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Pricing strategies for Italian red wine ☆

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ABSTRACT

Italian wine is one of the most famous products worldwide and yet very little is known about the pricing strategies and the characteristics of consumers on the domestic market. In this article we attempt to partially fill this gap via the estimation of a hedonic price function for Italian red wine sold in the domestic market for the period 2007–2008. In particular we assess the importance of label characteristics (that can be inferred from the bottle), chemical and sensory characteristics (that can be inferred through testing and tasting) and panel judgements. Our results have been obtained using an innovative procedure that consists in applying dimensionality reduction methods in order to construct latent variables to be used with hedonic price techniques. The analysis shows that price formation follows quite different patterns in the large-scale retail trade and in the wine shops. In the large-scale retail trade, the price mainly depends on the label characteristics (the alcohol content being the most relevant) of the wine sold; other indicators, even when statistically significant, are fairly irrelevant. For wine shops the story is rather different: the price depends also on the sensory characteristics of the wine and it is on this market that wines with particular tastes and characteristics may obtain a better selling price.

1. Introduction

The Italian wine market is one of the most important markets in terms of numbers of bottles sold. According to Ismea Nielsen (2009a,b), it has constantly grown and only in the first months of this year the market seems to have experienced a sudden downturn that may require producers to re-think their selling strategies in the future. Although it is one of the largest markets for wine in Europe, very few studies have been proposed to explain the main determinants of price formation.

In Italy, alcohol consumption is increasing, especially among teenagers. Apart from the health risks of this phenomenon, it has important implications for the wine market: consumers are on average more interested in the alcohol content of what they drink than in its quality. A second important aspect is that "quality" may not necessarily mean that the wine is palatable and "easy" to drink. Some highly acclaimed wines (Aglianico for example) have a very strong and difficult taste which makes them not fit for large-scale distribution.

The supply side is very fragmented: the first 100 producers represent about 30% of total production. The rest is made up of small, scattered wine makers that sometimes form consortia (*cantine sociali* or *consorzi*) for the distribution of their products. Such fragmentation means that only a few producers have a scale of production that makes marketing strategies cost effective. The medium to small producers have to rely on reputation and word of mouth to promote their products. As a result, in Italy wine is sold through the large-scale retail trade (*GDO*) and through wine shops (*ENO*) and we argue that market strategies are tailor-made to the specific distribution channel.

In this paper we show that for small producers, selling through wine shops may be the right strategy given the characteristics of the Italian wine market. This is especially true if the wine has a very high standard, good quality, and sensory characteristics that differentiate it from other wines with the same alcohol content.

Brentari and Levaggi (2010) showed that pricing strategies for red wine are specific to the channel chosen to distribute the product. They also show that sensory characteristics have a marginal role in price formation and this is especially true for the wine sold via the large-scale retail trade. The aim of this paper is to study this relationship in greater detail and to propose the use of an innovative estimation procedure that consists of combining dimensionality reduction techniques with hedonic price estimation. This technique allows to overcome some of the problems related to the lack of theory behind hedonic pricing estimation techniques.

More specifically, we point out that our dataset has all features required by other studies in this field (see for example Combris, Lecocq, & Visser, 1997), but via a canonical correlation analysis (Brentari & Zuccolotto, 2010a) we can reduce the number of vari-

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ables that are potentially multicollinear without making an explicit choice. The analysis we propose is innovative mainly with respect to two points:

(a) Our sample allows us to evaluate the impact of label variables, sensory characteristics, jury grades and chemical variables.
(b) We can test for market strategies using a more objective and general approach than Steiner (2004) and Costanigro and McCluskey (2007). Steiner tests the existence of reputation effect at supermarket level in the UK by testing the existence of premium prices for own brand of the same appellation (*Asda Merlot vs. Marks and Spencer Merlot*) instead of the same bottle of wine. Costanigro and McCluskey (2007) arbitrarily segment the market according to the price and they then estimate the reputation effect in each submarket. We will instead follow a completely different approach. Given that our sample reports for the same bottle the average price in large-scale distribution and in wine shops, we find price determinants for wine sold in *large scale distribution* (*GDO*) and we can compare the results with price determination in wine shops (*ENO*). We can also find the presence of interactions between the two channels by using the information on whether a specific bottle is sold also using the other distribution channel.

The paper is organised as follows: in Section 2 we present a brief review of the literature; in Section 3 we present our database; in Section 4 we present the model and in Section 5 the results of our analysis. Finally, Section 6 concludes.

2. Review of the literature

Since the seminal paper by Combris et al. (1997), several authors have attempted to estimate how quality is perceived by consumers in the wine market.

The literature has studied the problem from several perspectives: varieties of wines, region or national production (Combris et al., 1997; Combris, Lecocq, & Visser, 2000; Lima, 2006; Lutzeyer, 2008; Fogarty, 2006; Landon & Smith, 1997; Schamel & Anderson, 2003; Lecocq & Visser, 2006; Cardebat & Figuet, 2004; Panzone, 2009; Priilaid, 2006), price formation in specific markets (Davis, 2005; Nerlove, 1995), price determinants for wines produced in specific regions and sold in a foreign market (Steiner, 2004; Schamel 2006, 2010).

