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Abstract

Purpose – Given the growing supply of wines and the large number of new consumers with purchasing power but lacking knowledge of the subtleties of high-quality wines, expert opinions are used for consumers as proxies for quality. This study aims to determine the determinants of prices in top-quality wine market. The authors also seek to estimate the role for country of origin, grape, producing region and winery in prices. And, finally, the authors try to show how countries, regions and wineries can help increase their position in international rankings.

Design/methodology/approach – The authors try to answer: What factors explain the price of top-quality wines (defined as best rated in a standardized ranking)? To some extent, in the hands of producers influence prices, which imply long-term decisions or large investments in land and marketing. Other variables that consumer value does affect prices. The authors try also to detect undervalued or overvalued wines, grapes, regions, wineries or producer countries. The authors estimate an econometric model of hedonic prices using a 14-year sample of the Wine Spectator's 100 top-rated wines for the American market between 2003 and 2016, totaling 1,400 observations. The sample is a great cross-section because each wine is unique.

Findings – The authors' contribution is twofold: the determination of the price explanatory values and the identification and attribution of price differences by country, grape, region and winery. Also, the authors detected grapes, countries, regions and wineries which are overvalued or undervalued with respect to the average prediction of the model.

Research limitations/implications – The findings are useful to understand the role of price explanatory variables, as well as for making policy and managerial decisions. From the model, collective or managerial actions can be derived to increase particular wines' positions in international rankings. The proxy for "quality" in the study is not the only possible definition.

Practical implications – In some cases, managerial choices could be conditioned by the policies or history. There is some room for collective action and public policies to improve regions' and countries' reputation.

Social implications – There are clear synergies for policies that can raise the prestige of countries and regions and their spillovers on the brand name reputation of individual wineries.

Originality/value – The results, policy and managerial implications are of interest for business, countries interested in improving their position in international rankings and for consumers to make more informed decisions.

Keywords Economics, Pricing, Quality assessment, Econometric model, Economic sectors, Hedonic model, Quality ratings, Wine prices

Paper type Research paper

1. Introduction

Given the growing supply of wines and the large number of new consumers with purchasing power but lacking knowledge of the subtleties of high-quality wines, expert opinions are used for consumers as proxies for quality.

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Expert scores are a matter of debate: some analysts claim the price can be determined only by the weather conditions of the vintage; others criticize the rankings for their subjectivity and inconsistency (no universal consensus exists and a top wine in one contest does not necessarily guarantee a similar consideration in other competitions). What does matter is whether consumers consider the score as a proxy of quality. In a meta-regression analysis, Oczkowski and Doucouliagos (2015) find that, in 90 per cent out of 180 hedonic price studies accumulated over 20 years, the simple correlation between wine price and points is +0.3, while in our sample of top-quality wines, it exceeds +0.7, suggesting that consumers are more intensively influenced by quality signals in this market.

We try to answer what factors explain the price of top-quality wines, defined as best rated in a standardized ranking. That definition is not the only possible when studying quality, but has some advantages: first, it provides a cardinal measure of "quality", set by an uniform criteria; second, because of the consumers' sensitivity to the rankings, it can be said that they react "as if" at some extent rankings proxied quality. We are also aware that there are more than one ranking and that there are not universal consensus among them, and that intrinsic effect of quality on prices can be biased by reputation or publicity factors. Finally, we aim to orientate collective or managerial action for countries, regions and wineries who want to improve their position in international rankings.

In the prices' explanatory factors, there are elements to some extent, in the hands of producers, which imply long-term decisions or large investments in land and marketing. There are also variables that consumers value affecting prices. We are also interested in detecting undervalued or overvalued wines, grapes, regions, wineries or producer countries.

We estimate an econometric model of hedonic prices using a 14-year sample of the Wine Spectator's 100 top-rated wines for the American market between 2003 and 2016, totaling 1,400 observations. The sample is a great cross-section because each wine is unique.

