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SANJA LUTZEYER

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SANJA LUTZEYER
DEPARTMENT OF ECONOMICS
UNIVERSITY OF STELLENBOSCH
PRIVATE BAG X1, 7602
MATIELAND, SOUTH AFRICA
DEPARTMENT OF ECONOMICS
NORTH CAROLINA STATE UNIVERSITY
E-MAIL: SANJA.LUTZEYER@GMAIL.COM

UNIVERSITEIT
STELLENBOSCH
UNIVERSITY

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ABSTRACT

This paper estimates a hedonic price function for Stellenbosch wines to determine the association between market value and different characteristics of these wines. In such a hedonic price function, the price of a bottle of wine is ascribed to the implicit value of its attributes. Besides contributing to both South African and international wine pricing literature, the benefits of developing a hedonic wine pricing model extend to numerous players in the wine industry. Consumers are provided with guidelines on how to utilize their wine purchasing budget more efficiently, while producers are able to use estimates of the function to guide future investment decisions. The hedonic price function estimated in this paper includes numerous 'objective' characteristics, appearing on the label of the bottle, as well as subjective characteristics in the form of expert wine ratings. In an effort to address possible heterogeneity of wine as a product, separate regressions are run for red and white wines.

The estimation of the hedonic price equation shows that, in general, wine quality (as modelled by blind and sighted wine ratings) and age of the wine are relevant in accounting for price deviations from average red wine prices. Further, it is found that only limited numbers of red wine varieties and sub-districts of production significantly influence the average price of Stellenbosch red wines. For white wines, only sighted wine ratings as well as age of the wine were found to significantly account for deviations from average white wine prices. While blind wine ratings and white wine varieties were not found to significantly influence average white wine prices, certain regions of production where found to be relevant in accounting for deviations from average white wine prices.

Keywords: Hedonic pricing, Wine, Stellenbosch, South Africa
JEL codes: Q11, C13, C21

1. Introduction

South Africa is currently the 9th largest wine producing country in the world – cultivating 101 607 hectares of land through 4360 farmers, whose grapes are processed by around 572 cellars (du Plessis, 2006:14). Of the wine regions in South Africa, Stellenbosch is arguably the most well known. Indeed, Stellenbosch is renowned to be the 'de facto' capital of the South African winelands - claiming around 70% of local and international awards presented annually to South African wines (GreatWineCapitals, 2007).

This paper aims to determine the market value of different characteristics of Stellenbosch wines through the estimation of a hedonic price function – a function in which the price of a bottle of wine is ascribed to the implicit value of its attributes. The last decade has brought with it an extensive interest in estimating hedonic functions for wine. Hedonic price indexes have been determined for wines sold in Australia (Oczkowski, 1994), France (Combris et al., 2007), Spain (Angulo et al., 2000), Sweden (Nerlove, 1995) and the USA (Costanigro et al., 2007), among others.

The benefits of developing a hedonic wine pricing model for the Stellenbosch region are plentiful. Wine consumers are faced daily with a myriad of wines and prices, and have to adjudicate on these so as to best use their wine purchasing budget. Producers similarly have to make investment decisions about which types of wine they believe to be optimal and most profitable to produce. The scope for using empirical analysis to determine the relationship between wine characteristics and the price of Stellenbosch wines is thus large. Besides providing valuable information to the wine market, this study aims to contribute to existing South African, as well as international wine pricing literature by addressing several econometric criticisms raised against prevailing hedonic wine pricing studies.

This paper is organized as follows: section 2 given a brief overview of the hedonic model and its theoretical foundations and assumptions. Section 3 examines the adequacy of the hedonic method for the wine industry in general, and then proceeds to investigate the suitability of the theoretical framework for the South African retail wine market in particular. Section 4 provides

a review of existing hedonic wine pricing literature, section 5 describes the dataset, while the empirical specification of the model is discussed in section 6. In section 7, the results of the model are presented and discussed, and the marketing and policy implications following from these results are discussed in section 8. Section 9 concludes.

2. Theoretical Context

The core of the hedonic hypothesis is that all products are characterized by the set of their attributes (Brachinger, 2002:2). It is assumed that the price of any good can be viewed as a function of these immanent, utility-bearing characteristics (Lancaster, 1966; Rosen, 1974:34). Employing the standard hedonic price model developed by Rosen (1974), the price, P, of a bottle of wine is assumed to be explained by a hedonic price function, $P = f(\mathbf{z})$, where z represents a vector of wine attributes. Each wine consumer chooses a bundle of wine characteristics so as to maximize utility subject to a budget constraint. The *implicit* or *hedonic* price of a given characteristic, z_i, gives the change in the price P of a product, if that product is endowed with an additional unit of characteristic z_i, *ceteris paribus* (Brachinger, 2002:2). In essence the implicit price of an attribute indicates the marginal willingness to pay for a change in that attribute. If the characteristic in question is continuously measurable, the implicit price is found by taking the partial derivative of the hedonic price function with respect to z_i: $\delta P/\delta z_i$. If the characteristic in question is discretely measurable, the finite difference $\Delta P/\Delta z_i$ represents the marginal willingness to pay for the attribute z_i (Costanigro et al., 2007:457).

