Taste or reputation: what drives market prices in the wine industry? Estimation of a hedonic model for Italian premium wines

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TASTE OR REPUTATION: WHAT DRIVES MARKET PRICES IN THE WINE INDUSTRY?

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TASTE OR REPUTATION: WHAT DRIVES MARKET PRICES IN THE WINE INDUSTRY ? ESTIMATION OF A HEDONIC MODEL FOR ITALIAN PREMIUM WINES

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Abstract

The aim of this paper is to provide new evidence on the factors affecting wine prices on both methodological and factual grounds. On the methodological ground, this study is the first to apply a general Box-Cox transformation within the context of hedonic models which exploit all the variables (objective and sensorial characteristics, reputation) pointed out by previous literature as relevant in driving market prices. On the factual ground, the paper fills the lack of empirical evidence on the issue for Italy, one of the leading wine producers, by using a large dataset on two premium quality wines (Barolo and Barbaresco) covering the 1995-1998 vintages. Our results support the evidence obtained using data from other countries, showing that sensorial traits, the reputation of wines and producers, as well as objective variables are all important factors influencing the consumers' willingness to pay. More importantly, by resorting to a non-nested statistical test (Vuong, 1989) we compare two alternative specifications (taste vs. reputation) and find that the reputation model significantly outperforms the taste one, whereby suggesting that a greater amount of information on how the wine price is formed is contained in the reputation specification.

Keywords: Hedonic pricing; Box-Cox estimation; Sensorial characteristics; Reputation; Vuong test

JEL Classification: C52; D43; L66

CONTENTS

1. Introduction

The so-called *hedonic price technique* relates the price of a differentiated product to its characteristics, whereby allowing an estimate of the consumers' evaluation of the latter. Classic applications of this technique have analysed durable goods, such as cars, computers, and houses. However, in the last decade hedonic price analyses have been performed also for some non-durable goods, in particular wine. Whereas wine is a widely differentiated product and therefore a suitable candidate for this sort of empirical studies, it is difficult to identify the proper characteristics which affect prices. The relevant characteristics could relate to tasting properties (the so-called *sensorial* variables), such as the wine's aroma, body, and finish. However, these variables could be hardly recognised by consumers, in particular in advance with respect to purchase (in fact, wine is an *experience* good). Given the imperfect information setting, other kinds of variables – such as reputation and observable traits appearing on the label – become additional candidates as determinants of wine price.

Not surprisingly, the very few hedonic analyses carried out so far on wine have explained price formation with different sets of variables. Broadly speaking, two different approaches have been followed. The first one (Combris *et al*. 1997, 2000) examines the role of wine's *sensorial* characteristics as opposed to observable "objective" attributes such as vintage, denomination, grape variety and the like, which usually appear on the label. This approach claims that consumers recognize the latter more easily, so that the former tends to be insignificant in determining the market price. The second approach (Landon and Smith; 1997, 1998) points out the importance of the *reputation* of wines and producers among consumers. Imperfect information (Akerlof, 1970) could be overcome if producers acquire reputation over time, so that *expected* wine quality could be proxied by long-term reputation. In turn, reputation would influence market prices and it would seem economically far more important than *current* quality as measured by overall sensory quality scores (e.g. evaluation given by professional tasters, as for example those provided by *Wine Spectator* magazine). To the best of our knowledge, no previous paper has attempted to jointly use all these kinds of variables (objective, sensorial, reputation, and quality) in order to assess their relative importance.

The main purpose of this paper is to try to fill this gap and compare the relative importance of sensorial characteristics and reputation variables, taking into account the effect of objective traits. To this end, we exploit a unique data set on two Italian premium wines (Barolo and Barbaresco) produced in a very restricted area in the Piedmont region in Northern Italy. Compared with those used by previous literature, our dataset enjoys at least two advantages. Firstly, it contains all the variables which might influence wine price. Secondly, observations are very homogeneous, in terms of both origin and characteristics, whereby allowing us to focus on *single producer* and *single wine* reputation instead of *collective* reputation (i.e. reputation of groups of producers and wines). As a secondary purpose, our analysis intends to provide evidence on the factors driving wine price also for Italy which, in spite of its leading role as a wine producer, has not been so far the object of empirical analyses.

By way of anticipation, our results show that all various kinds of variables, except current quality, play an important role in explaining market prices. More importantly, we find that a hedonic model including objective and reputation variables outperforms, on statistical grounds, a model with objective and sensorial characteristics. In turn, this suggests that a greater amount of information on how the wine price is formed is contained in the reputation specification.

The rest of the paper unfolds as follows. The next section motivates this paper by reviewing the relevant previous literature on hedonic price in the wine industry. Section 3 presents the main characteristics of the two wines and describes the dataset used. Section 4 specifies the empirical strategy whereas section 5 presents the ensuing econometric results. Section 6 provides some final remarks and a data appendix concludes the paper.

2. Motivation and previous literature

Since the seminal contributions by Griliches (1971) and Rosen (1974), several papers have estimated, using the hedonic price technique, the implicit prices of some characteristics which differentiate closely related products. In order to illustrate the approach in the simplest possible manner, let us consider two units of a given good that are identical except for a particular attribute. One would expect their prices to differ. If consumers place a value on this characteristic, the difference in market price between the two units should, *ceteris paribus*, express their *willingness to pay* for an improvement in the attribute. More generally, it is possible to isolate the contribution of various factors to the market price through the use of econometric techniques.[1]

Not surprisingly, these studies have mostly used data on housing (e.g. Brookshire et al., 1981; Can, 1992), cars (e.g. Griliches 1971; Murray and Sarantis, 1999), and personal computers (e.g. Chow, 1967; Berndt and Griliches, 1990; Baker, 1997) which lend themselves to this kind of analysis being highly differentiated and with easy-to-identify characteristics. In recent years, however, researchers have also analysed the relationship between prices and characteristics for some non-durable goods. In particular, a few papers have recently estimated hedonic price functions for the wine industry, as wine is highly differentiated and then suitable for hedonic analyses. Generally speaking, three main types of variables appear in the specification of hedonic models for the wine price. A first basic category embraces the so-called *objective* characteristics – such as the wine's year of vintage, denomination (i.e. whether the wine comes from a particular "cru"), region, or grape variety – which usually appear on the label and are therefore easy to identify by consumers. The two remaining sets of variables relate to wine quality. In fact, a peculiar feature of wine is that quality attributes, reasonably expected to affect consumer preferences and then market prices, are not easy to evaluate objectively. To this regard, previous literature has focused on two broad groups of variables which are related to quality evaluations, inserting them into hedonic regressions alongside with objective characteristics.