Our contribution is twofold: the determination of the price explanatory values and the identification and attribution of price differences by country, grape, region and winery. We conclude that price can be explained by quantity, quality (as approximated by rates in a top-quality ranking), some rough classifications of wines made by the ranking responsibles ("elegant reds" and "big reds") and storage time. Also, we detected grapes, countries, regions and wineries which are overvalued or undervalued with respect to the average prediction of the sample, even when there are no significant effects on prices for most of the regions and wineries.

The model can help winery managers in better pricing their wine according to their attributes; can orientate collective actions from wineries sharing an ill-reputed region or country; can inspire policies to promote top-down actions in favor of grapes, producer regions or countries; and can help consumers to better informed decisions.

Section 2 presents the literature review and Section 3 describes the methodology, including the theory of hedonic prices, the model and estimation procedure. Sections 4, 5 and 6 present the database, the discussion of the results and conclusions, respectively.

2. Literature

Our work rests on the literature of hedonic prices and recent empirical research on wine economics. We discuss the wine economics literature related to our paper in this section.

Oczkowski (1994), who studied Australian and New Zealand wines based on 1991-1992 data, tried to detect the influence of grape regions on prices and found mixed results with most grape regions having major price effects.

Accumulated evidence suggests that wine prices depend on quality, reputation and objective characteristics. Oczkowski's (2001) study of Australian premium wines finds

significant reputation effects but insignificant quality effects – proxied by points in a ranking.

Schamel (2003a) develops a hedonic pricing model for German quality wine. Sensorial quality awards have a statistically significant and positive price impact. There are also significant relative differences between growing regions and other control variables.

Using California wine data from Wine Spectator, Bombrun and Sumner (2003) established that recognized California place names, as well as specific local appellations, commanded substantial premiums, holding other factors like variety, expert score, vintage and the age of wine constant.

If quality signals improve over time with the quality performance of a wine producer, possible spillovers will affect other producers within the same region. Schamel (2003b) estimates a hedonic pricing model for premium California wine. The data confirm that a wine's price is related to its own quality and to producer/regional reputation for quality.

Schamel and Anderson (2003) estimate hedonic price functions for premium wine from Australia and New Zealand. In each country, price premia associated with both sensorial quality ratings, winery ratings and designations are statistically significant. In addition, Bicknell *et al.* (2005) estimate a hedonic price analysis of premium wines in New Zealand. The results show that the price premium associated with a quality rating is increasingly statistically significant throughout the study's period.

Lecocq and Visser (2006) develop a hedonic model for Bordeaux and Burgundy wines, including objective characteristics appearing on the label, as well as sensory characteristics and a grade assigned by expert tasters. A particularity of their analysis is that rates are assigned by blind testing.

Troncoso and Aguirre (2006) develop a hedonic function relating the retail price of Chilean wine in the US market to a number of relevant variables. The overall conclusion is that variety and location are more influential for the commercial success of wines than quality ratings and aging. Nevertheless, Costanigro *et al.* (2007) indicate that the grape region becomes less important as the wine market becomes more exclusive. In contrast, Ribeiro and Santos (2007), studying Portuguese quality wine and the region's effect on consumers' and retailers' perceptions, find that factor to be crucial.

Schamel and Anderson (2003) estimate hedonic price functions for premium wines from Australia and New Zealand. They find a clear trend toward greater regional differentiation, particularly in Australia. San Martín *et al.* (2008) estimate a hedonic price function for Argentine wines in the US market to evaluate the effect of a wine's most important attributes on price. The results show that labeling practices and the choice of the right wine's quality attributes are far more influential than expert panel opinions or oenological wine improvements, such as age.

Malorgio *et al.* (2008) analyze habits and motivations behind wine consumption in Italy and focuses on the attributes affecting wine choice. They conclude that consumers are interested in a wide concept of quality, which covers the whole production process. Both the notoriety of the industrial brand and the designation of origin constitute important quality signals.