3. Application to the Wine Industry: a Focus on South Africa

The application of hedonic pricing theory to wines differs from its application to consumer durables because the identification and measurement of relevant wine characteristics is not always facile. Although some information about a wine, such as its vintage and its origin, is easily obtainable from the label of the wine bottle, other characteristics such as taste and texture are more difficult to identify (Combris et al., 1997:391). Nevertheless, wine is a prime example of a differentiated good. While different wines vary with respect to numerous attributes, they are so closely related in the minds of consumers that they can essentially be viewed as one commodity (Day, 2001:2). Moreover, wines are bought and sold at a wide range

of prices and are produced and consumed under increasingly competitive conditions. This paper argues that, despite the possible difficulties mentioned above, the wine market serves as an attractive candidate for the application of hedonic theory.

The theoretical framework discussed under section 2 is based on the strict assumption of a competitive market structure – it assumes that "consumers' bid functions are always tangential to producers' offer functions at the equilibrium hedonic price gradient" (Oczkowski, 1994:95). Given competitive market conditions, the hedonic price function is determined solely by product attributes, and is thus independent of individual consumer and producer characteristics (Oczkowski, 1994:95). As this assumption is rarely satisfied in practice, the question of the suitability of the hedonic pricing method for the South African retail wine market arises. Accordingly, it was decided to briefly assess the extent to which this market accords with Rosen's (1974) framework of pure competition[1]. Firstly, the flow of information to wine consumers and producers appears to be adequate, with wine attributes and recommended retail prices and professional wine ratings published regularly in national newspapers[2] as well as magazines[3]. Although it could be argued that new wine drinkers may not have the ability to assess the overall quality of the wine, widely accessible expert wine ratings circumvent the need for individual wine expertise (Oczkowski, 1994:96). Secondly, the existence of over 4000 wine producers and close to 600 wine cellars in 2005 (du Plessis, 2006:549) implies that no significant barriers to entry exist in the South African wine industry. Finally, with regard to the possible existence of price-making power among large wine producers, Froud (2008) argues that there is no obvious price leader, and no price collusion taking place among South African wine producers. On the contrary, he argues that South African wine producers could, like the Australian wine producers, do more to work together and provide something like a "South African wine front" on the international market (Froud, 2008).

This paper will proceed to assume that the South African wine market does not deviate significantly from Rosen's (1974) state of pure competition – thus warranting the use of the

[1] This analysis follows Oczkowski's (1994:96) efforts to assess the "suitability of Rosen's pure competition equilibrium framework for the Australian retail premium table market."
[2] Wine columns are published regularly in the Sunday Times (Neil Pendock), the Weekender (Michael Fridjhon), the Cape Times (Graham Howe) and Die Burger (Christine Rudman), among others – writers given in brackets (du Plessis, 2006:471-478).
[3] Examples include Wine Magazine (Christian Eedes, Mike Froud), Farmer's Weekly (Sonja Burger) and Grape Magazine (Tim James), among others – writers given in brackets (du Plessis, 2006:471-478).

standard OLS regression framework. It must be kept in mind, however, that it is unlikely that the South African wine market completely satisfies the theoretical concept of perfect competition, leading to a likely bias of estimated coefficients. Accordingly, this paper will attempt to describe the influence of wine attributes on wine prices in a numerical fashion rather than making causal statements about consumer behaviour and preferences (Thrane, 2004:126-127).

4. Literature Review

Oczkowski (1994)[4] was arguably the first author to apply hedonic price theory to the wine industry when he estimated a hedonic price index for Australian table wine. Since then, literature seeking to determine which wine characteristics significantly influence wine prices has been plentiful. In general, four broad categories have been used in hedonic wine function literature: objective, sensory, chemical and climatic. Objective characteristics are those easily observable by the consumer. These attributes are normally discernable on the label of a bottle of wine: the wine's vintage, the grape variety and the region from which the grapes were sourced (Oczkowski, 1994). Sensory attributes include a wine's aromatic intensity, body and firmness, among other things. These attributes are subjectively assessed, usually by a jury of wine experts (Combris et al., 1997; Lecocq and Visser, 2006). Chemical attributes involve technical measures such as a wine's alcoholic content, sugar content and level of acidity (Nerlove, 1995). Finally, climatic attributes measure the influence of weather on grapes used in wine production (Ashenfelter et al., 1995).