One of the most important problems faced by this literature is the absence of a reference model as regards the functional form and the literature does not agree on the variables and the functional form that should be used to determine the price of the wine. Nerlove (1995) compares log linear, log–log and Box–Cox transformation; Landon and Smith (1997) choose the reciprocal square root form; other studies point to the use of a log-linear form (Oczokswski, 2001; Oczkowski, 1994; Combris et al., 1997; Nerlove, 1995; Schamel & Anderson, 2003), Brentari and Zuccolotto (2010b) use a basically nonparametric approach consisting in a nonlinear regression fitted through the ensemble learning algorithm called Random Forest. For this reason, Rosen (1974) and Combris et al. (1997) suggest that the dataset should include a great number of variables, especially as regards the sensory characteristics of the wine. Only a few databases have such requirements and even when the data requirement is fulfilled, estimation problems may arise. Given the absence of a reference model, no variables or functional forms can be excluded *a priori*; most of the tests proposed to guide in this choice are robust only if the variables have specific characteristics which large datasets, where most attributes can be evaluated using dummy variables, may not have. The variety of proxies for chemical and sensory characteristics may imply a certain degree of multicollinearity among these variables which makes interpretation of the estimates quite difficult. The estimates may not in fact be robust to small changes in the dataset; the variables that are quite similar may be under-represented in final estimation because they have a low explicative power when they are considered separately and it may be difficult to isolate their effect on the price.

One of the most important questions addressed by the literature relates to the relative influence of label, reputation and sensory characteristics on the price of the wine.

Since Combris et al. (1997) seminal paper, the literature agrees that consumers' willingness to pay depends on observable characteristics and reputation, while sensory variables and jury grades usually have a rather limited explanatory power. The former can be inferred by the label of the wine or by the ranking in wine guides, the latter requires tasting, something that most consumers do after buying the wine (for a review on this point, see Benfratello, Piacenza, & Sacchetto, 2009).

Mueller and Szolnoki (2010) have further investigated this relationship and have concluded that appearance matters: packaging accounts for as much as 40% in price formation while the layout of the label is less important.

Another important part of the literature concentrates on the importance of the distribution channel, on market segmentation and on the influences of specific variables through time.

The large-scale retail trade sells own brands of specific appellations at a significantly different price (Costanigro & McCluskey, 2007; Steiner, 2004). Finally, producers face a quality-quantity trade-off (Schamel, 2010) which may undermine the growth of specific markets.

Despite the importance of the market in terms of bottles produced and consumed, few studies are available on the hedonic price of Italian wine.

Benfratello et al. (2009) use a hedonic price approach to study price formation of Barbaresco and Barolo, two high quality wines produced in Piedmont; Galizzi (2007) and Galizzi and Miniaci (2009) propose a similar analysis for Franciacorta Bollicine. Corsi and Strom (2009) use a hedonic price function approach to assess whether organic wines benefit from a price premium and finally Defrancesco and Trestini (2008) study the likely impact that the new directive on the use of the appellation Tocai may have on the price of the Italian variety. Brentari and Levaggi (2010) show that sensory variables and jury grades have a marginal role in price formation. The driving factor in price formation is the information that can be inferred from the label, especially if the wine is sold via large-scale distribution.

3. Description of the dataset

In this study we work the unique dataset that Altroconsumo, an Italian Independent Consumers' Association, uses for its guide (Guida Vini, 2006-2008) which has all requirements specified by Combris et al. (1997). Each year about 300 wines (red and white) are bought and their characteristics are evaluated using a panel of experts. The market studied is the low to medium/high market since Altroconsumo excludes wines that cost more than 15–16 euro. Within this range wines are chosen in order to represent the variety of Italian wines as regards vineyards, producers and region of origin. The sensory analysis is performed using a detailed protocol and the price of each wine is estimated using a specific market analysis. For *GDO* the price used is the IRI Infoscan price (http://www.symphony-iri.it/), for wine shops, an *ad hoc* market analysis has been undertaken by Altroconsumo. For our estimation we use the prices for red wines only for the period 2007–2008. We have preferred to

concentrate on this specific group of wines to elicit the most relevant characteristics of the market for this specific type of wine. Our database comprises 359 observations (185 for 2007 and 174 for 2008). The choice of the sample reflects Altroconsumo's judgement about the domestic market for Italian wine. The sample is relatively small if compared to the large variety of wines sold in Italy, but it is representative of the focus market of Altroconsumo's studies. The appellations used in this study are described in Section 4, while the descriptive statistics are presented in Table 1.

This dataset allows us to obtain information on several characteristic of the wine which we have grouped into different categories:

- what can be observed without tasting the wine, which in our sample are the characteristics that can be inferred from the label (*label characteristics*);
- the results of an analysis aimed at assessing some characteristics of the wine as regards its chemical components (*chemical characteristics*);
- *the sensory characteristics*, rated by a panel of experts, aimed at assessing some intrinsic characteristics of the wine;
- *information about the price charged in different channels*, information on whether a specific bottle of wine is sold via the large-scale distribution and wine shops or using only one of the two channels.