Taylor and Barber's (2009) study suggests that the wholesale price and vintage of a wine are significant in the prediction of the wine's rating. Instead, Schamel (2009) assumes that consumers continue to regard regional origin as a dominant criterion in their wine-buying decisions. Oczkowski (2010) estimates a hedonic wine price function to predict "average" wine prices, and hence, to identify overpriced and underpriced wines. Estimates of the marginal attribute impact on Australian wines do differ with the distribution used. However, the performance of distribution differs according to price range.

Roberto Luppe *et al.* (2009) measure the impact of producing country, vintage, variety of grape and the specific growing region on the prices of Brazilian, Argentine and Chilean wines. According to Estrella Orrego *et al.*'s (2012) estimates, "Old and New World" consumers seem to value wine characteristics differently. Berríos and Saens (2012) relate price to quality and country brand. They find a positive and statistically significant relationship between price and quality and a stable penalty or premium by country.

Brentari *et al.* (2011) estimate a hedonic price function for Italian red wine sold in the domestic market for the period 2007-2008. They assess the importance of label characteristics, chemical and sensory features and panel judgements. Their analysis shows that price formation follows quite different patterns in the large-scale retail trade and in the wine shops.

Cuellar and Claps (2013) study the purchasing behavior of US wine consumers and show how brand, region and ratings interact, as well as how each has a different effect depending on price segments and varietal. They attribute these differences to unobserved heterogeneity across consumers who respond differently to quality signals.

Corsi and Strøm (2013) estimate a hedonic price function for Piedmont organic and conventional wines. They find that, along with characteristics that are of interest to consumers, like the appellation and the variety, some farm and producer characteristics that are not directly relevant for consumers do significantly affect wine prices.

Caracciolo *et al.* (2013) provide a monetary valuation of attributes, such as certifications and quality ratings given by expert tasters. Levaggi and Brentari (2014) study the main price determinants for Italian red wine sold in local markets. They conclude that, in the large-scale retail trade, consumers most value label characteristics, but only if they are verifiable. Label characteristics are also important in wine shops, but a selection process filters access to this market. Di Vita *et al.* (2015) analyze the role of wine attributes and their implicit price affecting wine consumers' choices of domestically consumed Sicilian wines. The results indicate that origin and geographical certification is the main determinant in the wine price and that certified wines achieve premium prices together with the wine price level.

Oczkowski and Doucouliagos (2015) consider over 180 hedonic wine price models developed over the past two decades that cover many countries. The research states that the price of wine and its sensorial quality rating has a partial correlation of +0.30 on average. This correlation is statistically significant in approximately 90 per cent of the cases. The results from the meta-regression analysis point to the absence of any publication bias and attribute the asymmetry in estimates to the studies' heterogeneity. The analysis suggests that the observed heterogeneity can be explained by the wine's reputation, the 100-point quality rating scale, the analysis of a single wine variety/style and the functional form used. The most important implication from the analysis is the relative importance of a wine's reputation over its sensorial quality, implying that producers need to sustain the sensorial quality of a wine over time to obtain satisfactory returns.

Oczkowski (2016) examines the impact of such attributes as sensorial quality, winery reputation and grape region on Australian wine hedonic price estimates. The main identified differences in estimates are related to the producer's size and some regional impacts, while an authoritative wine guide appears to have a negligible influence on prices in Australia.

3. Methodology

3.1 Hedonic price theory

The hedonic price theory originated in Lancaster (1966) approach to consumer theory and the later theoretical and empirical development by Rosen (1974). Lancaster (1966) proposes

that the intrinsic characteristics of goods yield utility, which are appreciated instead of the goods themselves. Rosen (1974) applies Lancaster's model to heterogeneous goods, which differentiates one from the other by their different attributes.

Rosen (1974) presents his model in a competitive market where goods are described by objective, quantitatively measurable characteristics. Each good is considered a bundle of characteristics. Therefore, the price of good z is defined as:

$$p(z) = p(z_1, ..., z_n) \tag{1}$$

Where z is a composed good integrated by i different attributes or characteristics, z_i, and n is the number of considered attributes. Rosen (1974) assumes that the bundle of offered characteristics is the same as the bundle of demand ones; buyers and sellers optimize their behavior; nobody can improve an individual situation given the choice made from all feasible options; equilibrium prices represented by $p(z)$ are determined by buyers' preferences and sellers' costs.