Combris et al. (1997) applied the hedonic wine pricing technique to Bordeaux wine and showed that the market price of wine is almost solely determined by objective wine characteristics. They found, on the other hand, that jury grades / expert ratings are essentially a function of sensory characteristics. Much of the literature (Oczkowski, 1994; Landon and Smith, 1997; Lecocq and Visser, 2006) demonstrates that wine ratings by specialized agencies or magazines significantly influence wine prices and so should be included in hedonic wine pricing models. Combris et al. (1997:401) suggest that a possible explanation for the insignificance of sensory cues is imperfect information. Sensory characteristics are often

[4] Although Golan and Shalit developed a model in 1993, these authors made use of grape data rather than wine data, and so their paper is not directly comparable to later work in the field (Golan and Shalit, 1993).

difficult and costly to identify as they can only be obtained through tasting, learning and through the use of expert wine guides. As such, expert wine ratings are often used as a signal by the consumer.

The first paper to apply the idea behind the hedonic wine pricing method to South Africa was written by Paul van Rensburg and David Priilaid in 2004. Although not explicitly making use of the hedonic framework, the article introduces an econometric valuation tool to determine the relationship between wine price and value for three South African red wines cultivars (Cabernet Sauvignon, Merlot and Shiraz) from a consumer's perspective. Value is modelled using blind and sighted ratings from local wine guides (measured in stars) as quality metrics. The 'intrinsic values' of different wines are calculated and used to create a value frontier demonstrating which wines have maximum value relative to their price.

Their argument is built upon, and the model improved, in a further paper (Priilaid and van Rensburg, 2006). Contrary to the first paper, in which a linear/ordinal approach is used to model the relationship between price and quality, the paper makes use of a "dummy-styled" approach to allow for different price increments in wine quality (measured in stars) at the top and bottom ends of the quality spectrum. Further, the paper is broadened to include five South African red wine cultivars: Cabernet, Merlot, Pinotage, Pinot Noir, and Shiraz.

Priilaid and van Rensburg (2006:167-168) provide a lengthy argument suggesting that blind and sighted ratings together are sufficient to model consumer decisions in purchasing wine, and furthermore, that extrinsic signals such as vintage and area of origin are "ultimately captured in either or both the sighted and blind quality metrics" (Priilaid and van Rensburg, 2006:168). Although objective characteristics are to some extent captured by wine star ratings, it is doubtful whether only the inclusion of blind and sighted ratings is sufficient to create a hedonic wine pricing model for the South African wine industry – especially because hedonic price equations are supposed to be a function of intrinsic product characteristics alone. Therefore, although Priilaid and van Rensburg's (2006) research provides a useful basis for scrutinizing the determination of wine prices in South Africa, it could be argued that the paper hinges too heavily on the connection between consumer behaviour models and hedonic models – a relationship that exists only in very rare cases. Furthermore, if the link between consumer

behaviour and price determination were credible, it is nevertheless unlikely that ratings are sufficient to model the effect of different wine attributes on wine price from the consumer side. Firstly, not all consumers have access to wine guides and so the ratings included in the model presented and secondly, it is unlikely that objective characteristics provided on the wine bottle do not play a large role in determining wine price.

5. The Data

In an effort to examine the relevance of as many wine characteristics as possible, major role-players in the SA wine industry were contacted[5] to obtain data relevant to this study. Unfortunately, however, data was limited, and if available, was at too aggregated a level to be useful for econometric analysis. *Wine* Magazine was found to be the only source keeping a record of South African retail wine prices (database beginning in 2005). Accordingly, characteristics used as regressors in the hedonic analysis were to some extent dictated by the availability of South African wine data[6].

The data used in this study was obtained from three main sources. The first is the locally published, monthly *Wine* Magazine. This magazine has, since its inception in 1993, kept record of a wide variety of wine related information. Since 2005, the database includes details of retail wine prices for all wines assessed by the magazine. The second information source is the annual *John Platter* Wine Guide. Together, these two sources provided valuable information about objective characteristics such as wine varieties and wine vintage, as well as providing invaluable information about wine quality, in the form of wine ratings[7].

[5] Roleplayers contacted for information include South African Wine Industry Information and Systems (SAWIS), Wines of South Africa (WOSA), the South African Wine and Spirit Board, Stellenbosch University, as well as *Wine* magazine and the *John Platter* South African Wine Guide.

[6] The lack of official South African wine statistics encountered in this study, together with South Africa's role as one of the major global players on the wine market, suggests that more resources should be channelled toward a more in-depth examination of the South African wine industry.

[7] To the extent that the wines found in the *Wine* Magazine and the *Platter* databases are not a random sample, a possibility of selectivity bias is expected in the results estimated. Unfortunately, no information was available for which wines were rejected by the rating agencies, and assessment of the potential selectivity bias is impossible. For that reason, this study will assume that the sample obtained is random, keeping in mind that in the hedonic function estimated in the next section of this paper, certain wine attributes might appear to significantly influence the price of a bottle of wine, while in reality this might not be the case.