[1] Formally, following Johansson (1987), suppose any unit x of a given good can be completely described by k characteristics. Then the price of this good is a function of its attributes:

$$P_x = f_x(C_{x1},...,C_{xk}) \quad \text{for all } x$$

where $\boldsymbol{C}$ denotes good's characteristics. This is a hedonic or implicit price function. In fact, this function is a locus of equilibrium consumers' marginal willignesses to pay for improvements in the k attributes of good x.
Supposing that a particular form of the hedonic function has been estimated, the coefficient for the partial derivative with respect to the j^{th} characteristic

$$\frac{\partial P_x}{\partial C_{xj}} = f_{xC}(C_{xj})$$

indicates the increase in market equilibrium expenditure on good x that is required to obtain the good with one more unit of attribute C_{xj} (for more details on this issue see Freeman, 1979).

A first approach rests on the argument that wine quality is generally recognized to depend on sensory evaluations. Although tastes are intrinsically subjective, wine experts claim that few codified characteristics univocally determine the quality of the wine and, in turn, its price. These codified characteristics are the so-called *sensorial* variables such as the wine's aroma, finish or harmony of components. According to this line of reasoning, Combris *et al.* (1997, 2000) use data for Bordeaux and Burgundy wine to estimate a hedonic price function and what is referred to as a jury grade equation to explain the variation in price and quality respectively. In both studies sensorial characteristics are found to be important in determining wine quality, while price is strongly explained by objective attributes appearing on the label of the bottle. As for the role of sensorial variables in price formation, the evidence is partially inconclusive. Indeed, unlike the Bordeaux study where most of sensorial characteristics have poor relevance, results of the Burgundy analysis show three sensorial attributes (acidity, fat, and concentration) having a significant impact on the wine price in all estimates. Notwithstanding, the authors conclude that consumers may decide to vary their willingness to pay for wine primarily according to observable attributes.[2] In fact, given the context of imperfect information, objective characteristics (in particular ranking and vintage) are much easier and less costly to identify by consumers than sensorial attributes.[3]

A second approach emphasizes the importance of the *reputation* of wines and producers among consumers. Imperfect information could be overcome if producers acquire reputation over time, so that *well-established* or *expected* wine quality could be proxied by long-term reputation, which, in turn, would influence market prices. Furthermore, *current* quality could be proxied by overall sensory quality score measures from widely accessible published wine guides. However, consumers may not possess this information before price is determined and whether this information increases consumers' knowledge of the product is therefore unclear. Following this line of reasoning, Landon and Smith (1997) use an unbalanced panel of 196 red wines (559 observations) from the five Bordeaux vintages of 1987 to 1991 and estimate two hedonic price equations. The first equation includes only objective variables and an

[2] The relevance of the objective traits is also underlined in Oczkowski (1994).

[3] Indeed, the acquisition of information about sensorial variables would require tasting, learning, and buying wine guides.

overall sensory quality index; the second one considers observable characteristics and reputation variables, the latter being referred to both single wines (individual reputation) and groups of wines (collective reputation). Apart from confirming the relevance of the objective traits, the authors find that long-term reputation explains much more variation in the consumers' willingness to pay than does short-term quality changes and that ignoring reputation indicators leads to overstate the impact of current quality on market price. This finding has been corroborated by focusing only on a balanced panel of 151 wines for the 1989 and 1990 vintages (Landon and Smith, 1998).[4] Subsequent applications to Australian premium wines by Oczkowski (2001) and to premium wines from North America, Australia, South Africa and Chile by Schamel (2000) support the presence of significant reputation effects. However, while Oczkowski's results indicate an irrelevant impact of current quality, the econometric evidence in Schamel points to highly significant implicit prices also for overall sensory wine quality.

Summing up, the previous literature on hedonic wine prices has alternatively employed, in addition to objective characteristics, sensorial and reputation variables in order to take into account the effects of quality attributes. However, to the best of our knowledge, no study has so far attempted to jointly use both types of factors to assess their relative importance in determining market prices. As a consequence, whether taste or reputation is more relevant in explaining wine price is still unclear. To shed light on the issue, this paper exploits a very rich dataset embracing information on all kinds of aforementioned variables for two premium Italian wines: Barolo and Barbaresco. The description of the dataset is the object of the next section.

3. Data Description

3.1. The Barolo and Barbaresco wines

The present paper exploits a unique dataset collecting data on two premium Italian red wines: Barolo and Barbaresco. Although the former is more widely known than the latter, these two wines have several common features whereby justifying the joint

[4] In this study expected quality is explicitely assumed to depend on reputation according to a forecasting equation which is estimated jointly with the hedonic price function, the latter having as arguments current quality and expected quality.

analysis put forth in this paper. In particular, the *Disciplinary Texts* of their "Denominazione d'Origine Controllata e Garantita" (DOCG) label specifies that the basic grape must be the same for both wines (the Nebbiolo variety). Furthermore, both wines come from the same area in the Piedmont region in Northern Italy, the Langhe, which is quite restricted (only 1,930 hectares). In turn, the amount produced is very small (approximately 12 million bottles per year) and the two wines display quite similar sensorial characteristics and vintage quality.[5] The most noteworthy differences between the two wines concern the maturing process imposed by the *Disciplinary Texts* (2 years for the Barbaresco wine and 3 for Barolo) and the production areas, very close to each other but carried out in different villages.