Let y be consumer income level which makes it possible to consume the differentiated good z and other goods x, and let $\omega(z_1,\ldots, z_n;u,\ \gamma)$ be a willingness to pay function or value curve for the characteristics of good z depending on the u level of the utility function $U(y - \omega, z_1,\ldots, z_n)$ and consumer characteristics γ. The expenditure at different $(z_1,\ldots, z_n)$ levels, given the values for u and y, is represented by the value curve $\omega(.)$. There will be different value curves $\omega(.)$ for different fixed levels of u.

Considering $p(z)$ as a function relating prices to characteristics, utility will be maximized when $\omega_{z_i}(z^*; u^*, y) = p_i(z^*)$, $I = 1, \ldots, n$ – where z^* and u^* are optimal quantities – that is, when the marginal rate of substitution between characteristics equals the relative price of the characteristics.

In addition, let $Q\ (z)$ be the units of z produced, and $C(Q, z;\varepsilon)$ be a total cost function, where ε reflects the technological and other characteristics of producers, considering the factor prices and the production function parameters. Each producer maximized a profit function $\pi = Qp(z) - C(Q, z_1,\ldots, z_n)$ choosing optimal quantities of Q and z, by equalizing the marginal revenue for (additional) attributes with the marginal cost of production. Thus, we can define a function $\varphi(z_1,\ldots, z_n;\pi,\ \varepsilon)$ relating the prices producers are willing to receive for different quantities of z given fixed levels of profits, and the optimum amount of z is determined by the condition $\varphi_{z_i}(z^*; \pi^*, \varepsilon) = p_i(z^*)$.

In sum, consumers maximize their utility when the price they pay in the market $p(z)$ equals their willingness to pay for z and suppliers maximize their profits when the price they achieve in the market $p(z)$ equals the cost of producing z.

To obtain the demand D and supply S functions of each characteristic of the good under analysis, the model consists of the following equation system:

$$p_i(z) = D^i(z_1, z_2, ..., z_n, \gamma) \tag{2}$$

$$p_i(z) = S^i(z_1, z_2, ..., z_n, \varepsilon) \tag{3}$$

Where γ is the consumers' characteristic vector (variables which influence their purchases) and ε characterizes the suppliers' technology or any other factor that can modify their cost conditions. Either p_i or z_i are jointly dependent variables and the vectors γ and ε, are exogenous variables.

3.2 Model

To apply this formulation to any market, a two-stage procedure is needed:

(1) Estimate $p_i(z)$ through the hedonic method, without γ or ε: this implies regressing the good's prices on all its characteristics, using the more appropriate functional form. Then, computing the set of marginal implicit prices $\partial p(z)/\partial z_i = \hat{p}_i(z)$ – evaluated at each characteristic quantity – which can vary according to the level of each characteristic depending on the functional form in use. If it is linear, the implicit price will not vary, making the second stage (estimating demand and supply characteristic functions) impossible due to the nil variability of the dependent variable.

(2) Use estimated marginal prices $\hat{p}_i(z)$ as endogenous variables in the second stage of the simultaneous estimation of equations (2) and (3), where vector γ (with buyers' characteristics) and ε (with suppliers' characteristics) are included in each equation.

In empirical studies, it is generally necessary to use equilibrium prices, which tend to create an "identification problem" in the single equation model. To address this, it is necessary to detect some relevant variables for supply and some for demand to avoid the unintended estimation of one of the two relationships.

The estimated model is:

$$p^{(\theta)} = \alpha + \sum_{j=1}^{J} \beta_j x_j^{(\lambda)} + \sum_{l=1}^{L} \gamma_l y_l^{(\lambda)} + \varepsilon \tag{4}$$

where x_j represents the characteristics of each wine (quantity, points, etc.) and y_l represents the other variables (such as, type of wine, grape, region, country and winery).