The dataset obtained from *Wine* Magazine contained information on 6378 wines, while the *Platter* dataset was made up of an equally impressive 6064 observations. Due to the size of the datasets, it was decided to focus only on one wine region of South Africa – albeit the most well-known one: Stellenbosch. Of the 2458 wines of Stellenbosch origin rated in the *Wine* Magazine, 493 coincided with wines tasted in the *Platter* guide. From these observations, bottles of irregular sizes[8], Dessert wines, Port wines and Sparkling wines were deleted, thus restricting the focus of the study to white and red wines. Categories (such as wine types) with less than 5 observations were also dropped from the dataset. The final dataset comprised of 442 wines – 283 red wines and 159 white wines.

In order to test for the presence of a sub-regional effect on wine prices within the Stellenbosch region, the dataset was divided into numerous sub-districts. This was done by matching wine cellars present on the final database with the farm names as registered under SAWIS, the third source of data, and then allocating each wine cellar to a sub-district, based on its 'Divisional Council Region' as found in the SAWIS database.

No data on chemical, climatic or sensory wine characteristics was available for the South African wine industry. According to Oczkowski (1994, 2001) and Landon and Smith (1997), however, the perfect information assumption of the Rosen (1974) hedonic framework should guide the choice of attributes included in the determination of a hedonic price index. The extent to which consumers can significantly influence wine prices from the demand side of the market depends on consumer knowledge of a wine's characteristics. As the average consumer does not have access to information about the chemical and climatic characteristics, and is generally not aware of the sensory characteristics of a wine at the time of purchase, it could be argued that these characteristics are not ideally suited for inclusion within hedonic wine pricing functions. Objective characteristics on the other hand, which are easily observable by the consumer, provide attractive candidate variables for the task at hand (Oczkowski, 2001:375). Oczkowski (2001:375) argues, however, that the above reasoning does not rule out the use of overall quality ratings found in widely accessible wine guides, as these ratings inform consumers about a wine's quality – effectively serving as a risk-reducing proxy – and so may also

[8] The dependent variable used in this study is the price in South African Rand (R) for a bottle of wine (750ml).

contribute to demand side influences on wine prices (Priilaid and van Rensburg, 2006:168)[9]. Data about different wine producer sizes was also not available for South Africa. Due to high levels of competition among wine producers, however, this was not viewed as problematic.

The proxies used for wine quality in this paper include both blind (*Wine* Magazine) and sighted (*Platter*) ratings[10]. The tasting protocols followed by both these sources are standard to the wine industry. *Wine* Magazine tastings are conducted blindly by a panel of experienced Cape Wine Masters. Stars are awarded on the bases of discussion and consensus, rather than by simple arithmetic averaging (*Wine* Magazine, 2007). Moreover, wine tasting procedures as well as results are reviewed by a professional auditing firm. Unlike *Wine* Magazine, the *Platter* tastings are not conducted blindly and as such contain an element of subjectivity (van Zyl, 2004:6).

Both rating systems work on a 20-point scoring system. Wines scoring 13 out of 20 are awarded 1 star and are viewed as acceptable. Average, or appealing wines which score 14 points are awarded a 2-star rating. Wines which score 15 points out of 20 are awarded 3 stars and are rated as good wines with cellaring potential. 4 Stars are awarded to excellent wines scoring 16 to 17 points. Finally, wines scoring 18 points or more are labelled as superlative, world-class wines and are awarded 5 stars. Unacceptable wines, without any redeeming attributes, receive a zero star rating (Priilaid and van Rensburg, 2006:171; Wine Magazine, 2007; John Platter South African Wine Guide, 2007). Wines whose scores fall between these established categories are in this paper labelled as modest wines (2.5 stars), very good wines (3.5 stars), and brilliant wines (4.5 stars) respectively.

A description of wine rating and price variables is given in Table 1 below.

[9] This assumption is supported by the study by Combris et al. (1997:396-397), who find that while "the price of a wine is essentially determined by the objective characteristics of the bottle," (Combris et al., 1997:397) jury grades are essentially determined by sensory characteristics – suggesting that jury ratings are a suitable proxy for wine quality.

[10] Although other rating systems for South African wines do exist (examples include Fairbaim Capital, Veritas, and the Michael Angelo awards), the ratings of *Wine* Magazine, and especially the *John Platter* ratings, are arguably the most used wine purchase guides in the country (Priilaid and van Rensburg, 2006:171).