The production of Barolo and Barbaresco wines is very fragmented, due to the large number of landowners: there are approximately 750 producers of Barolo and 380 producers of Barbaresco. The combined effect of the small overall quantity and the large number of producers results in a very low output per firm: in fact, only 4.15% of Barolo winemakers produce more than 100,000 bottles and this figure reduces to 2% for Barbaresco.

3.2. The variables

The variables used in this paper have been collected by inspecting several published sources and through direct or phone interviews with the wine producers carried out during the July – September 2002 period.[6]

In particular, our starting point in constructing the database has been the analysis of two leading wine guides: *Wine Spectator*, probably the best known wine guide which has also been used by some previous literature (e.g. Landon and Smith; 1997, 1998), and the *Duemila Vini* guide edited by the *Italian Association of Sommeliers* (professional wine tasters, *AIS* henceforth). Both guides might be reasonably supposed

[5] For comparison purposes, consider that the Bordeaux region is much wider (250,000 hectars), production is larger (approximately 660 million bottles) and uses five different grape varieties.
[6] For more detailed information on variable definition and sources refer to the Appendix 1 at the end of the paper. For descriptive statistics on the variables see Table 1. For more details on data collection and variable caracteristics see Sacchetto (2002).

to be independent from wine producers and therefore represent reliable sources of information.[7]

We identified all the Barolo and Barbaresco wines cited in the two guides for the 1995-97 vintages for Barolo and the 1996-98 vintages for Barbaresco (i.e. the last three vintages for which information was available in 2002). We kept only those 227 wines for which data were available for at least two of the three years (603 observations, 111 different producers). Henceforth, we will use the term "bottle" to identify a specific producer-wine-year observation.

From these two guides we retrieved information on several variables of interest. Firstly, *Wine Spectator* reports an *overall* judgement of the wine, ranging from a minimum of 50 to a maximum of 100 (variable *VSPE*). Secondly, from the *AIS* guide we derived wines' alcoholic gradation (*ALC*). Finally, from both guides we derived: *i*) data on quantity produced (*BOTT*); *ii*) a *specific* judgement on six *sensorial* traits for each wine (*INTE*, *FINE*, *COMP*, *HARM*, *TANI*, *FINI*); *iii*) three *objective* variables, namely vintage (*AN97*), type, i.e. whether the wine is a Barolo or a Barbaresco (*TYPE*), and denomination, i.e. whether the label identifies a particular "*cru*" (*DEN*). It is worthwhile to give some details about the three objective traits and their expected impact on wine price. As for vintage, all the four years considered in this paper (1995–1998) are good quality vintages. However, 1997 is unanimously considered the best year and therefore is the only vintage we single out through a dummy variable (*AN97*) in the econometric analysis to check the presence of a positive effect on market price. The variable *TYPE* is included in the hedonic model to take into account that, in spite of the common high quality standard, Barolo wine is more widely known than Barbaresco and this circumstance could lead to a higher willingness to pay for the former. Finally, the mark on the label of a special denomination ("*cru*") in addition to DOCG, such as,

[7] Combris et al. (1997, p. 392) rigthly point out that wine guides might suffer from some drawbacks when used as sources for estimating edonic price equations. In particular, guides tend to overrepresent good wines and condition purchases might be different. As for overrepresentation of good quality wines, this is unlikely to occurr in our sample, as it is drawn from a populaton of high quality wines and the median price in the sample is 26 euros, which shows that low and medium price wines are well represented in our sample. Furthermore, selling prices in our sample are fairly homogeneous, as they all have been collected through direct or phone interviews with the producers (see the data appendix). Unfortunately, the same sort of controlled experiment Combris et al. (1997, 2000) have relied upon is not available, to the best of our knowledge, for Barolo and Barbaresco wines. We thank an anonimous referee for raising this point.

for instance, the origin from particular vineyards, is likely to represent an important distinction factor for consumers, able to push wine price upward.

The very localised production area allowed us to keep also direct and phone interviews with producers. Through these contacts we recovered information on prices and on whether wine passed an aging period in *barrique* barrels. In particular, we asked producers to report the retail price at which they would sell the bottles directly to the consumer in their estate wineshop, tax included. Inspection of Table 1, which presents the descriptive statistics for the variables, reveals the very large variability in price, which ranges from 11.5 to 93 euros per bottle. *Barrique* barrels are smaller and manufactured from higher quality oak than traditional ones, so that they convey a special taste to the wine. Several producers nowadays blend wine aged in these barrels with wine aged in traditional barrels. As this information is not reported in the guides (nor on the label) we asked producers whether their wine contains wine aged in *barrique* barrels.[8]

[INSERT TABLE 1 ABOUT HERE]

Finally, we relied on wine publications to construct two crucial groups of variables, those linked with the reputation of wines and producers. As for *single wine reputation*, we used three widely known Italian guides (*I vini di Veronelli* by Veronelli, *Guida dei Vini Italiani* by Maroni, and *Guida ai Vini d'Italia* by AA. VV.) to construct three bottle-specific dummy variables (*ECVER*, *ECMAR*, *ECGAM*, respectively) representing *single wine reputation* among consumers. In fact, these guides select, according to various criteria, "best" wines, which soon become well known among consumers. Each of our dummies takes a value of 1 (and 0 otherwise) if the bottle has been selected as one of these "best" wines. We include all the three variables as guides might differ in their judgment, so that the choice of "best" wines differ from one guide to the other, but all of them represent a noteworthy source of information for consumers. As far as the *reputation of producers* is concerned, we constructed three producer-specific time-invariant variables. The first one, labeled *FIT*, represents producers' reputation *in Italy*: it is the number of excellence ratings given by the *Guida ai Vini*

[8] The direct contact with producers allowed us also to check data on the quantity produced and to fill some missing values in the alcoholic gradation.

d'Italia publication over the 1987-2002 period to any wine (not only Barolo and Barbaresco) of a single producer[9]. Likewise, the variable *PREST* captures producers' reputation *abroad*: it is the number of ratings provided to each producer by the *Wine Spectator* magazine. Finally, we constructed a dummy variable (*FAMA*) which takes a value of 1 only for producers ranked in some well known charts (see the Appendix 1 for further details).