Table 1
Descriptive statistics.

	Complete sample ($N = 359$)		Price in *GDO* ($N = 244$)		Price in wine shops ($N = 115$)	
Variables	Mean	St. dev	Mean	St. dev	Mean	St. dev
Price	6.365	3.316	5.403	2.970	8.406	3.087
Alcver	12.820	0.678	12.691	0.674	13.096	0.603
Sugar	3.312	1.623	3.403	1.705	3.118	1.422
Acitot	5.421	0.387	5.386	0.358	5.497	0.434
Acivol	0.512	0.109	0.500	0.109	0.539	0.106
RSO_2	0.245	0.097	0.236	0.093	0.263	0.103
SO_2	74.825	24.074	75.410	22.754	73.583	26.723
Colour	6.893	0.774	6.838	0.759	7.009	0.797
Violet	5.217	1.148	5.174	1.138	5.309	1.167
Orange	2.437	1.165	2.469	1.204	2.370	1.080
Intolf	6.804	0.526	6.771	0.526	6.874	0.521
Floral	3.822	0.668	3.816	0.663	3.835	0.681
Fruits	5.196	0.691	5.193	0.697	5.204	0.682
Spicy	3.710	0.794	3.662	0.772	3.813	0.834
Vegetal	3.120	0.798	3.137	0.791	3.083	0.814
Structure	6.586	0.529	6.559	0.542	6.644	0.499
Roundness	5.773	0.640	5.764	0.673	5.791	0.566
Acidity	4.054	0.721	4.076	0.714	4.009	0.737
Bitterness	2.134	0.555	2.107	0.551	2.191	0.560
Astringency	4.362	0.732	4.301	0.746	4.491	0.688
Aromrich	6.325	0.567	6.268	0.581	6.444	0.516
Persistency	6.283	0.694	6.223	0.706	6.409	0.654
Attraency	6.930	0.554	6.889	0.561	7.017	0.530
Clean	6.692	0.588	6.666	0.583	6.748	0.597
Quality	6.826	0.468	6.805	0.482	6.870	0.435
Harnony	6.450	0.525	6.457	0.522	6.435	0.532
Afterclean	6.894	0.414	6.857	0.421	6.974	0.391
Afterquality	6.618	0.510	6.580	0.508	6.700	0.508
IIE	7.399	0.369	7.370	0.379	7.460	0.339
IZOB	0.547	0.043	0.545	0.043	0.552	0.044
IIC	73.600	3.893	73.215	3.994	74.416	3.548
LFC1	0.000	1.000	0.145	0.980	−0.307	0.976
LFC2	0.000	1.000	−0.108	0.992	0.230	0.982
LFS1	0.000	1.000	0.105	1.034	−0.224	0.888
LFS2	0.000	1.000	−0.079	1.010	0.167	0.962
Binary variables	Sample composition (%)					
Montepulciano	4.20		4.50		3.50	
Other_S	35.70		37.30		32.20	
Aglianico	4.50		3.30		7.00	
Merlot	4.50		4.90		3.50	
Valtellina	3.90		2.00		7.80	
Other_G	8.40		7.40		10.40	
Barbera	3.60		4.50		1.70	
Dolcetto	3.90		4.10		3.50	
Nero_Avola	6.10		5.30		7.80	
Syrah	3.10		2.90		3.50	
Chianti	10.9		11.50		9.60	
Cabernet	3.60		3.70		3.50	
Nebbiolo	3.30		2.90		4.30	
Sangiovese	4.50		5.70		1.70	
Other_C	15.60		18.40		9.60	
Other_N	15.90		12.30		23.50	
Other_Su	14.80		13.90		16.50	
Piedmont	15.00		16.40		12.20	
Sicily	13.10		11.50		16.50	
Veneto	7.50		9.80		2.60	
Tuscany	18.10		17.60		19.10	

In the following we describe for each category the available variables, while in Table 1 we have recorded the most important statistical descriptors of each variable.

3.1. Label variables

In our sample we use several variables that can be inferred from the label; they can be organised in the following categories:

