of other published wine guides and/or the national daily press and their wine recommendations for a broad indicator of quality. Alternatively before making a large purchase of a particular wine, the consumer could evaluate the wine 'objectively' herself. Failing all this, two limits to the prediction of 'average price' could be provided by calculating the price at the extreme ratings of 2.5 and 5.0 for quality.

For producers the function provides important information upon which longer-term investment decisions may be made. To warrant redirecting resources to attain 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. Given that the quality rating has been determined as objectively as possible through the use of the international show judging system evaluation technique, producers could investigate objectively the benefits and costs of altering the quality of their wine. For example, moving from a 'good wine' (-12.3%) to a 'very rare wine' (+17.9%), at sample mean

[12] In an attempt to identify the principal causes of the previously identified heteroscedasticity, the squared residuals of the preferred function were regressed against all the regressors included in the model. The variables found to be significant at a 5 per cent level were: the quality rating of a very rare wine (+); the regions of Hunter Valley (–) and Clare Valley (+); the 1985 vintage (+); very large producers (+); and the interaction between Barossa Valley and Shiraz (+). These results, especially those for the quality rating and producer size, may be explained by our use of RRP rather than some measure of discounted prices. For example, wines produced by the large conglomerates tend to be discounted more frequently and to larger degrees than those wines of smaller producers. Such differences will result in the variability of the error variance.

[13] To reduce the small sample bias in predicting raw prices from the log-linear model, predictions should be scaled by exp $(\hat{\sigma}^2/2)$, see Dadkah (1984). This result stems from the fact that in any log-linear model of the form: $\ln Y = \alpha + \beta X + u$ we have $Y = e^{\alpha} e^{\beta x} e^{u}$, and since $E(e^{u}) = e^{\sigma^2/2} \neq 1$, an adjustment should be made when forming predictions.

prices, translates to a \$4.28 [= (0.179 – –0.123) * \$14.16] increase in price, all other things constant. This benefit should be compared to the costs of improving quality (e.g., 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, redirecting resources to produce the more desirable attributes should not significantly invalidate the estimated market determined benefits. Thus planning can be undertaken with some certainty. However, 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 that their quantity changes and the reaction of their 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 being estimated to have large wine price premiums, the grapes are projected to be in significant excess supply over the period 1992/3 to 1993/4 (see Proctor and Phillips, 1991, p 19). 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 mitigate the undesirable consequences of grape demand and supply imbalances, then increased production of those grape varieties with the largest identified negative price impacts, could be discouraged through policies such as 'vine pull' schemes. Moreover, if there is a desire to further enhance exports then specific incentives (e.g., tax concessions, marketing promotions, etc.) should be directed to those wines identified as having the most desirable attributes.

Concluding Comments

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

The interaction terms provide important insights into the effects that grape demand and supply imbalances have on wine prices, and into the negative price impacts of poor regional vintages. Finally, the time of marketing variables indicate that between 1991 and 1992 there were general downward pressures on wine prices, despite economy wide inflationary pressures.

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