4. Empirical strategy

Although the hedonic price technique has been widely used in the empirical applications to study the process of price formation in several markets, economic theory provides little guidance about the functional form of the dependence of price on good's attributes. The research strategy followed by the previous literature on the wine industry is characterized by the preliminary choice of the hedonic price model to estimate (i.e. sensorial or reputation), and the subsequent selection of the appropriate functional form (e.g. log-log, log-linear, reciprocal, and the like) according to some specification tests (e.g. the Reset test). The present study sharply departs from this strategy, as we neither select *ex ante* the model type nor its functional form.

More specifically, the research line of this paper relies on three steps. We firstly estimate different Box-Cox transformations (Box and Cox, 1964) of the dependent and independent variables for each of the two models suggested by previous literature (the Combris *et al.* specification – CLV henceforth – and the Landon & Smith one – LS henceforth). This allows us to screen among different models without imposing any structure *a priori*, so that the data can suggest the proper specification of the hedonic price function[10]. We then select the best sensorial and the best reputation model on the

[9] This guide has been preferred to the other two (*I vini di Veronelli* and *Guida ai vini d'Italia*) for several reasons: it is the best known, it covers the largest set of wines, and it is the most selective in providing excellence ratings.

[10] Our choice to start from a linear Box-Cox approximation is motivated by both previous empirical research and theoretical arguments. Goodman (1978) – one of the first applications of the Box-Cox transformation within the context of hedonic prices – finds that a simple linear specification is generally rejected in favor of the Box-Cox model. Cropper *et al.* (1988) compare through a Monte Carlo analysis the behavior of six different hedonic price specifications (linear, semi-log, log-log, quadratic, linear and quadratic Box-Cox), with regressors either perfectly observed or proxied (as in our case). The authors point out the superior performance of the linear Box-Cox regression which is "the functional form of choice when estimating hedonic price functions" (p. 675). On the theoretical side, log linear models imply

basis of standard likelihood ratio (LR) statistics. In the second step, we simplify the two preferred models by applying zero-restrictions LR tests on coefficients. As the simplified best models are non-nested, in the final stage we compare them through the Vuong (1989) test.

In the first stage, we consider several variants of the Box-Cox transformations. The most general model we estimate is:

$$p^{(\theta)} = \sum_{j \in J} \beta_j x_j^{(\lambda)} + \sum_{k \in K} \gamma_k x_k + \varepsilon \qquad [1]$$

where $V^{(b)}$ – for a generic variable $V = p$, x and a generic parameter $b = \theta, \lambda$ – denotes the Box-Cox metric

$$V^{(b)} = \begin{cases} \dfrac{V^b - 1}{b} & \text{for } b \neq 0 \\ \ln V & \text{for } b \to 0, \end{cases} \qquad [1b]$$

J is the set of regressors x_j which can be sensibly logged, K is the set of regressors x_k which cannot sensibly logged (including variables such as constant term, dummies, time trends, etc.), and β_j (γ_k) is the coefficient associated with variable x_j (x_k). Statistical noise is represented by ε, a i.i.d. normally distributed random variable with 0 mean and variance σ^2. The crucial feature of this model is that both regressand (p) and at least a set of regressors (J) are transformed through a *different* Box-Cox parameter (θ and λ respectively). We will refer to this model as THETA.

A slightly less general specification than [1] is as follows:

$$p^{(\lambda)} = \sum_{j \in J} \beta_j x_j^{(\lambda)} + \sum_{k \in K} \gamma_k x_k + \varepsilon \qquad [2]$$

where both regressand and at least a set of regressors are transformed through the *same* Box-Cox parameter (λ). We will refer to model [2] as LAMBDA.

Proceeding with further simplifications, we can imagine to transform only (a set of) regressors or the regressand only, leading to the following specifications:

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the quite restrictive assumption that variation in marginal attribute prices occurr only through variation in selling price but not through variation in attribute quantity. In other words, two wines sold at the same price will have the same vector of marginal attribute prices, even if those wines have very different attribute bundles (on this issue see Rasmussen and Zuehlke, 1990).

$$p = \sum_{j \in J} \beta_j x_j^{(\lambda)} + \sum_{k \in K} \gamma_k x_k + \varepsilon \quad [3]$$

$$p^{(\theta)} = \sum_{j \in J} \beta_j x_j + \sum_{k \in K} \gamma_k x_k + \varepsilon \quad [4]$$

Again, we will refer to model [3] as LIN-RHS and to model [4] as LHS-LIN.

Note finally that model [1] can be further simplified by letting $\theta = \lambda = 0$ (LOG-LOG model), $\theta = \lambda = 1$ (LIN-LIN model), $\theta = 0$(LOG-RHS model) and $\lambda = 0$ (LHS-LOG model).

All eight models (models [1]-[4] and the four LOG and LIN transformations) have been estimated for both the CLV and the LS specifications. Variables common to all models are the *objective* and other characteristics (*AN97*, *TYPE*, *ALC*, and *DEN*; *BOTT* and *BARR*).[11] We included only *INTE*, *FINE*, *COMP*, *HARM*, *TANI*, *FINI* (sensorial characteristics) in the CLV models and only *VSPE* (current quality)[12], *ECGAM*, *ECMAR*, *ECVER* (individual *wine* reputation), *FIT*, *PREST*, *FAMA* (individual *producer* reputation) in the LS specifications. Notice that the set of transformed variables *J* includes *ALC*, *BOTT*, *VSPE*, *FIT* and *PREST*, whereas the remaining regressors belong to the set *K* of untransformed variables.[13] Once we have estimated all the 16 hedonic models, we select the one *best fitting* the data within each category (CLV, LS) using standard LR tests.

For the sake of parsimony, in the second stage we simplify the two preferred CLV and LS specifications through a stepwise procedure: we gradually delete the least significant variable and stop only when all the estimated coefficients for retained regressors are significant at least at the 5% level.

