Journal of Wine Economics, Volume 1, Number 1, Spring 2006, Pages 42–56

What Determines Wine Prices: Objective vs. Sensory Characteristics*

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Abstract

The hedonic technique is applied to wines. In the price equation we include objective characteristics appearing on the label, as well as sensory characteristics and a grade assigned by expert tasters. We have three almost identically structured data sets (two on Bordeaux wines, and one on Burgundy wines). The results are used to make comparisons between two of the most important wine regions in France, and comparisons over time (the two Bordeaux data sets are sampled at different points in time). (JEL Classification: D49.)

Another puzzle is the lack of correlation between price and pleasure. Perhaps it is not so surprising that a first-rate example of a little known wine can seem much more memorable than something more famous selling at ten times the price; part of the thrill is the excitement of discovery and the feeling of having beaten the system. What is more extraordinary is the wild price variation at the very top end. Demand bubbles up mysteriously, apparently fuelled by fashion and rumour as much as by intrinsic quality.—Jancis Robinson, *Confessions of a Wine Lover*, Penguin Books, 1997.

I. Introduction

There are many types and kinds of wines.[1] Walking through an arbitrary supermarket, one is impressed by the high number of different wines on the shelves. Whereas the number of different brands of say beer or whiskey that are on sale does usually not exceed ten or fifteen, shoppers typically have the choice between hundreds or sometimes even thousands of different wines. The wines originate not only from the traditional wine countries such as France, Italy, and Spain, but also from new world countries such as Argentina, Australia,

*This paper was written while the first author was visiting the Department of Economics at University College London. We would like to thank O. Ashenfelter, F. Etilé, V. Ginsburgh and an anonymous referee for their comments and suggestions.

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[1]In writing this introduction, the wine survey that appeared in The Economist (1999) was very helpful.

Chile, New Zealand, and the USA. These wine countries produce bottles that can cost just $2 (the simple and plain table wines) but also several hundreds of dollars (for the most prestigious wines such as Bordeaux's Haut-Brion, Lafite-Rothschild, Latour, Margaux, and Mouton-Rothschild; Romanée Conti from Burgundy; Grange, Australia's most famous wine; California's Opus One; Vega Sicilia from Spain; Brunello di Montalcino Riserva from Italy, etc.), young wines that are ready to drink as well as wines that improve even after decades of keeping, wines that are made of different combinations and proportions of grape varieties, and wines that originate from various sorts of soils.

Given the huge variability in both the types of wines and their prices, it is of interest to understand how wine prices and wine characteristics are related: What are the precise effects of the features mentioned on the label of the bottle, such as vintage, name, or ranking? What are the consequences of weather conditions during the growing season? In what way do natural endowments (type of soil, exposure of the vineyards) and technology (the manner in which grapes are picked, pressing and racking techniques, type of barrels in which the wine ferments, etc.) influence wine prices?

Also of interest is how the price of a bottle relates to its quality. Perhaps because the notion of quality is in itself somewhat vague and imprecise, the price-quality debate has always been animated and controversial, with opponents firmly defending their points of view. Some claim that price differences reflect quality differences very accurately, arguing that consumers cannot be fooled all the time and that market forces adjust prices to levels in accordance with quality levels. While this is perhaps true for the select group of top wines that are actively traded in auctions throughout the world (in which wine experts intervene, so that indeed prices are likely to adapt more or less continuously to fluctuations in quality), we feel that this argument is less convincing for the majority of wines that are less known: the sheer range and variety of products, the relative absence of information on these wines (unlike for the very top wines, wine tasting sessions are rarely organized for the less known ones), makes it likely that in this case prices are more rigid and less strongly correlated with quality.