(1) three different appellation levels (*DOC,* Denominazione di Origine Controllata, Controlled Designation of Origin; *DOCG*, Denominazione di Origine controllata e Garantita, Controlled and Guaranteed Designation of Origin; *IGT, Indicazione Geografica Tipica, Geographical Denomination).* Such variable represents both a reputation and a cost variable. For an appellation to be attributed to a wine, the producer has to fulfill specific production rules (including limitations in yields). This process increases cost, but it may also be interpreted as signal to the consumer of superior quality (for further details and a presentation of the denomination of origin used in Italy, see Corrado & Odorici, 2007). About 60% of the wines have a DOC appellation, 18.5% are DOCG and 20% IGT. Our sample is a good approximation of the market for wine in Italy. According to Ismea Nielsen (2009a) about 2/3 of wines are DOC, 25% IGT and 9% DOCG. In our sample DOCG are overestimated and IGT underestimated. However such data refers to white and red wines, while in our sample we have considered only red wines where the DOCG appellation is more frequent;
(2) some less verifiable elements related to quality such as "superiore" (*Superior*) and "riserva" (*Reserve*). Only DOC wines can use this further appellation and very few wines in our sample present this indication on the label (about 0.3% and 1%, respectively);
(3) the appellation (*AP*) on the bottle which may represent the type of grape used to produce the wine (*Nebbiolo*), a blend (*Rosso* di Montalcino) or maturation before being sold.[1] In our sample we have 47 different appellations that have been modelled as binary variables;
(4) the Region of production (REG). In our sample we have wine from 18 Italian Regions; the most represented is Tuscany, followed by Piedmont, Lombardy and Veneto. The regional distribution of the sample basically reflects the production of red wine in Italy;
(5) the declared alcoholic content (Alcdic).

3.2. Chemical variables

This is a set of variables that measure objective characteristics of the wine and it is aimed at checking that wine making has been carried out according to rules, and that the wine is well preserved. Some of these characteristics also determine the flavour, taste and finish of the wine. In our database the following variables have been recorded for each bottle:

(1) the verified alcoholic content (*Alcver*). This variable is very similar to the declared content. It is a more continuous variable given that on the label the content is expressed in grades and half grades. In our data, we note a downward estimation of the alcoholic content since the sample mean of the verified alcoholic content is slightly higher than for the declared content;
(2) residual sugar (*Sugar*) which measures the presence of glucose, fructose and other sugars. It determines the organolectic characteristics of the wine;
(3) volatile acidity (*Acivol*) determined by the quantity of acetic acid. It is a quality index which signals how well the wine is preserved and how it fermented. If the volatile acidity is higher than 1.2 g/l the wine cannot be sold;
(4) total acidity (*Acitot*) which by convention is represented by the grams of tartaric acid. It influences the flavour of the wine; the total acidity level of a well preserved red wine should range between 4.5 and 7.5 g/l;
(5) sulphur anhydrides (SO_2), it is an additive used in the wine making process which alters the characteristic of the wine. It helps in the wine making process, but it is dangerous and the law fixes precise maximum levels for this additive: for red wine the maximum allowed level is 160 mg/l;
(6) the ratio between free sulphur anhydrides and total (RSO_2). The former has an antiseptic and antioxidant action. This index allows us to infer the quality of the technology used for wine making; wine obtained with high-level production technologies should have a ratio greater than 0.3.

More detailed explanations about the meaning of the chemical variables can be found also in Altroconsumo's guide.

3.3. Sensory variables

The Altroconsumo guide takes into account also the sensory aspect of the wines. In order to achieve this goal it relies on the collaboration of Brescia's *Centro Studi Assaggiatori.*

Each year the Centro Studi Assaggiatori assesses the sensory characteristics of the wine selected by Altroconsumo. An average of 21 judges divided into three panels evaluate the sensory characteristics of wines of our sample. They all are experienced judges with several specific qualifications who have been grouped into panels balanced in terms of age, sex and experience. The tasting is blind with replication. The judges are asked to give a grade to the most important sensory variables used, such as:

- the appearance of the wine which is described by: the intensity of the colour (*Colour*), for red wines by the presence of orange and violet reflections (*Orange–Violet*), the attraency (*Attraency*) which measures how pleasant the aspect of the wine is;
- the bouquet which is represented by the intensity of the bouquet (*Intolf*) and by the several perfumes that can be perceived in the wine (*Floral, Fruits, Vegetal, and Spicy*), how well they are perceived (*Clean*) and how well they are harmonized (*Quality*);
- the flavour which is described by its structure (*Structure*), the harmony of the different components (*Roundness and Harmony*), the taste and mouth feel (*acidity, bitterness, and astringency*) and finish (*Aromrich and Persistency*), with two specific variables for the cleanness and the quality of aftertaste (*Afterclean,an Afterquality*);
- an overall evaluation of the wine (*Overall*).

The perception of each descriptor is recorded using a 0–9 scale where 0 denotes the lowest and 9 the highest score.

Scores: In the Altroconsumo datates the scores of the sensory analysis are summarised by the following indices:

1. *Hedonic index* (*IE*) which determines the score as the average of *Attraency, Clean, Quality, Harmony, Afterclean, Afterquality and Overall.*
2. *ZOB index* which determines the score as the average of the following quality parameters: *Colour, Roundness, Structure, Flower, Fruit, Spicy* (Zironi, Odello, & Brentari, 2003).

[1] Barolo and Barbaresco are both made with Nebbiolo grapes. The main difference between the two is that the Disciplinary text imposes at least two years maturation for Barbaresco and two years for Barolo.

3. *Competition index* (*IC*) which determines the quality level as the average of the scores obtained on *Structure, Finish, Attraency, Cleanness, Harmony* and is largely used in wine competitions.