[11] The number of bottles sold and ageing in barrique are not objective variables as they do not appear systematically on the label. Their expected effect on price is uncertain. The number of bottles can play the role of snob variable exerting a positive impact on price insofar as consumers value the rarity of the wine, but it can also be viewed as a means of diffusion of wine reputation. Ageing in barrique gives wine a particular flavour, which might be valued positively or not by consumers.

[12] In a preliminary regression we checked that wine quality (*VSPE*) is well explained by the sensorial characteristics. These results, available upon request to the authors, confirm that the *Wine Spectator* rating is given on the basis of some widely recognised and objective criteria, whereby justifying the use of this variable in the price equations.

[13] To avoid tranformations of zero values, we replaced the variables *FIT* with (*FIT* + 1) and *PREST* with (*PREST* + 1). Furthermore, we estimated all models by standardizing the dependent variable by its geometric mean. As discussed, among the others, in Davidson and MacKinnon (1993, chapter 14), this transformation does not affect the values of the estimated λ and θ. However, it does affect the values of β and γ; therefore, in testing the significance of these coefficients we will rely on LR and not on Wald tests which, as is well known, are not invariant with respect to non-linear transformations of the variables.

Finally, we resort to the Vuong (1989) test to compare the *best simplified* models. As suggested by Gasmi, Laffont and Vuong (1992), this statistic must be adjusted to take into account the different number of parameters included in the compared models. Three adjustments have been proposed by the literature, differing in the penalties for the number of estimated parameters, namely the Hannan and Quinn (1979), the Akaike (1973), and the Schwarz (1978) correction factors. In order to check the robustness of our results, we decided to apply all the three adjustments. We will refer to these corrected statistics as “Vuong Adjusted Likelihood Ratio” (VALR).

5. Results

All the models above have been estimated by Maximum Likelihood with the Stata software, version 9.2. The results are presented in Tables 2 to 8.

Estimates of the eight Box-Cox specifications for the CLV-type hedonic equation (or *sensorial* model) are shown in Table 2. Both parameters of the general model (THETA) have reasonable magnitude and are statistically significant at the 5% level. Proceeding across the possible simplifications, we notice that the estimated parameter θ (i.e. the one transforming the dependent variable p) proves to be quite stable (values ranging from -0.52 and -0.50), whereas the estimates of λ (the parameter transforming the independent variables) show high variability. Comparisons between the THETA model and its various simplifications are presented in Table 3. Not surprisingly, all the specification where the transformation of regressand is restricted to a given value (LIN-RHS, LOG-LOG, LIN-LIN, LOG-RHS) are strongly rejected whereas the chi-squared statistic for the other models is much lower. Notwithstanding, the only specification not rejected at the 10% level is the LAMBDA model.

[INSERT TABLES 2 AND 3 ABOUT HERE]

As for the LS-type hedonic equation (or *reputation* model), estimates of the Box-Cox transformations reported in Table 4 reveal remarkable differences with respect to those of the CLV-type models. In fact, in the THETA specification the transformation of the independent variables (λ) is 0.49 and proves to be statistically significant, whereas the parameter θ is fairly small in value and insignificant. Again, the estimates for parameter θ are quite robust across the different specification and close to zero, while λ shows larger variability (ranging between 0.06 and 1.27). LR tests comparing general and restricted specifications (see Table 5) clearly favour the LOG-RHS model where the value of θ is constrained to be zero.

[INSERT TABLES 4 AND 5 ABOUT HERE]

We then simplified the two preferred Box-Cox transformations for the CLV (LAMBDA) and LS (LOG-RHS) specifications by applying the stepwise procedure described above. Coefficients estimates for the general and simplified versions of the two models are presented in Table 6. As the values of retained explanatory variables are very similar in both cases, we will comment only upon the results of the restricted versions.

[INSERT TABLES 6 AND 7 ABOUT HERE]

The estimated parameters for the CLV (LAMBDA) hedonic model (third column) support the importance of both the objective and the sensorial variables. In fact, the dummies for the 1997 vintage (*AN97* = 1), for Barolo wines (*TYPE* = 1), and for a special denomination (*DEN* = 1) turn out to be positive and significant at the 2% level, whereby confirming our *a priori*. Turning to the sensorial characteristics, the only significant one is the harmony among wine components (*HARM*): this finding can be explained as this trait is the easiest among the sensorial ones to be recognised by consumers. Finally, the number of bottles (*BOTT*) exerts a positive and significant impact on prices.

The fifth column of Table 6 presents the results of the LS (LOG-RHS) hedonic model. All coefficients have the expected sign. Moreover, the variables representing individual *wine* reputation (*ECGAM*, *ECVER*, *ECMAR*) and *producer* reputation (*FIT*, *FAMA*, *PREST*) are all statistically significant at the 1% level. Estimated coefficients for objective and other characteristics have the same sign as those of CLV (LAMBDA) model, the only exceptions being the dummy for the use of *barrique* barrels (*BARR*), which turns out to exert a positive impact on prices, and the quantity produced (*BOTT*), which proves to have a negative sign. These findings suggest that in a model with only objective and reputation but no taste variables, barrique becomes positive and statistically significant as it conveys information of better wine flavour. The role of the number of bottles appear to differ according to the other covariates in the model: once taste variables are accounted for, it seems to play a reputation effect whereas it plays a "snob" effect due to the limited availability of a particular bottle in a reputation model.

Table 7 shows the marginal effects of the variables included in the restricted CLV and LS models on price[14]. Rather comfortably, impacts are precisely estimated and turn out to be quite similar for those regressors appearing in both specifications. Extra price consumers are willing to pay ranges from 1 to 7.2 Euros for objective and other attributes (bottle aged in barrique barrels, 1997 vintage, special denomination, Barolo wine). As for sensorial traits, an increase in harmony from a medium to a high level (from 2 to 3) is valued more than 4 Euros. Single wine reputation factors (*ECGAM*, *ECMAR*, *ECVER*) prove to exert marginal effects of similar magnitude (2.5, 3.4, 2.9 Euros respectively), whereas the variable implying the largest variation in the willingness to pay is by far *FAMA* (12.8 Euros). The latter result confirms how important is the inclusion of a producer in some well known charts from a consumer perspective.[15]

Finally, we proceeded to perform the main purpose of this study, namely the comparison of the relative importance of *sensorial* and *reputation* factors in determining market prices. To this end, we ran a Vuong (1989) test for non-nested models. In order to take into account the different number of estimated parameters in the CLV (LAMBDA) and LS (LOG-RHS) specifications, we adjusted the test statistic using the three correction factors mentioned above – Hannan and Quinn (1979), Akaike (1973), and Schwarz (1978) – and obtained the VALR values reported in Table 8.