At the other extreme, there are those who claim that there is basically hardly any price-quality relationship. While we do not completely adhere to this either, there is anecdotal evidence that suggests that there is indeed something of a price puzzle. For instance, Ernest Gallo, the patriarch of the family-owned E&J Gallo Winery in California (the largest winemaker in the world), recalls how, in the early stages of his career, he once sold wine in New York. He offered a buyer two glasses of the same red wine, the buyer drank the two glasses and asked for the prices of the "two" wines. Upon hearing that the first wine cost 5 cents per bottle, and the second 10 cents, the buyer declared he wanted the 10 cents bottle. The message behind this anecdote is confirmed by many wine auctioneers who have noticed that in the auction room higher wine prices act as a stimulant rather than as a deterrent, thereby reflecting that for bidders, part of the pleasure is apparently to know that a wine is famous and very expensive.

Other evidence that suggests that the price-quality relationship is far from perfect comes from the results of wine-tasting sessions. One famous wine-tasting session was organized in San Francisco, in 1995. On the initiative of G. Getty, an American billionaire and lover of Bordeaux wine, ten of the most talented wine tasters were reunited to taste blindly a sample of Bordeaux wines. The sample contained all the Médoc wines that were classified in 1855. In 1855, sixty one Médocs were ranked in five categories, and wine experts were asked to establish a new classification (from one to sixty one). Although the reshuffling did not turn out to be dramatic (for instance, the four first-category wines are still in the top fifteen), the 1855 and 1995 rankings were certainly not identical (for instance, one fifth-growth wine can be found among the top ten). Given the prices that these wines fetch at today's auctions are pretty well ordered the same way as the 1855 ordering (Di Vittorio and Ginsburgh, 1996), and interpreting the 1995 ranking as a quality ranking, the San Francisco tasting reflects a disparity between quality and price. This type of result is also found in tasting-sessions in which non-experts evaluate the wines. When non-experts blind-taste cheap and expensive wines they typically tend to prefer the cheaper ones.[2]

Many papers look at the determinants of prices, reporting estimation results of so-called hedonic price functions where wine prices are regressed on a set of characteristics in order to determine which characteristics have a significant effect. In what is probably the earliest article on the subject, Oczkowski (1994) applies the method to Australian table wine and includes in the set of characteristics attributes that are objective and easily observable for the consumer (vintage, vineyard region, grape variety), and also the grades that are published in a popular Australian wine guide. Grades are measured on a five-point scale, and introducing dummy variables for the five levels, Oczkowski shows that, as expected, wine prices increase with the rating level. Ashenfelter, Ashmore, and Lalonde (1995) (for Bordeaux wines) and Byron and Ashenfelter (1995) (for Australian wines) consider as characteristics vintage and weather conditions that prevailed during the growing season, and show that these variables alone explain more than 80% of the price variation in their samples. Ginsburgh, Monzak, and Monzak (1994) apply the hedonic price method to a sample of Médoc wines. Their fascinating data set allows them to disentangle the price effects of weather, reputation (as measured by the 1855 classification), natural endowments (soil, exposure of the vineyards or grapes), and all sorts of production factors. They show that technology and weather conditions explain two thirds of the price variation, and once the reputation variable is added the proportion of explained variance increases to almost 85%. They also show that more recent classifications (such as Parker's classification) do not lead to a better fit of the hedonic price equation than the 1855 classification. Di Vittorio and Ginsburgh (1996) regress auction prices of Haut-Médoc wines on the vintage and the name of the château. The estimated hedonic function allows them to calculate, for each château and vintage, a price index, and these price indices are compared with several classifications (Parker; Tastet and Lawton; Wine Spectator).

[2]Unlike blind-taste evaluations of whiskies, where usually the more expensive brands are the preferred ones (see The Economist, 1999).

Gergaud (1998) applies the hedonic technique to Champagne wines. He finds that the price of Champagne varies significantly with producer characteristics and the appellation of the wine. His estimations also suggest that neither the sensory variables nor the grade assigned by wine connoisseurs matter in the price determination of Champagne. Lima (1999) examines the prices of Californian wines and uses medals won in nine tasting events in 1995 as indices of quality. Regressing prices on dummy variables for the four possible medals (double gold, gold, silver, and bronze), he finds that the San Francisco Fair is the best predictor for California's wine prices. Schamel and Anderson (2001) estimate hedonic price functions for premium wine from Australia and New Zealand, including as independent variables the ratings compiled in Halliday's wine guide and an Australian wine magazine called Winestate, regional dummies and the grape varieties of the wines. Exploiting the time-series aspect of their data (the observations cover the period from 1992 to 2000), the authors study how the effects of these variables evolve over time. Their results show that the effect of the ratings remains fairly constant over time. The relative implicit prices of grape varieties do vary, and price differences between regions tend to increase in the late nineties.