Table1: Descriptive statistics for selected study variables

	Variable	Min	Max	Mean	Std. Deviation
Red	Price	17	350	84.42	54.85
	Platter rating	1	5	3.61	0.67
	Wine magazine rating	0	4	2.47	0.84
White	Price	15.99	245	57.38	32.24
	Platter rating	1.5	5	3.53	0.61
	Wine magazine rating	0	4	2.54	0.76

Note: Own calculations from Wine Magazine, John Platter and SAWIS data

6. Specification

According to Costanigro et al. (2007:456) "extreme heterogeneity of wine as a product class is a prima facie reason why fundamental model specification issues should be of principal concern to market analysts." This relates to Thrane's (2004:124) argument that it is likely that different hedonic functions exist for red and white wines. Much of the hedonic wine pricing literature available entails the simultaneous analysis of red and white wines (see Oczkowski, 1994, 2001; Nerlove, 1995; Combris et al., 1997). This single hedonic function assumes, however, that the implicit prices of wine characteristics are the same for red and white wines. For characteristics such as vintage, this assumption appears incorrect on *a priori* grounds – the ageing potential for red wines is very different to that of white wines (Costanigro et al., 2007:456). In order to address the issue of heterogeneity between red and white wines, the wine data is split into two separate samples: one for red wines and one for white wines[11].

Due to the limited time dimension available for wine prices, cross sections from different time periods had to be pooled – restricting the study to cross-section analysis[12]. On the basis of diagnostic tests (see Table 2 below), goodness of fit, as well as due to the ease of interpretation of coefficients and summary statistics, it was decided to make use of the semi-log model. The

[11] A second possible approach to address the issue of heterogeneity entails running a standard OLS regression, but including interaction terms between wine characteristics and a dummy variable indicating red wine. Although splitting of the data into two samples assumes independence between the implicit prices of red and white wine characteristics, this approach was nevertheless viewed as preferable, as it allows for more meaningful analysis of coefficients relative to reference categories in a regression making exclusive use of dummy variables.

[12] In an effort to capture the possible effects of inflation on wine prices obtained in different years, dummies for different dates of rating were included in the regression. Retail wine prices found in the *Wine* Magazine dataset were recorded at the date of rating.

natural logarithmic transformation of the dependent variable has the further advantage that it is the most prevalent in hedonic wine pricing studies, allowing for a more direct comparison between studies. To test for and remove outliers, Cook's Distances were used. Observations with a Cook's D larger than 0.014 (red wine regression) and 0.028 (white wine regression) were excluded from the regression analysis[13]. As the residuals under this specification are not normally distributed, hypothesis tests reported in this paper should be viewed with caution.

Table 2: Test Statistics for Different Specifications of the Dependent Variable

		Fit		Normality*			Specification	Heteroscedasticity
	Transformation	**Adj. R^2.**	**F**	**Skewness**	**Kurtosis**	**Joint**	**RESET**	**Breusch-Pagan**
						χ^2	**F-value**	**χ^2**
Red	**Linear**	0.560	10.700	2.021	11.327		2.880	33.850
				0.000	0.000	0.000	0.037	0.000
	ln(price)	0.598	12.350	0.494	5.062	22.720	0.500	1.940
				0.001	0.000	0.000	0.686	0.163
White	**Linear**	0.618	8.670	3.703	24.267		4.090	23.340
				0.000	0.000	0.000	0.009	0.000
	ln(price)	0.676	10.910	1.153	8.102	38.690	0.220	0.260
				0.000	0.000	0.000	0.884	0.610

NOTES: Probability values are displayed below statistical test values.
*Normality was assessed by examining summary statistics of residuals and running the sktest in Stata
Own calculations from *Wine Magazine, John Platter* and SAWIS data

The final specification of the independent variable was determined by examining possible transformations of the non-binary variables: *Platter* and *Wine* ratings[14]. Due to the ordinal nature of *Platter* and *Wine* ratings, the use of single variables (covering the rating range) would assume homogeneous rates of change for each consecutive star rating. However, there is no *a priori* reasoning for such an assumption. To allow for non-linearity of the impacts of wine ratings on price, and to allow for a less restrictive model specification, a series of dummy variables were created for different wine ratings. The dummy variable specification has the further advantage that measurement errors in the variables will have a smaller misspecification impact (Oczkowski, 1994:99-100).

In order to test for multicollinearity (a data pathology detected in most previous hedonic wine pricing literature) a correlation analysis was conducted for all variables in the model. It was

[13] The conventional Cook's D cut-off point of 4/n was chosen (Chen et al., 2003).
[14] *Wine* magazine ratings will from here on simply be referred to as *Wine* ratings.

found that the highest correlation coefficient was 0.285 – between the variables *Wine* and the *Platter* ratings (a correlation matrix between price and the two rating variables is given in Table 3 below). The low correlation between these two rating measures indicates that each rating variable has the potential to contribute explanatory power to the model. It was decided that this degree of multicollinearity is acceptable and so no remedial measures were taken to counter the problem.