[INSERT TABLE 8 ABOUT HERE]

[14] We followed Abrevaya (2002) in using the so-called *smearing technique*, which provides consistent estimators, to measure marginal effects. We also bootstrapped the (higly non-linear) marginal effects to compute standard errors. Further details on formulas and software program used are available upon request to the authors.

[15] Marginal effects for continuous variables (*BOTT*, *FIT*, and *PREST*) have no direct interpretation, as they depend on their unit of measurement. We therefore computed the economic impact of each attribute as the difference of the expected value of the dependent variable at the 10^{th} and at the 90^{th} percentile of each regressor distribution. In all cases the increase in wine price turned out to be small (below 1 euro).

Inspection of VALR-statistics reveals that, even applying the correction factor according the highest penalty for the number of estimated parameters (Schwarz, 1979), the model LS (LOG-RHS) significantly outperforms the CLV (LAMBDA) specification, the *P*-value of the test being always less than 1%. This leads to conclude that the former model is closer than the latter to the true model which generates the data and therefore contains a greater amount of information about the wine price formation. In turn, this finding points to a major role of reputation compared with sensorial traits in explaining differences in the consumers' willingness to pay.

6. Final remarks

This paper aimed at providing new empirical evidence on factors affecting wine prices on both methodological and factual grounds. In particular, building on previous literature, which highlighted the importance of objective, sensorial, and reputation variables, the study intended to assess the role played by sensorial characteristics versus reputation, taking into account the effect of objective variables. To this end, we focused on two premium Italian red wines, Barolo and Barbaresco, whereby filling the gap of no empirical evidence on the issue for Italy, and constructed, through the inspection of wine publications as well as interviews with producers, a database which collects all these sorts of variables.

The results from the general Box-Cox estimation of different sensorial (CLV) and reputation (LS) models, which does not impose *a priori* restrictions on the form of the hedonic price function, confirm previous evidence obtained using data from countries other than Italy: the consumers' choice with respect to wine is a quite complex process which involves a variety of factors such as objective characteristics, sensorial traits, and reputation. However, on the basis of a non-nested statistical test (Vuong, 1989), the LS specification is to be preferred to the CLV one. As a consequence, we can infer that, although both sets of variables are relevant factors influencing consumers' preferences and their willingness to pay, the reputation acquired by wines and producers during the years is more important than taste in driving market prices.

The results we obtained have some relevant implications for firms' strategy. Producers' marketing has been recently directed toward the search of an increased quality in terms of improved taste characteristics. Although our findings show that consumers to some extent appreciate these improvements, they foremost suggest that producers should aim at building a well established reputation – both at wine and at firm level – by promotional activities (e.g. participation to wine exhibitions) which facilitate citations in well known guides.

7. Data Appendix

Appendix 1: Variable definition and data sources

ALC: alcoholic content as it appears on the label of the bottle. As imposed from the *Disciplinary Text* for Barolo and Barbaresco, the alcoholic degree reported on the label can differ from the actual value determined by chemical analysis by at most ±0,5% vol. Sources: AA.VV. *Duemila vini*, Associazione Italiana Sommeliers ed., years 2000, 2001, 2002 and direct or phone interviews with producers between July and September 2002.

AN97: a dummy variable which equals 1 if the wine vintage is 1997 and 0 otherwise.

BARR: a dummy variable which equals 1 if a percentage of the wine passed an aging period in *barrique* barrels and 0 otherwise. Source: direct or phone interviews with producers between July and September 2002.

BOTT: number of bottles produced for each wine in thousands. Sources: AA.VV. *Duemila vini*, Associazione Italiana Sommeliers ed., years 2000, 2001, 2002 and the wine ratings database at www.winespectator.com. We checked the information provided by *Wine Spectator* through direct or phone interviews with producers between July and September 2002.

COMP: a dummy variable which reflects the complexity of the aroma. It equals 2 if the olfactory characteristic is present, 1 otherwise. Sources: AA.VV. *Duemila vini*, Associazione Italiana Sommeliers ed., years 2000, 2001, 2002 and the wine ratings database at www.winespectator.com.

DEN: a dummy variable which equals 1 if the wine appellation on the label is not just "Barolo" or "Barbaresco", but it contains more information (e.g. the vineyard or the indications of the *terroir* where the grapes are produced, or the word *Riserva*: these dictions have been intended as indicators of a special wine, i.e. a "*cru"* one) and 0 otherwise.

ECGAM: a dummy variable which equals 1 (0 otherwise) if the wine obtained a "Tre Bicchieri" award from the Italian wine guidebook "Guida ai Vini d'Italia" during the 2000-02 period. Sources: AA.VV. *Guida ai Vini d'Italia*, Gambero Rosso ed., years 2000, 2001, 2002, and the web site www.gamberorosso.it.

ECMAR: a dummy variable which equals 1 (0 otherwise) if the wine obtained a rating higher than 76/100 from the Italian wine guidebook "Guida dei Vini Italiani" during the 2000-02 period. This threshold is used by the author to identify "excellent wines". Source: Maroni, L. *Guida dei Vini Italiani*, LM ed., years 2000, 2001, 2002.

ECVER: a dummy variable which equals 1 (0 otherwise) if the wine obtained a rating higher than 90/100 from the Italian wine guidebook "I vini di Veronelli" during the 2000-02 period. This threshold is used by the author to identify "excellent wines". Source: Veronelli, L. *I vini di Veronelli*, Veronelli ed., years 2000, 2001, 2002.