Jones and Storchmann (2001) use wine auction prices for twenty one prestigious Bordeaux wines to assess the respective effects of the vintage, the grape composition (acid and sugar levels), and expert-assessed quality (as measured by Parker-points). The authors distinguish Merlot-dominated and Cabernet Sauvignon-dominated wines. The effect of the Parker-point rating is stronger for the latter ones. In addition, the price of Merlot-dominated wines increases more rapidly with age.

Finally, Oczkowski (2001) estimates a hedonic equation for Australian wines and considers the effects of some objective characteristics (red wine or not, old vintage or not), a quality index (a score assigned to the wine based on the International Show Judging System that allocates 50 percent of the score for palate, 35 percent for nose and 15 percent for color), and a reputation index (a score reflecting the long-term quality over numerous vintages).[3] He argues that the quality and reputation variables are measured with error. Correcting for measurement errors, he finds that reputation has a significant impact but that the effect of quality is insignificant.

The present paper contributes to this literature. We report estimation results of hedonic price equations based on three data sets. The first one (Bordeaux I) is a sample of Bordeaux wines and formed the basis of the paper by Combris, Lecocq and Visser (1997); the second one (Burgundy) is a sample of Burgundy wines and was exploited in Combris, Lecocq and Visser (2000); the third and most recent data set is another sample of Bordeaux wines (Bordeaux II) and was analyzed in Lecocq and Visser (2001). The three data sets were generated in almost exactly the same way, and all three contain the same set of variables. The results can thus easily be used to make comparisons between two of the most important

[3]See also Landon and Smith (1997, 1998) who estimate similar equations for Bordeaux wines using short-term lagged quality scores as a measure of reputation.

wine regions in France (Bordeaux and Burgundy), and to make comparisons over time (the Bordeaux I sample is drawn in 1992, and the Bordeaux II sample in 2000).

For each wine in the three samples we observe the price and the following objective characteristics: name, color, ranking, appellation, and vintage. The wines in the three samples were blind-tasted by expert tasters who were required to record their olfactory (aromatic intensity, finesse of aromas, etc.) and gustatory findings (firmness of attack, suppleness, presence of fine tannins, etc.). These variables will be referred to as sensory characteristics. The experts were also requested to assign a grade between 0 and 20 to each wine, a measure that we will interpret as a measure of quality.

As in the studies described above, our objective is to determine which variables significantly affect the price of Bordeaux and Burgundy wines. At this point it is important to note that our measure of quality differs in several important ways from the quality indices used in the previous literature. First, the wines were evaluated via blind-tasting sessions. Unlike the grades compiled in wine guides or magazines, the wine experts assigned their grades without being influenced by the name of the wine, its price or its ranking. Second, since the wines were purchased before the tasting sessions, the grades were unknown when the wine prices were established.[4] Therefore, it is our feeling that our measure of quality reflects in a better way the pure intrinsic effect of quality on prices, and not an effect that is biased by reputation or publicity factors.

The paper proceeds as follows. The next section presents the data, section 3 gives the empirical results, and section 4 concludes.

II. The Data

This section describes the essential ingredients of our three data sets. For more details we refer to the papers by Combris, Lecocq and Visser (1997, 2000), and Lecocq and Visser (2001).