Given that these indices do not use the same scale, they have been harmonized in a 0–5 score (*Puzob, Puie, Puic, Pfin*) through a simple arithmetic procedure. The details about their construction and motivation can be found in the Altroconsumo guide.

3.4. Prices

For bottles of wine sold through the *GDO*, Altroconsumo uses the IRI Infoscan prices (p_{GDO}), for those sold through wine shops (p_{ENO}) an *ad hoc* market analysis has been performed.

For each bottle of wine both prices are available unless the wine is sold only via one channel. To study the effect of the distribution channel we introduced three dummy variables: *ENOp* which takes the value of 1 if the price is for the wine sold in the wine shop and 0 otherwise; *GDOn* which takes the value of 1 if the wine is sold only through the large-scale retail trade and *ENOn* which takes the value of 1 if the wine is sold only in wine shops.

4. The model

Although various approaches could be used to estimate the price of wine, the vast majority of the literature adopts the hedonic price approach. The general specification of a hedonic price function is given by:

$$E(p) = g(Z)$$

where $E(p)$ is the expected value of price and Z is a vector of observable characteristics which for our analysis can be written as:

$$E(p) = g(L, C, S, D)$$

where L groups the characteristics of the wine that can be inferred from the label, C its chemical characteristics, S the sensory characteristics and D the variables that describe the distribution process.

As previously stated, the aprioristic characteristic of hedonic price estimation means that the dataset on which the estimation is performed has a great number of explanatory variables none of which can be excluded a priori. This may be a serious impairment to the use of these techniques if the objective is a more refined analysis than a simple investigation of the main determinants of price formation. For this reason in this paper we have used two approaches to reduce the number of explanatory variables. For the wines with more than 10 observations (*Aglianico, Barbera, Dolcetto, Nero d'Avola, Syrah, Chianti, Cabernet, Nebbiolo, Sangiovese*) a specific dummy variable has been defined. The other wines have been grouped into two appellations: *Other_S* (*Lagrein, Sacravite, Cirò, Refosco dal Peduncolo Rosso, Terre Di Franciacorta, Barolo, Grignolino d'Asti, Primitivo del Salento, Isola dei Nuraghi, Monica di Sardegna, Morellino di Scansano, Teroldego, Amarone, Cannonau di Sardegna, Montefalco Rosso, Negramaro del Salento, Rosso Conero, Pomino Rosso, Rosso di Montalcino*) which comprises well-known specific appellations, for the most part DOC and DOCG, and *Other_G* (*Sicilia, Toscana, Venezia Giulia*) which comprises less known and more generic appellations.

The same grouping was performed for regions. In this case the cut-off mark is set at 20 observations. For this reason Piedmont, Tuscany, Veneto and Sicily are considered separately through a specific dummy, all the others have been grouped into three variables according to the geographical position of each region (North: *Other_N*; Centre: *Other_C*; South: *Other_SU*).

4.1. Latent factors for wine quality formation

As pointed out before, the impact of chemical and sensory variables on price has been widely explored in the literature. Similarly to what was found in other studies, also with this dataset the empirical evidence has suggested that chemical and sensory variables, although important in explaining quality, apparently do not play a role in determination of the market price (Brentari & Levaggi, 2010). Starting from the assumption that the variables explaining quality should be important for price formation, Brentari and Zuccolotto (2010a) make use of a dimensionality reduction technique in order to define latent factors able to capture the quality of wine. Following Brentari and Zuccolotto (2010a), we have carried out a canonical correlation analysis between the set C and S of chemical and sensory variables. *Canonical correlation analysis* (CCA), introduced by Hotelling, 1936, is a multivariate statistical technique aimed at defining the coordinate system that describes the maximum cross-covariance between two datasets. More specifically, let X_1 and X_2 be the vectors containing the p_1 chemical variables and the p_2 sensory variables in the set C and S respectively. The objective of CCA is to find successively for $k = 1, 2,\ldots, \min[p_1, p_2]$, pairs $\{\alpha_{k1}X_1, \alpha_{k2}X_2\}$ of linear functions of X_1 and X_2 respectively, called *canonical variates*, such that the correlation between $\alpha_{k1}X_1$ and $\alpha_{k2}X_2$ is maximized, subject to $\alpha_{k1}X_1$ and $\alpha_{k2}X_2$ both being uncorrelated with $\alpha_{jh}X_h$, $j = 1, 2, \ldots, (k-1)$, $h = 1, 2$. The correlation coefficient $\rho_k = \mathrm{Corr}(\alpha_{k1}X_1, \alpha_{k2}X_2)$ is called k-th canonical correlation coefficient. Formally, we denote with Σ_C and Σ_S the variance-covariance matrix of X_1 and X_2 respectively and with $\Sigma_{CS}t\ \Sigma_{SC}$) their cross-covariance matrix, where the symbol $t(\cdot)$ stands for matrix transposition. It can be shown that the vectors α_{k1} and α_{k2} defining the canonical variates are given by the eigenvectors of the matrices $\Sigma_C{}^{-1}\ \Sigma_{CS}\ \Sigma_S{}^{-1}\ \Sigma_{SC}$ and $\Sigma_S{}^{-1}\ \Sigma_{SC}\ \Sigma_C{}^{-1}\ \Sigma_{CS}$, respectively, sharing the same eigenvalues, which are equal to the squared canonical correlation coefficients. In this context, CCA applied to the set C and S of chemical and sensory variables leads to the construction of some chemical and sensory latent factors, given respectively by $\alpha_{k1}X_1$ and $\alpha_{k2}X_2$. In doing so, we rely on the conjecture that forcing chemical and sensory latent factors to be correlated with each other should hopefully result in latent factors globally correlated with the wine's quality. We have decided to use only the first two latent factors ($k = 1, 2$), exhibiting the most significant canonical correlation coefficients. Hereafter the latent factors will be denoted by $LFC_1 = \alpha_{11}X_1$, $LFC_2 = \alpha_{21}X_1$, $LFS_1 = \alpha_{12}X_2$, $LFS_2 = \alpha_{22}X_2$ (respectively the first and the second chemical and sensory latent factors). Their canonical correlation coefficients are given by $\rho_1 = \rho(LFC_1, LFS_1) = 0.68$ and $\rho_2 = \rho(LFC_2, LFS_2) = 0.57$. They will be added to the database and used as explanatory variables as shown in the following sections. For interpretation purpose, it is important to point out that the meaning of the latent factors can't be related to the single characteristics which enter the linear combination: they have to be regarded as composite overall sensory and chemical quality indices.