FAMA: a dummy variable which equals 1 (0 otherwise) if the wine producer has been included at least once in one of the following charts:

- 1992-2002 "Top 100" wines of the year chart, yearly published by the *Wine Spectator* Magazine. The source is the wine ratings database at www.winespectator.com.

- "Outstanding Wine" rating in the chart of Piedmont wines made by Robert Parker. The sources are the web site www.erobertparker.com and Parker, R. *Robert Parker's Wine Buyers' guide*, 2002.

- the chart proposed by the Italian wine review *Civiltà del Bere* (April 2002), which indicates the wine producers that obtained a rating of excellence in 2002 from at least three of the five most important Italian wine guidebooks (Veronelli, L. *I vini di Veronelli*; Masnaghetti, A. *I Vini d'Italia* 2002; Maroni, L. *Guida dei Vini Italiani*; AIS ed., *Duemila vini*; Gambero Rosso ed., *Guida ai Vini d'Italia*);

FINE: a dummy variable which equals 2 if the wine is characterized by finesse of aroma, 1 otherwise. The sources are the same as for *COMP*.

FINI: a dummy variable which reflects the persistence of the taste in the finish. It equals 3 if the finish is long, 2 if it is medium, 1 if it is short. The sources are the same as for *COMP*.

FIT: total number of "Tre Bicchieri" awarded during the 1987-2002 period to any wine of a producer by the Italian wine guidebook "Guida ai Vini d'Italia". The source is the same as for *ECGAM*.

HARM: a dummy gustatory variable which contemplates the harmony between the components of the wine. It equals 3 if the wine is well balanced, 2 if it is balanced, 1 if it is unbalanced. The sources are the same as for *COMP*.

INTE: a dummy variable which reflects the level of aromatic intensity of the wine. It equals 3 if the wine's aroma is strong, 2 if it is classic and 1 if it is discreet. The sources are the same as for *COMP*.

p: price per bottle of wine in current Euros. Data have been collected by direct or phone interviews with the wine producers during the July – September 2002 period. The producers were asked to provide the retail price at which they would sell the wine directly to the consumer in their estate wineshop.

PREST: number of ratings assigned to any wine of a producer during the years by the *Wine Spectator* Magazine. Source: the wine ratings database at www.winespectator.com.

TANI: a dummy variable which indicates the presence of fine tannins. It equals 2 if there are fine tannins, 1 otherwise. The sources are the same as for *COMP*.

TYPE: a dummy variable which equals 1 if the wine is a Barolo and 0 if it is a Barbaresco.

VSPE: a variable which indicates the valuation in a 100 points scale assigned to each bottle by the *Wine Spectator* Magazine if the rating is not missing (452 observations out of 603). The remaining 151 cases have been adjusted according to two criteria: *i*) the average *Wine Spectator* rating obtained from the same wine in other vintages; *ii*) the average rating obtained from the same vineyard's and producer's wines. Source: the wine ratings database at www.winespectator.com.

Table 1. Descriptive statistics of the variables

Variable	Mean	St.dev	Min	Max	% = 0	% = 1	% = 2	% = 3
PRICE								
p	28.92	11.55	11.36	93.00	---	---	---	---
OBJECTIVE CHARACTERISTICS								
AN97	---	---	---	---	65.67	34.33	---	---
TYPE	---	---	---	---	28.19	71.81	---	---
ALC	13.79	0.36	13.0	14.5	---	---	---	---
DEN	---	---	---	---	17.91	82.09	---	---
CURRENT QUALITY								
VSPE	89.12	3.97	69	100	---	---	---	---
REPUTATION								
▪ Single wine reputation according to Italian guides:								
ECGAM	---	---	---	---	88.06	11.94	---	---
ECMAR	---	---	---	---	85.41	14.59	---	---
ECVER	---	---	---	---	69.68	30.02	---	---
▪ Single producer reputation:								
FIT	3.18	4.20	0	29	---	---	---	---
PREST	33.02	31.61	0	131	---	---	---	---
FAMA	---	---	---	---	86.57	13.43	---	---
SENSORIAL CHARACTERISTICS								
▪ Olfactory characteristics:								
INTE	---	---	---	---	---	5.47	49.09	45.44
FINE	---	---	---	---	---	14.10	85.90	---
COMP	---	---	---	---	---	22.55	77.45	---
▪ Gustatory characteristics:								
HARM	---	---	---	---	---	2.32	37.31	60.36
TANI	---	---	---	---	---	20.56	79.44	---
FINI	---	---	---	---	---	7.46	40.13	52.40
OTHER CHARACTERISTICS								
BOTT	15.9	27.8	1	260	---	---	---	---
BARR	---	---	---	---	53.07	46.93	---	---

Notes: mean, standard deviation, minimum and maximum are reported for continuous variables; the percentage of observation falling into a given category is provided for discrete variables. Price is in current euro. Production is in thousand bottles. The number of observations is 603.

Table 2. *Sensorial* (CLV) model estimates for different Box-Cox transformations

Specification		Box-Cox parameters	*P*-value	Log *L*
θ, λ	[THETA]	$\lambda =$ 2.28 $\theta =$ - 0.52	0.025 0.000	-152.96
$\theta = \lambda$	[LAMBDA]	$\lambda =$ - 0.52	0.000	-153.69
$\theta = 1, \lambda$	[LIN-RHS]	$\lambda =$ - 0.92	0.043	-284.16
$\theta, \lambda = 1$	[LHS-LIN]	$\theta =$ - 0.52	0.000	-154.57
$\theta = \lambda = 0$	[LOG-LOG]	---	---	-169.36
$\theta = \lambda = 1$	[LIN-LIN]	---	---	-288.92
$\theta = 0, \lambda$	[LOG-RHS]	$\lambda =$ 2.52	0.048	-168.35
$\theta, \lambda = 0$	[LHS-LOG]	$\theta =$ - 0.50	0.000	-155.25

Note: we report p-values of the null hypothesis that each coefficient is equal to 0.