The data sets come from three very similar experimental studies conducted by the Institut National de la Consommation (INC), and published in 60 Millions de Consommateurs (December 1992 for the Bordeaux I sample, November 1993 for the Burgundy sample, and October/November 2001 for the Bordeaux II sample). The samples were randomly selected. The INC agents bought all the wines anonymously directly from the producers. This circumvents a bias that is present in wine tasting events organized by (even famous)

[4]In the previous literature, there is generally a time lag between the moment the grades are attributed and the moment the wine prices are established. For instance in Jones and Storchmann (2001), the wine prices are the prices fetched at auctions in 1996/1997, whereas the quality index is the Parker-rating of these wines published in 1994/1995. The reported estimated effect of the Parker-rating therefore reflects not only a direct quality effect (Parker's opinion on the wine), but also an indirect publicity effect, which is not necessarily related to quality but which measures instead how Parker-points modify consumers' purchase behavior and wine producers' price strategy.

guides, where wine producers select specially prepared samples for the contest. Wines were tasted and evaluated by independent wine experts. This avoids the lack of objectivity of some wine guides often sponsored by wine producers where the editor, possibly assisted by a team of colleagues, evaluates the wines.

In the Bordeaux I sample, 519 wines were evaluated; in the Burgundy sample, 613 wines and in the Bordeaux II sample, 255 wines. In each case the wines were evaluated by a jury of 4 or 5 experts. After tasting a wine, each jury member was asked to write down his personal technical comments concerned with olfactory findings (aromatic intensity, finesse and complexity of aromas), gustatory findings (firmness of attack, suppleness, flatness, fat, harmony of components, finish, etc.) as well as some general remarks about alcohol level, need for keeping, etc. A synthesis of these comments is published by 60 Millions de Consommateurs, which leads to the sensory wine characteristics that we use. Each member also assigned a grade between 0 and 20 to the wines he tasted. 60 Millions de Consommateurs only publishes the average of these grades. This average grade will be referred to as the jury grade and constitutes our measure of wine quality. There is also information about the name, color, ranking,[5] vintage, and (in the case of Bordeaux) appellation. These are objective wine characteristics. Finally, the data record the prices at which the bottles were purchased.

The list of variables and some descriptive statistics are given in Appendix 1.

III. Empirical Results

In the hedonic price equations, the dependent variable is the logarithm of the price of a bottle of wine, the explanatory variables are the jury grade (i.e. the average of the individual grades) and the objective and sensory variables defined above. Table 1 presents Ordinary Least Squares (OLS) estimates. To facilitate the comparison of the different variable-effects, the reported estimates are the "β-coefficients."[6] The overall fit of the hedonic price equations is relatively good since the corrected $\overline{R}^2$ s range from 0.606 to 0.634. Given the large number of explanatory variables and the absence of theory as to which variable should be kept, we use a stepwise procedure to select the variables that are significant at the 5% level. The final set of selected variables is the same whether we use a backward procedure or a forward procedure.

[5]In the case of the two Bordeaux samples the three possible levels are cru and grand cru classé, cru bourgeois, or cru non classé; in the case of the Burgundy sample the four possible levels are AOC grand cru, AOC premier cru, AOC communale, or AOC régionale.

[6]β-coefficients can be interpreted as regression coefficients that would have been obtained had the regressors been standardized (zero mean and unit variance). Their magnitude can thus be used to measure the relative contribution of each regressor (see Goldberger, 1964, pp. 197-198).

Table 1
Hedonic Price Equations

	Bordeaux I		*Bordeaux II*		*Burgundy*	
Jury grade	0.081	(0.007)	0.090	(0.018)	0.110	(0.010)
Sensory variables						
Firmness of attack			-0.108	(0.098)		
Well concentrated					0.055	(0.063)
Needs keeping	0.097	(0.041)	0.169	(0.056)	0.070	(0.030)
Objective variables						
Ranking	0.309	(0.030)	0.232	(0.045)	0.650	(0.017)
Vintages						
1989	0.580	(0.074)				
1990	0.413	(0.077)			0.258	(0.043)
1991					0.195	(0.040)
1996			0.646	(0.099)		
1997			0.451	(0.119)		
1998			0.388	(0.118)		
Bordeaux groups						
Bordeaux	-0.326	(0.052)	-0.366	(0.091)		
Côtes	-0.203	(0.050)	-0.280	(0.083)		
St-Emilion Pom. Fr.	0.138	(0.042)				
Blancs doux	0.128	(0.073)				
Constant	1.799	(0.228)	1.694	(0.452)	1.771	(0.167)
$\bar{R}^2$	0.634		0.633		0.606	

Notes: Reported estimates are β-coefficients; standard errors in parentheses; since we are running stepwise regressions, the only coefficients given in the table are those which are significantly different from zero.