Table 3: Correlation Matrix

Red Wine Regression

	Price	Platter	Winemag
Price	1.000	0.605	0.373
Platter	0.605	1.000	0.265
Winemag	0.373	0.265	1.000

White Wine Regression

	Price	Platter	Winemag
Price	1.000	0.598	0.288
Platter	0.598	1.000	0.285
Winemag	0.288	0.285	1.000

Note: Own calculations from Wine Magazine, John Platter and SAWIS data

Due to the limited number of observations (n≤5) present in the following categories: *Platter* rating (1.0), *Platter* rating (1.5), *Platter* rating (5.0) and 'no vintage,' these categories were omitted from the regressions. For the white wine regression, the above decision resulted in the further exclusion of the categories: *Platter* rating (2.0), *Wine* rating (0), 'date of rating' 2005 and region Somerset West. Wine types with less than five observations were also omitted from the regressions.

Due to the different years in which wines of the dataset were rated, vintages of the wine do not accurately represent age of the wine. Accordingly, a variable representing the 'age of wine' was created by subtracting the vintage of the wine from the date at which the wine was rated.

The functional form of the hedonic function finally selected was the following:

$$\ln p = \beta_0 + \sum_i \beta_i \, (DateRating_i) + \sum_i \beta_i \, (Platter_i) + \sum_i \beta_i (Wine_i) + \sum_i \beta_i \, (Wine\ Variety_i) + \sum_i \beta_i \, (Age\ of\ Wine_i) + \sum_i \beta_i \, (Region_i) + \varepsilon_i$$

7. Results and Discussion

Estimated coefficients of the pooled OLS are reported in Table 4 below. In models where the regressand is logarithmic and the regressors are linear, slope coefficients of the regressors represent semi-elasticities, i.e. the percentage change in the dependant variable for a one unit change in the independent variable. The above is however not true for models, such as the one used in this paper, where the regressors are dummy variables[15]. In this case, the intercept (or constant), represents the *mean log wine price*, while the slope coefficients give the difference in the mean log wine price of the respective dummy categories. However, if the antilog of the constant is taken, the *median* wine price, rather than the mean wine price is obtained (Gujarati, 2003:320). Nevertheless, semi-elasticities for dummy regressors can be obtained by subtracting 1 from the antilog (to the base e) of the dummy coefficient and multiplying the difference by 100 (Halvorsen and Palmquist, 1980:474). The semi-elasticities associated with the estimated coefficients are given in the third column of Table 4.

[15] The derivative of the dependent variable with respect to a dichotomous dummy variable does not exist (Halvorsen and Palmquist, 1980:474).

Table 4: Ordinary least squares estimates for pooled hedonic function[16]

RED WINE				WHITE WINE			
Variable	**Coefficient**	**Semi-elasticity***	**P-value**	**Variable**	**Coefficient**	**Semi-elasticity***	**P-value**
Constant	2.846	1622.254	0.000		3.391	2868.35	0.000
Date of Rating							
2006	0.199	21.96	0.055		0.189	20.80	0.119
2007	0.293	34.02	0.001				
Platter							
Modest (2.5)	0.016	1.62	0.923				
Good (3.0)	0.162	17.63	0.262		0.066	6.77	0.544
Very Good (3.5)	0.422	52.53	0.004		0.366	44.14	0.001
Excellent (4.0)	0.659	93.19	0.000		0.678	96.91	0.000
Brilliant (4.5)	1.112	204.03	0.000		0.825	128.26	0.000
Wine Magazine							
Acceptable (1.0)	0.058	5.97	0.749				
Average (2.0)	0.125	13.33	0.473		-0.145	-13.48	0.205
Modest (2.5)	0.234	26.33	0.184		-0.116	-10.94	0.284
Good (3.0)	0.316	37.22	0.072		0.001	0.09	0.994
Very Good (3.5)	0.399	49.09	0.030		0.018	1.86	0.884
Excellent (4.0)	0.458	58.14	0.024		0.152	16.38	0.284
Red Variety				***White Variety***			
Cabernet Sauvignon	-0.068	-6.58	0.355	Chardonnay	0.072	7.45	0.409
Merlot	-0.018	-1.75	0.819	Chenin Blanc	-0.079	-7.62	0.341
Pinotage	0.014	1.44	0.856	Sauvignon Blanc	-0.007	-0.72	0.930
Shiraz	-0.007	-0.67	0.915	Viognier	0.157	17.01	0.248
Pinot Noir	0.408	50.32	0.005				
Age of wine				***Age of wine***			
2 years	0.339	40.32	0.000	1 year	0.092	9.61	0.166
3 years	0.466	59.44	0.000	2 - 3 years	0.231	26.01	0.085
4 years	0.243	27.53	0.058				
5 - 7 years	0.384	46.76	0.045				
Region							
Banhoek	0.099	10.44	0.435		0.172	18.74	0.054
Bottelary	-0.016	-1.60	0.867		-0.016	-1.55	0.864
Firgrove/Faure	0.119	12.65	0.176		0.005	0.51	0.955
Jonkershoek	0.060	6.23	0.780		0.074	7.67	0.621
Koelenhof	-0.036	-3.58	0.709		0.070	7.27	0.425
Kuilsrivier	-0.074	-7.12	0.563		0.250	28.43	0.114
Lynedoch	0.164	17.78	0.083		0.353	42.37	0.001
Muldersvlei	-0.036	-3.52	0.747		0.133	14.26	0.168
Stellenbosch	0.058	5.95	0.456		0.111	11.68	0.156
Vlottenburg	0.014	1.42	0.887		0.248	28.15	0.008
Sir Lowry's Pass	-0.285	-24.79	0.043		-0.085	-8.14	0.487
Somerset West	0.702	101.68	0.053				
Number of observations	260				129		
R^2	0.651				0.745		
adjusted R^2	0.598				0.676		