4.2. Functional form

For hedonic price, the functional form to be estimated is a matter of empirical investigation. In our study we restricted the choice to linear and log linear equations and performed a RESET test to choose the functional form. The RESET test is 40.19 for the linear form and 1.79 for the log linear form, hence the latter should be used. The same result is obtained via comparison of the R^2 (0.8010 and 0.8082, respectively).

The characteristic of our dataset allows us to run three separate regressions for price formation in the market as a whole and in the two subsets represented by large-scale distribution and the wine shops.

Table 2
Explicative power of the single group of variables.

Dependent variable	Complete	Hedonic	Latent variables	Mix 1	Mix 2
p					
R^2 (adjusted in brackets)	0.820 (0.809)	0.811 (0.803)	0.800 (0.791)	0.803 (0.795)	0.814 (0.805)
p_{GDO}					
R^2 (adjusted in brackets)	0.790 (0.775)	0.790 (0.775)	0.768 (0.756)	0.764 (0.761)	0.790 (0.775)
p_{ENO}					
R^2 (adjusted in brackets)	0.722 (0.692)	0.670 (0.641)	0.642 (0.610)	0.671 (0.643)	0.716 (0.686)

5. Results

In this section we present the results of our model. To test for the presence of different retailing strategies, we have estimated a single equation for the price of the red wine sold in Italy and two separate regressions according to the distribution channel used by the producer.

5.1. Price of the red wine

The equation that has been estimated will then be as follows:

$$\ln p = k + aDOC + bDOCG + \sum_{i=1}^{10} c_i AP_i + \sum_{i=1}^{6} d_i REG_i + \sum_i e_i C_i + \sum f_i S_i + \sum^{4} g_i Scor + \sum_{i=1}^{2} k_i LFC_i + \sum_{i=1}^{2} l_i LFS_i + mENOp + nGDOn + qENOn + \varepsilon_i$$

In order to gain a better understanding of the determinants of price formation, we ran a regression using all the variables and separate regressions where subsets of the explanatory variables were used. We then compared the explanatory power of each group in order to test whether sensory and chemical variables as a whole have an influence in price formation. Several tests were run for homoscedasticity and normality of residuals. They are all satisfactory and suggest that neither hypothesis can be rejected.

The results are presented in Table 2 where we have reported the R^2 (unadjusted and adjusted) of the complete regression and of the following variables combinations:

- Hedonic: we have used all the variables described in Section 3 and we have excluded the four latent factors derived in the previous section;
- Latent factors: all the sensory and chemical variables have been replaced with the four latent factors obtained by CCA;
- Mix 1: original chemical variables and sensory latent factors;
- Mix 2: original sensory variables and chemical latent factors.

A stepwise regression (forward and backward) procedure has been performed for each market we have considered in order to include only the significant variables. For the full sample, the complete regression has the highest explanatory power. In fact the stepwise procedure has included both latent factors and single chemical and sensory variables. The complete set of the explanatory variables is presented in Table 3. About 80% of the total variance in price is explained by the model, thus suggesting that the market power of each producer and of omitted variables may account for 20% at the most. The distribution channel is important; when the wine is sold in the wine shops, its price is on average 15% higher than in the large-scale retail trade[2]; if the wine is sold only in the latter, the price difference increases to about 35%. The alcohol content is as important as label characteristics. In particular the appellation can increase the price as in the case of the wine with a higher reputation (*Aglianico*:+44%; *Other_S*:+22%) or it may decrease it for the wine with a lower reputation or with a strong taste.