Nine variables are selected in the two Bordeaux equations and six in the Burgundy equation. It is remarkable that among the nine selected variables in the hedonic price equation for the Bordeaux I (and Bordeaux II, resp.) sample, only one (or two, resp.) belongs to the set of sensory variables. In the Burgundy equation, two out of six are sensory variables, but their effect is considerably smaller than the effect of the objective variables.[7] This suggests that the price of Bordeaux and Burgundy is essentially determined by objective characteristics (ranking, vintage and appellation) that are easily identifiable by all consumers. A possible explanation for this result could be that sensory characteristics are only available through tasting, learning and the reading of guides. For consumers it may then be less expensive to make purchase decisions primarily on the basis of the information displayed on the label, which causes most of the sensory variables to be insignificant.

The jury grade has a positive and significant impact on prices. Yet this impact is considerably smaller than the impact of any objective variable. As the jury grade seems a priori a

[7]Given that jury grades are highly correlated with sensory characteristics, one might wonder whether the presence of the former prevent the latter to enter the hedonic price equations. To verify this possibility, we performed the same estimations excluding grades from the set of explanatory variables. The fat variable for the Bordeaux II sample and the excessive acidity and fat variables for the Burgundy sample were the only sensory characteristics to become significant.

reasonable measure of quality, one might have expected this variable to have a more important influence on prices. There are at least two types of explanations for the small correlation between price and average tasting grade.

In the first explanation it is argued that the jury members essentially agree on the quality of the wine but make evaluation errors in determining the precise quality level. The jury grade is then the sum of the intrinsic quality level plus the average of expert-specific evaluation errors. In this setup the jury grade is, therefore, a measure of quality which is contaminated by measurement errors. More formally, let $i = 1,\ldots, N$ be the index of wines, $j = 1,\ldots, J$ the index of expert tasters and g_{ij} the grade assigned to wine i by expert j. The expert-specific grade g_{ij} can be decomposed as $g_{ij} = q_i + \varepsilon_{ij}$, where q_i is a component common to all tasters representing the quality level of wine i and an error term ε_{ij} with zero mean reflecting the judgment error made by jury member j. The true relationship between price p_i and quality q_i is assumed to be

$$p_i = \alpha + X_i\beta + \gamma q_i + \nu_i$$

with ν_i independent of X_i and q_i. In the data we do not observe q_i but only the average of grades (the jury grade)

$$\bar{g}_i = \frac{1}{J_i}\sum_{j=1}^{J_i} g_{ij} = q_i + \frac{1}{J_i}\sum_{j=1}^{J_i}\varepsilon_{ij}.$$

The estimated hedonic price equation is therefore

$$p_i = \alpha + X_i\beta + \gamma\bar{g}_i + u_i \qquad (1)$$

where $u_i = \nu_i - \gamma\frac{1}{J_i}\sum_{j=1}^{J_i}\varepsilon_{ij}$. Since u_i is correlated with $\bar{g}_i$, OLS of equation (1) leads to biased estimates. Using the fact that individual grades are observed in Bordeaux II,[8] we can, however, determine the magnitude of the bias affecting the estimate of γ in our three samples.[9] This is shown in the appendix for the case $\beta = 0$ and $J_i = J$.

Table 2 reports the estimate of γ before correction for measurement errors (OLS of equation 1) and its true value (i.e. the true impact of quality on price). The results show that the bias is important when the average grade is used as a proxy for quality: the true impact

[8]Unlike the Bordeaux I and Burgundy data sets, in which only the average grades are available, the Bordeaux II data set also records the expert-specific grades. These were directly obtained by us from INC.