NOTES: * price differences compared to the reference category in percentages.
Own calculations from *Wine Magazine*, *John Platter* and SAWIS data

[16] For the red wine regression, the reference category wine is a Red Blend, with a *Platter* rating of 2 stars and a *Wine* rating of 0 stars (rated in 2005), an age of one year or less and no specified region of production. The reference category in the white wine regression is a White Blend, with a *Platter* rating of 2.5 stars and a *Wine* rating of 1 star (rated in 2007), an age of less than one year and no specified region of production.

a. Red wine analysis

When examining the pooled OLS output (Table 4), it follows that the base price for a red wine of the sample is approximately R16.20[17]. The coefficient signs of all ordinal variables conform to *a priori* expectations – increases in quality ratings and age result in a more expensive red wine. While the magnitudes of quality rating coefficients are as expected, the magnitudes of the coefficients of the age of the wine appear slightly counterintuitive, with a 4 year old red wine claiming a lower price than a 3 year old red wine, *ceteris paribus.* Both high *Platter* ratings, as well as high *Wine* ratings seem to have a significant effect on the price of a bottle of red wine. A wine with a *Platter* rating of 4.5 stars has a median price which is 204.03% higher than the median price of a wine with a *Platter* rating of 2 stars, *ceteris paribus* (exp(1.112) – 1 = - 0.4515). Similarly, a *Wine* rating of 4 stars adds 58.14% to the price of a bottle of red wine, while a red wine which has aged for 2 years is 40.32% more expensive that red wine which has had one year or less to age. Other coefficients can be similarly interpreted. Insofar as wine ratings are viewed as a proxy for wine quality, it appears that the age of a bottle of red wine has additional, inherent value to the wine consumer.

The date at which the wine ratings took place also seems to significantly affect wine price – suggesting that inflation has played a role in increasing wine prices over the years[18]. Accurate interpretation of the 'date of rating' coefficient is, however, not possible due to the dual effect of inflation as well as heterogeneity in the samples of wines chosen each year.

Except for the Pinot Noir, the price of red wines made from other grape varietals does not seem to be significantly different from the price of a Red Blend. A Pinot Noir is found to be approximately 50.23% more expensive than a red blend.

With the exception of wine farms registered in Lynedoch, Sir Lowry's Pass and Somerset West, the location of the wine farms does not seem to significantly impact the price of a red wine. A possible explanation for the above is that cellars are allowed to source their wines from regions other than the ones they are registered in. Red wines from wine farms located in

[17] The reference price of a wine is the price of a wine with all the characteristics of the excluded dummy reference categories. The reference category wine for the red wine regression is a Red Blend, with a *Platter* rating of 2 stars and a *Wine* rating of 0 stars (rated in 2005), an age of one year or less and no specified region of production.
[18] Note again that prices were taken from *Wine* Magazine data, and all thus relate to the year of rating.

Lynedoch and Somerset West are 17.78% and 101.86% more expensive than red wines indicating no specific origin. In contrast, wines from wine farms located in Sir Lowry's Pass, are 24.79% cheaper than red wines indicating no specific origin.

b. White wine analysis

The base price for a white wine of the sample was found to be approximately R28.68[19]. Unlike the red wine sample, only *Platter* quality ratings appear to have a statistically significant effect on the price of a bottle of white wine. A white wine with a *Platter* rating of 4.5 stars is found to be 128.26% more expensive than a white wine with a *Platter* rating of 2.5 stars, *ceteris paribus.* The magnitude of *Platter* coefficients is in line with *a priori* expectations – as the star rating of the white wine increases, its price increases correspondingly. *Wine* Magazine rating coefficients are not found to be statistically significant at conventional levels of significance. A 2 year old white wine is found to be 26.01% more expensive than a white wine which is younger than 1 year of age. Although not significant at conventional levels of significance, the coefficient of a white wine aged one year should not be disregarded completely.