It is interesting to note that both the sensory latent factors and sensory variables enter the regression. This is because the market is particularly responsive to specific characteristics of the wine such as the alcohol content, but also to an overall judgement of the taste of the wine according to the buyers in the wine shops. It is our opinion that these results can be interpreted in line with the qualitative evidences that can be derived from market analyses of Italian wine consumers. In fact, according to Ismea (2008) several types of consumers coexist in the market. A first category consists of the less educated consumers, that mostly use information on the label to make their purchase. In this case they choose the wine on the basis of the alcoholic content, and they interpret the appellation level as a proxy for the quality of the wine. A second category is represented by more sophisticated consumers who have already tasted the wine, know its characteristics and buy it through the large-scale retail trade for reasons of time or price. Our idea is that both of them in this market take account of what is written on the label: the former because they are uneducated, the latter because for them it is a repeat purchase. On the other hand, we argue that in the wine shop market the purchase may be more related to specific characteristics of the wine either because the consumer is an expert or because his choice is influenced by the advice of an expert (the shopkeeper). Some of these effects may however be determined by retail strategies as shown in Table 1. The descriptive statistics of the complete set and the two samples show that the price difference is substantially higher (about 60% against our 35% estimation) than the simple distribution channel we have isolated, but it also shows that the composition of the sample is rather different. The sale of the wines with a higher reputation (*Aglianico*, *Valtellina*) is concentrated through wine shops. For this reason, we have estimated our model separately for each distribution channel.

5.2. Price of wine in large-scale retail trade

The equation that has been estimated will then be as follows:

$$\ln p_{GDO} = k + aDOC + bDOCG + \sum_{i=1}^{11} c_i AP_i + \sum_{i=1}^{6} d_i REG_i + \sum_i e_i C_i + \sum f_i S_i + \sum^{4} g_i Scor + \sum_{1}^{2} k_i LFC_i + \sum_{1}^{2} l_i LFS_i + nGDOn + \varepsilon_i$$

For the wine sold via large-scale distribution, the pure hedonic regression has the highest explanatory power. In fact the stepwise procedure has excluded all the quality and chemical latent factors. The complete set of the explanatory variables is presented in Table 3. The model explains about 80% of the total variance in price. Even in this more homogeneous subsample, the distribution channel is important; wine sold only through the *GDO* channel is

[2] The effect of a binary variable on price is equal to $\frac{\Delta p}{p} = e^c - 1$, where c is the coefficient of the parameter obtained through OLS. When two variables interact, their combined effect can be evaluated as follows: $\frac{\Delta p}{p} = e^{c+d} - 1$. See Halvorsen and Palmquist (1980).

Table 3
Stepwise regression. Prices in the large-scale retail trade and in wine shops.

Variables	Complete	p*GDO*	pENO
Constant	−1.86 (4.38)	−2.79 (7.98)	0.663 (2.81)
DOCG	0.334 (8.37)	0.398 (8.54)	0.392 (6.21)
Aglianico	0.366 (5.13)	0.562 (5.59)	0.270 (2.80)
Barbera	−0.377 (5.07)		
Dolcetto		0.250 (3.10)	
Nebbiolo		0.426 (4.35)	
Nero D'Avola	−0.241 (4.21)		−0.224 (2.98)
Sangiovese		0.156 (2.02)	
Syriah	−0.182 (2.40)		
Other_S	0.204 (6.46)	0.331 (8.31)	0.252 (5.21)
Piedmont	0.250 (5.63)		0.189 (3.06)
Other_N	0.110 (2.78)	0.143 (2.77)	
Other _C	−0.292 (7.22)	−0.335 (6.77)	−0.152 (2.24)
Other_S	−0.364 (7.33)	−0.410 (6.98)	−0.404 (5.34)
Alcver	0.272 (10.7)	0.299 (9.77)	
Sugar			−0.035 (2.55)
Acivol	0.350 (2.61)		
Orange	−0.032 (2.45)		
Bittteness	−0.048 (2.12)	−0.081 (2.76)	
Astringency		0.079 (3.54)	
Quality	−0.065 (2.08)		
Persistency		0.072 (2.78)	
Afterclean	0.100 (2.87)		0.195 (3.75)
LFC1			0.159 (7.95)
LFS1	0.0744 (4.38)		
LFS2			0.054 (2.33)
ENOp	0.134 (4.04)		
GDOn	−0.271 (7.60)	−0.291 (7.68)	
R^{2**}	0.820 (0.809)	0.790 (0.775)	0.722 (0.692)
N	359	244	115
LL	40.60	16.79	32.33
LM	0.551	0.433	0.688
JB	6.38	2.71	0.29

* In brackets Student's *t* statistics.
** In brackets the adjusted R^2.

about 30% cheaper. Selling using both channels allows the producer to get a higher price in this market. There are several reasons for this result: it may be a reputation or a quality effect. This result is confirmed by other studies (Defrancesco & Trestini, 2008). The alcohol content is as important as the label characteristics. As shown in Table 3, most of the appellations considered enter the regression function and for those that were significant also in the complete regression, their effect is higher[3]. This means that producers in this market use the reputation effect of the appellation.