[9]The idea is to estimate the variance of ε_{ij} on the Bordeaux II sample and to use it to assess the bias in all three samples, assuming that the dispersion of judgment errors does not differ across samples.

Table 2

Impact of Jury Grades on Prices

	Bordeaux I	*Bordeaux II*	*Burgundy*
	(J = 4)	*(J = 5)*	*(J = 5)*
OLS estimate ($\hat{\gamma}$)	0.358	0.316	0.236
True value (γ)	0.442	0.548	0.436

of quality is much larger than the estimated one. For example, in the case of the Burgundy sample the OLS estimate of γ is 0.236 whereas the true value of this parameter is 0.436. This is the well known attenuation effect due to measurement errors in an explanatory variable (see for instance Chesher, 1991). Augmenting the number of members in a jury might reduce the variance of the mean of judgment errors, thereby reducing the attenuation effect. In this view the correlation coefficient between price and jury grade might thus increase by adding more persons to the jury.

In the second explanation it is argued that jury members do not make evaluation errors but disagree on the quality of the wine because of taste heterogeneity. As the experts attribute different quality levels to each wine the jury grade will always express a compromise between the different tasters' evaluations. The market, on the other hand, is a reflection of the opposite; a compromise is not needed since the price level can reflect the preferences of subsets of consumers. A high market price can then be compatible with a modest appreciation of the wine (by the public as a whole) if a small group of individuals intensely likes the product. If indeed there is strong taste heterogeneity among the experts (and if the experts adequately represent the different sub-groups of consumers), it is not surprising that the average tasting grades are not closely connected to price.

We also estimate jury grade equations by regressing the logarithm of jury grades on the attributes of wines. Table 3 presents the OLS estimates for each sample. The $\overline{R}^2$ s range from 0.436 to 0.597, again indicating a relatively good overall fit. In the Bordeaux samples, it does not matter whether we use a backward or a forward stepwise procedure, but it does for the Burgundy sample. We only retain variables that are selected in both procedures.

Sixteen variables appear in the Bordeaux I equation, eleven in the Bordeaux II equation, and ten in the Burgundy equation. The only sensory variable that does not have the expected effect is the excessive acidity in the Bordeaux I equation: the jury grade increases if the wine is considered too acidic. In our three samples, the grade increases if the aromatic intensity of the wine is strong, the wine has a complex nose, is considered fat, the harmony between its components is well balanced, its finish is long and if it needs keeping. In contrast to the hedonic price equations, the jury grades are essentially determined by sensory variables: they are thirteen out of sixteen in the Bordeaux I equation, nine out of eleven in the Bordeaux II equation, and eight out of ten in the Burgundy equation.

Table 3
Jury Grade Equations

	Bordeaux I		*Bordeaux II*		*Burgundy*	
Sensory variables						
Aromatic intensity	0.176	(0.006)	0.109	(0.004)	0.329	(0.007)
Finesse of aromas	0.115	(0.019)	0.105	(0.013)		
Complexity	0.133	(0.018)	0.183	(0.012)	0.094	(0.011)
Firmness of attack	0.073	(0.018)				
Excessive acidity	0.081	(0.021)				
Suppleness	0.096	(0.016)				
Flatness			-0.170	(0.032)	-0.063	(0.034)
Fat	0.126	(0.016)	0.142	(0.012)	0.071	(0.011)
Well concentrated	0.100	(0.021)				
Harmony	0.290	(0.011)	0.319	(0.009)	0.349	(0.007)
Fine tannins	0.065	(0.018)	0.106	(0.018)		
Finish	0.303	(0.015)	0.430	(0.007)	0.138	(0.003)
Traces of staleness					-0.086	(0.015)
Touch of reduction	-0.060	(0.038)				
Needs keeping	0.210	(0.018)	0.207	(0.011)	0.186	(0.009)
Objective variables						
Ranking					0.117	(0.005)
White	-0.107	(0.020)				
Vintages						
1990	0.080	(0.017)				
1991					-0.182	(0.008)
Bordeaux groups						
Côtes			-0.147	(0.016)		
St-Emilion Pom. Fr.	0.144	(0.018)	0.164	(0.010)		
Constant	1.284	(0.099)	2.202	(0.060)	2.301	(0.051)
$\bar{R}^2$	0.597		0.594		0.436	

Notes: Reported estimates are β-coefficients; standard errors in parentheses; since we are running stepwise regressions, the only coefficients given in the table are those which are significantly different from zero.