The 'date of rating' coefficient is not statistically significant at conventional levels of significance, suggesting that inflation is not a problem in the white wine sample.

The price of wines using grape varieties Chardonnay, Chenin Blanc, Sauvignon Blanc and Viognier does not appear to be significantly different to the price of White Blends in the sample, *ceteris paribus*.

For white wines, wines produced by wine farms registered in Banhoek, Lynedoch and Vottenburg are found to be 18.74%, 42.37% and 28.15% more expensive than white wines indicating no specific origin.

[19] The reference category wine for the white wine regression is a White Blend, with a *Platter* rating of 2.5 stars and a *Wine* rating of 1 stars (rated in 2007), an age of less than one year and no specified region of production. The 2007 date of rating was chosen as a reference year as almost all ratings for white wines were done in 2007.

8. Marketing and Policy implications

The hedonic wine pricing models above provide a wealth of important information for numerous players in the wine industry. For consumers (and so retailers), it provides a means to identify wines which are good value for money by comparing actual wine purchase prices with the prices as estimated by the hedonic wine function, allowing consumers to use their wine purchasing budget more efficiently (Oczkowski, 1994:107; van Rensburg and Priilaid, 2004:71). In line with the above, Table 5 below shows the wines in the model which offer the best value-for-money.

Table 5: Wines that offer exceptional value-for-money

	Wine Label	Price (ZAR)	Prediction (ZAR)	Extent of percentage mispricing (%)
Red	Bilton Matt Black 2004	42.00	166.90	-297.39
	Croydon Title Deed Cape Blend 2005	40.00	101.12	-152.81
	Vergelegen Cabernet Sauvignon 2004	132.00	333.39	-152.57
	Nietvoorbij Merlot 2004	19.50	45.06	-131.09
	Usana Cabernet Sauvignon 2004	41.00	91.14	-122.30
White	Kanu Chardonnay 2004	55.00	106.01	-92.74
	Tokara Zondernaam Chardonnay 2005 (screwcap)	45.00	86.22	-91.60
	De Meye Wooded Chardonnay 2005	48.00	87.47	-82.24
	Fort Simon Sauvignon Blanc 2005	45.00	81.79	-81.75
	Asara Reserve Chardonnay 2004	50.00	89.01	-78.02

Note: Own calculations from Wine Magazine, John Platter and SAWIS data

For producers, the estimates of the function provide valuable information on which future investment decisions can be made. The average benefits of redirecting resources to achieve a desired level of a specific attribute, as determined by the function, can be compared to the average costs associated with attaining that attribute – and investment decisions can be made accordingly (Oczkowski, 1994:107). Further, the use of expert wine ratings provides an indication to producers of the extent to which wine quality must increase in order to charge a desired price for a wine (van Rensburg and Priilaid, 2004:71-72). For example, moving a red wine from a 'Very good' *Platter* rating (52.53%) to a 'Brilliant' *Platter* rating (204.03%), at median sample prices, results in a R24.57 [= (2.0403 – 0.5253)* R16.22] increase in the price of the respective red wine, *ceteris paribus.* This price increase can be compared to the costs of bringing the red wine to the desired level of quality (e.g., by employing superior wine-making

skills, using superior quality grapes, utilizing new oak, etc.) to establish whether efforts to attain this quality would be financially worthwhile to producers (Oczkowski, 1994:108).

Finally, the hedonic price function can be used to guide policy decisions. If government wishes to boost exports, then certain incentives (such as tax breaks or marketing subsidies) could be directed toward those wines found to have the most valuable characteristics (Oczkowski, 1994:108).

9. Conclusion

In this paper hedonic price functions were estimated for Stellenbosch red and white wines. Efforts were made to construct the most comprehensive hedonic price model possible given data constraints. In an attempt to address heterogeneity of wine as a product class – and so provide more justifiable and more informative estimates of the implicit prices of different wine attributes – separate regressions were run for red and white wines.

For red wines, it was found that two broad attribute groupings are statistically significant in accounting for price deviations from average prices: quality (as modelled by blind (*Platter)* and sighted (*Wine)* wine ratings) and age of the wine. The impact of age on the price of red wines demonstrates the value of late introduction of red wines to the market place. Beside the Pinot Noir, red wine variety does not appear to significantly influence the average price of Stellenbosch red wines. Regional variation was found to only significantly affect average red wine prices in 3 out of the 12 wine producing regions examined.

For white wines, sighted (*Platter)* wine ratings as well as age of the wines were found to be the only broad attribute groupings which significantly accounted for deviations from average white wine prices. Blind (*Wine)* wine ratings as well as white wine variety were not, in general, found to impact significantly on the average price of Stellenbosch white wines. Similarly to red wines, only certain regions of production appeared to significantly impact the average price of white wines.

10. References

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