Table 3. Comparison among *sensorial* (CLV) specifications by LR test

Model [.] *versus* Model [.]	χ^2**-statistic**	***P*-value**
[LAMBDA] *versus* [THETA]	1.47	0.226
[LIN-RHS] *versus* [THETA]	262.4	0.000
[LHS-LIN] *versus* [THETA]	3.24	0.072
[LOG-LOG] *versus* [THETA]	32.82	0.000
[LIN-LIN] *versus* [THETA]	271.93	0.000
[LOG-RHS] *versus* [THETA]	30.79	0.000
[LHS-LOG] *versus* [THETA]	4.58	0.032

Table 4. *Reputation* (LS) model estimates for different Box-Cox transformations

Specification		Box-Cox parameters	*P*-value	Log *L*
θ, λ	[THETA]	$\lambda =$ 0.49 $\theta =$ - 0.05	0.000 0.572	68.88
$\theta = \lambda$	[LAMBDA]	$\lambda =$ 0.06	0.453	63.61
$\theta = 1, \lambda$	[LIN-RHS]	$\lambda =$ 1.27	0.000	-13.95
$\theta, \lambda = 1$	[LHS-LIN]	$\theta =$ 0.00	0.994	63.69
$\theta = \lambda = 0$	[LOG-LOG]	---	---	63.33
$\theta = \lambda = 1$	[LIN-LIN]	---	---	-14.30
$\theta = 0, \lambda$	[LOG-RHS]	$\lambda =$ 0.50	0.000	68.72
$\theta, \lambda = 0$	[LHS-LOG]	$\theta =$ - 0.06	0.471	63.60

Note: we report p-values of the null hypothesis that each coefficient is equal to 0.

Table 5. Comparison among *reputation* (LS) specifications by LR test

Model [.] *versus* Model [.]	χ^2-statistic	*P*-value
[LAMBDA] *versus* [THETA]	10.53	0.001
[LIN-RHS] *versus* [THETA]	165.66	0.000
[LHS-LIN] *versus* [THETA]	10.37	0.001
[LOG-LOG] *versus* [THETA]	11.09	0.001
[LIN-LIN] *versus* [THETA]	166.35	0.000
[LOG-RHS] *versus* [THETA]	0.32	0.571
[LHS-LOG] *versus* [THETA]	10.56	0.001

Table 6. Coefficient estimates of the general and restricted CVL and LS preferred models.

Variable	General CVL [LAMBDA]	Restricted CVL [LAMBDA]	General LS [LOG-RHS]	Restricted LS [LOG-RHS]
AN97	0.104 *(0.000)*	0.115 *(0.000)*	0.063 *(0.002)*	0.073 *(0.000)*
TYPE	0.075 *(0.010)*	0.067 *(0.020)*	0.068 *(0.001)*	0.068 *(0.001)*
ALC	0.985 *(0.667)*	---	0.117 *(0.312)*	---
DEN	0.286 *(0.000)*	0.301 *(0.000)*	0.154 *(0.000)*	0.166 *(0.000)*
BARR	0.038 *(0.176)*	---	0.036 *(0.069)*	0.045 *(0.018)*
BOTT	0.102 *(0.037)*	0.102 *(0.037)*	- 0.011 *(0.000)*	- 0.011 *(0.000)*
INTE	0.016 *(0.514)*	---	---	---
FINE	0.037 *(0.365)*	---	---	---
COMP	- 0.042 *(0.239)*	---	---	---
HARM	0.120 *(0.000)*	0.140 *(0.000)*	---	---
TANI	0.011 *(0.758)*	---	---	---
FINI	0.024 *(0.336)*	---	---	---
ECGAM	---	---	0.083 *(0.005)*	0.085 *(0.005)*
ECMAR	---	---	0.113 *(0.000)*	0.114 *(0.000)*
ECVER	---	---	0.093 *(0.000)*	0.100 *(0.000)*
FIT	---	---	0.039 *(0.000)*	0.043 *(0.000)*
PREST	---	---	0.015 *(0.000)*	0.015 *(0.000)*
FAMA	---	---	0.383 *(0.000)*	0.389 *(0.000)*
VSPE	---	---	0.034 *(0.147)*	---
Box-Cox parameter	- 0.515	- 0.521	0.503	0.497
Log *L*	- 153.69	- 157.15	68.72	66.96

Note: the dependent variable is the wine price (*p*). The number of observations is 603. P-values of the null hypothesis that each coefficient is equal to 0 are reported in brackets.

Table 7. Marginal effects on price

Variable	Restricted CVL [LAMBDA]	Restricted LS [LOG-RHS]
AN97	3.25 (0.77)	2.08 (0.56)
TYPE	1.80 (0.87)	1.91 (0.61)
DEN	7.18 (0.84)	4.46 (0.81)
BOTT	0.04 (0.02)	-0.08 (0.02)
HARM	4.34 (0.78)	---
BARR	---	1.28 (0.59)
ECGAM	---	2.47 (0.84)
ECMAR	---	3.36 (0.86)
ECVER	---	2.90 (0.63)
FIT	---	0.59 (0.09)
PREST	---	0.07 (0.001)
FAMA	---	12.77 (1.41)

Note: Marginal effects have been computed by using the *smearing technique*, as suggested by Abrevaya (2002). Bootstrapped standard errors based on 500 replications are reported in round brackets.
As for the CVL model, marginal effects are computed at the mean value of the regressors (except for *HARM*, computed at *HARM* = 2). For dummy variables (except *HARM*) the effect represents the difference in the expected value of the dependent variable when the dummy changes from 0 to 1 (from 2 to 3 for *HARM*).
In the LS model, effects have been computed at the mean value of all regressors. For dummy variables the effect represents the difference in the expected value of the dependent variable when the dummy changes from 0 to 1.

Table 8. Comparison among restricted CLV and LS models by Vuong (1989) test

LS [LOG-RHS] *versus* CLV [LAMBDA]	VALR-statistics [a]	*P*-value
Correction factor:		
- Hannan and Quinn	6.636	0.000
- Akaike	6.630	0.000
- Schwarz	6.432	0.000

[a] These statistics are distributed as a $N(0,1)$ under the null hypothesis that the two models are equally distant to the true model.

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