5.3. Price in wine shops

In this case the equation to be estimated can be written as:

$$\ln p_{ENO} = k + aDOC + bDOCG + \sum_{i=1}^{11} c_i AP_i + \sum_{i=1}^{6} d_i REG_i + \sum_i e_i C_i + \sum f_i S_i + \sum^{4} g_i Scor + \sum_{1}^{2} k_i LFC_i + \sum_{1}^{2} l_i LFS_i + nENOn + \varepsilon_i$$

As regards the price of the wine sold in the wine shops, a combination of hedonic price estimation and quality indices has the highest explanatory power. In fact the stepwise procedure has not excluded all the latent factors, but some of the chemical and sensory characteristics have a significant influence on price formation. The complete set of the explanatory variables is presented in Table 3. The alcohol content is no longer included among the important regressors, while our latent variables for chemical and sensory characteristics are significant. Their sign indicates that the overall sensory and chemical quality described by the latent factors positively affects the market price. The quantity of sugar has the expected sign in this market (sugary wines are more palatable, but they are not necessarily of good quality). Only a few characteristics can be inferred from the label such as specific appellations (*Aglianico*) or clear identifiable quality indicators (DOCG).This result shows that price formation in this market is significantly different from the large-scale retail trade.

[3] For *Aglianico*, for example, the premium is 44% in the complete set and 75% in this regression.

6. Conclusions

In this paper we present a hedonic price model concerning Italian red wines. The aim of the analysis was twofold, as attention was concentrated both on the determinants of wine prices and on the effect of distribution channels. Despite the importance of the Italian wine market, in the literature we find only a few attempts to evaluate the determinants of the price and most contributions deal with a specific type of grape or appellation, without looking more widely at the entire market. In this article we have tried to fill this gap by using the unique dataset presented by Altroconsumo in its yearly Guide. The dataset contains the so-called label variables, some chemical characteristics and sensory variables obtained by means of jury grades. In fact, one of its most noticeable virtues is the availability of all these different kinds of variables in a unique frame, even if each category (label, chemical, and sensory) is described only by means of its basic descriptors. More specifically, some experts have concerns about the lack of some important chemical variables, like for example tannin analyses, which could affect the results. As future research we intend to build a possibly more complete dataset. In spite of this deficiency, we find that the results we obtained exhibit some important evidence also from the chemical point of view.

From a statistical point of view, the main proposal of this paper is to use a two-step procedure consisting in preliminarily using a dimensionality reduction technique in order to create some composite chemical and sensory latent factors, which are subsequently included as covariates in a linear stepwise regression together with label variables.

The analysis shows that the price formation mechanism is different in the large-scale retail trade and in wine shops. This difference is not merely represented by a price gap, because the supply of the two channels is partly different, reflecting the diverse kind of demand. In fact, consumers who buy through the large-scale retail trade are either not sophisticated or have tasted the wine elsewhere and use this channel for price convenience. For this reason, in large-scale distribution, selling sophisticated and quite unknown wines is disadvantageous, whereas in wine shops the consumer is more aware of the intrinsic quality of wine and is conscious that the price reflects this characteristic. He basically seeks, beyond the wine, some experienced consulting. The determinants of wine price, as have emerged from the analysis presented, for the most part reflect these differences between the two channels. The most remarkable results are concerned with the traditional dilemma of whether the leading role in price determination is played by label or chemical/sensory variables. It is well-known that the literature is not unanimous on this point. Although the positive influence of sensory qualities has been demonstrated by several authors, they also frequently found that this influence is relatively less important than that of the label characteristics. Several chemical and sensory variables which could determine or explain quality apparently do not play a role in determination of the market price. In this paper the construction of chemical and sensory composite variables by means of the first

step of the statistical procedure seems to overcome this problem. In fact, the latent factors appear among the most influential variables, thus confirming that the price determination mechanism is affected by a mix of variables. The linear functional form of the employed model accounts for a great part of variability, nonetheless in our future research we intend to fit data with some nonlinear or algorithmic techniques, in order to model a possibly complex set of relationships among the involved variables.

Another important conclusion is that there is an asymmetric effect of the distribution channel on the price. The use of the double channel (*GDO* and wine shops), while not affecting the price in wine shops, has a positive impact on the price in *GDO*. The latter link is expected and confirmed by other studies, while the former had never been detected before. This can help producers to resort to the use of both channels as a distributive strategy. It allows them to rely on the reputation effect due to selling through wine shops, in order to increase the price in *GDO* without suffering a price reduction in the top price market.

It is our opinion that this analysis cannot be carried out on a sample of mixed red and white wines because of the profound differences in their chemical and sensory characteristics. For this reason we chose to analyse only red wines. In our future research we aim to extend the study to white wines, taking into account their peculiarities.

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