But the most interesting result is that ranking has a considerable impact on jury grades for Burgundy, whereas it is statistically not significant for Bordeaux wines. This result is not really surprising. In Bordeaux (and particularly in the Médoc region), the classification is old (1855) and the established hierarchy of châteaux does not reflect that the size and shape of vineyards have changed over time. The Burgundy classification, based on the cadastral survey, seems to be less rigid than its Bordeaux counterpart since approval tasting sessions are held each year and serve as the basis for authorizing (or not) a wine to be sold under its appellation class. If a wine loses class membership in a particular year it may be authorized to join a lower appellation class.

IV. Conclusion

In this paper we apply the hedonic technique to wines. In the price equation we include objective characteristics appearing on the label, as well as sensory characteristics and quality, as measured by expert tasters. We use three almost identically structured data sets (two on Bordeaux wines, and one on Burgundy wines), which enable us to make comparisons between two of the most important French wine regions and comparisons over time (the two Bordeaux data sets are sampled at different points in time).

Our results indicate that characteristics that are directly revealed to the consumer upon inspection of the bottle and its label (ranking, vintage and appellation) explain the major part of price differences. Sensory variables do not appear to play an important role. Out of some fifteen sensory characteristics, only two or three have a significant impact in the hedonic price equation.

Wine prices are also hardly affected by the grades assigned by professional wine tasters. Although jury grades have a significant effect, their impact on prices is very small compared to the impact of ranking and vintage. This is surprising given that the jury grade seems a reasonable measure of quality. A possible explanation for this result is that the jury grade is an imperfect measure of quality due to measurement errors in the expert-specific grades. Our most recent data set (Bordeaux II) allows to correct for these measurement errors (see section 3), and our results suggest that the true effect of quality is much larger than previously thought.

We also find that the jury grade, unlike the price, is primarily determined by sensory characteristics: only one fifth of the variables that have a significant influence on the jury grade equations are objective variables. Furthermore, ranking has no significant effect in the Bordeaux equations, but does significantly affect grades for Burgundy wines, a result that can be explained by the different classification systems used in the two wine-growing regions.

It would be interesting to check whether the findings reported in this paper are typical for Bordeaux and Burgundy wines, or whether they also hold for other regions and countries. In a comment on the Combris, Lecocq and Visser (1997) paper, Brown (1999) uses a sample of premium California wines to estimate a hedonic price equation and a jury grade equation. Unlike the results of our hedonic price equations, many sensory characteristics of California wines (six out of thirteen) do have a significant impact on prices. The results for this jury grade equation are, however, more in line with ours in that the appreciation of wine experts is essentially determined by sensory variables.

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Appendix 1

Descriptive Statistics

Variables	*Modalities*	*Bordeaux I*	*Bordeaux II*	*Burgundy*
Price	Continuous	52.78 (31.05)	69.10 (43.75)	55.82 (32.69)
Jury grade	Continuous	11.21 (2.41)	12.93 (1.37)	12.59 (1.44)
Sensory characteristics				
Olfactory examination				
Aromatic intensity	Strong	45.08	43.69	56.68
	Classic	32.64	33.98	32.35
	Discrete	22.28	22.33	13.97
Finesse of aromas	Yes/No	15.61	13.73	15.01
Complexity	Yes/No	23.70	16.08	15.33
Gustatory examination				
Firmness of attack	Yes/No	19.85	5.49	3.43
Excessive acidity	Yes/No	13.87	2.35	6.36
Suppleness	Yes/No	28.90	18.04	9.30
Flatness	Yes/No	8.29	1.96	1.31
Fat	Plump	17.34	10.59	7.50
	Medium	79.19	84.70	87.28
	Lean	3.47	4.71	5.22
Well concentrated	Yes/No	19.08	6.67	4.08
Harmony	Perfect	18.69	0.00	15.17
	Balanced	50.29	49.41	61.99
	Unbalanced	31.02	50.59	22.84
Fine tannins	Yes/No	19.08	6.67	3.59
Finish	Long	34.20	51.46	57.35
	Medium	50.78	13.59	25.00
	Short	15.02	34.95	17.65
General remarks				
Alcohol excess	Yes/No	15.41	13.33	6.69
Traces of staleness	Yes/No	10.60	9.41	7.50
Touch of reduction	Yes/No	3.47	0.00	0.65
Needs keeping	Yes/No	29.87	23.14	28.87
Objective characteristics				
Ranking				
Bordeaux	Cru classé	6.74	5.10	
	Cru bourgeois	9.25	12.55	
	Cru non classé	84.01	82.35	
Burgundy	AOC grand cru			1.80
	AOC premier cru			23.00
	AOC communale			40.29
	AOC régionale			34.91
Red wine	Yes/No	82.08	81.57	60.85
White wine	Yes/No	17.92	18.43	39.15

Descriptive Statistics (cont.)

Variables	*Modalities*	*Bordeaux I*	*Bordeaux II*	*Burgundy*
Vintages				
1989	Yes/No	61.66		
1990	Yes/No	33.33		30.83
1991	Yes/No	5.01		55.95
1992	Yes/No			13.21
1996	Yes/No		59.61	
1997	Yes/No		8.63	
1998	Yes/No		25.88	
1999	Yes/No		5.88	
Bordeaux groups				
Bordeaux	Yes/No	15.99	16.47	
Côtes	Yes/No	15.22	9.02	
Médoc and Graves	Yes/No	20.81	29.02	
St-Emilion Pomerol Fronsac	Yes/No	30.06	27.06	
Blancs secs	Yes/No	12.91	11.37	
Blancs doux	Yes/No	5.01	7.06	
Number of observations		519	255	613

Note: The three last columns contain the mean and standard deviation (in parentheses) for continuous variables, and the share of observations for each modality for discrete variables.

Appendix 2

Let $\sigma_\varepsilon^2 = \mathrm{Var}(\varepsilon_{ij})$ and $\sigma_q^2 = \mathrm{Var}(q_i)$. Since in the Bordeaux II sample we observe all the expert-specific grades g_{ij}, the variance σ_ε^2 can be estimated by

$$\hat{\sigma}_\varepsilon^2 = \frac{1}{N}\sum_{i=1}^{N}\frac{1}{J_i - 1}\sum_{j=1}^{J_i}(g_{ij} - \bar{g}_i)^2 \quad , \tag{A1}$$

where N is the number of observations in Bordeaux II.

Consider the case $\beta = 0$ and suppose that $J_i = J$ for all i. The probability limit of the OLS estimate $\hat{\gamma}$ is (the calculation is similar as in Maddala, 1977, p. 293)

$$\mathrm{plim}\,\hat{\gamma} = \frac{\gamma}{1 + \frac{1}{J}\frac{\sigma_\varepsilon^2}{\sigma_q^2}} \quad .$$

So the true value γ is approximately equal to

$$\gamma = \left(1 + \frac{1}{J}\frac{\sigma_{\varepsilon}^{2}}{\sigma_{q}^{2}}\right)\hat{\gamma} \quad . \tag{A2}$$

Under the assumption that σ_{ε}^{2} is identical in our three samples, the true value of γ can be determined for each of them using (A2), (A1) and the fact that $\sigma_{q}^{2} = \mathrm{Var}(\bar{g}_{i}) - \frac{1}{J}\sigma_{\varepsilon}^{2}$.