Of the hedonic price literature (see León, 2016, for a comprehensive study of the literature), the frequently used functional forms are logarithmic, semi-logarithmical (log-lin or lin-log) and the linear Box-Cox. The Box-Cox transformation (Box and Cox, 1964) not only proposes a flexible functional form, but also makes it possible to use the transformation to choose the best functional form between a set of possibilities as a good point of departure.

Following this methodology, the transformation of the dependent variable is:

$$Y(\theta) = \begin{cases} \dfrac{(Y^{\theta} - 1)}{\theta} & \text{if } (\theta \neq 0) \\ \ln y & \text{if } (\theta = 0) \end{cases} \tag{5}$$

θ being the parameter defining each transformation for the dependent variable.

The method also helps to transform the independent variables as (Greene, 2018):

$$y^{(\theta)} = \alpha + \sum\nolimits_{k=1}^{K} \beta_k x_k^{(\lambda)} + \varepsilon \tag{6}$$

where K is the number of total explanatory variables. θ and λ can be estimated for the same or different values of λ. Every regressor can be transformed by a different λ value. It is customarily assumed that λ value is the same for all the variables in the model.

According to the values θ and λ assume, and following equation (6), the functional forms are linear, semi-logarithmic (log-lin or lin-log) and logarithmic (or log-log) (Table I).

4. Database

In 1988, the publication *Wine Spectator* – the source of the database we built – began to publish its annual "Top 100 list" of best wines, whose latest rankings were selected from thousands of candidates. The ranking encompasses wines with scores between 90 and 100 points and enables us to build a database starting from 2003 and ending in 2016 (14 years), with data on price, production, quality (as proxied by the score), vintage, minimum years to release, maximum years to storage, country and region, grape (identifying varietals or blends) and winery.

The entire database includes 1,400 individual observations that are treated as a large pooled cross-section because each one is a different wine (some repetitions of brands exist, nevertheless, from different vintages). The list classifies wines in six broad categories (light whites, rich whites, elegant reds, big reds, rosé and sparkling[1]).

The formulation of a hedonic model entails the identification of attributes that are relevant to both supply and demand. Therefore, from the producers' perspective, we included attributes that influence costs and/or the productive process: time to start drinking, volume of production, region, grape varietal and winery. The first factor can vary greatly; in any case, the time of release implies a financial cost for the winery. Volume is also a producer decision. The region of production is important because every terroir has its distinctive characteristics and is an indicator of its collective regional reputation. Grape varieties differ in their difficulty to produce. Finally, the prestige associated with the winery condenses past achievements in quality and marketing investments to build a well-known brand, an indicator of individual reputation. In turn, from the consumers' point of view, important variables in their purchase decisions are the perception of quality implicit in an expert rating, origin associated with some desirable characteristic or reputation, and varietals or blends with some sensorial characteristics.

With respect to a possible simultaneity bias problem between PRICE and POINTS, note that the timing of the process is the following: the winery produces one wine with a specific quality and characteristics and puts it on point of sale shelves with some delay. The date of the score can or cannot be the same as the release of the wine. PRICE is determined in the market before the POINTS are assigned. Experts attribute POINTS based on sensorial attributes after the wine is produced and set the price. Consumers decide to buy the wine. Quantity is fixed and decreases over time given purchases and consumption.

Table II describes the database variables, which are grouped in four subsets:

(1) Qualitative variables, identifying each observation (year-ranking, position in the ranking, vintage and wine name).

(2) Quantitative variables, including the independent and the core of the explanatory ones (price, points scored in the ranking, production, minimum years before drinking and the maximum recommended years of storage and variants).

Values for θ and λ (*)	Function	Form	Marginal effect (implicit price)	Elasticities (∂Y/∂X) . (X/Y)
$\theta = \lambda = 1$	Linear	$Y = \alpha + \beta_1 X_1$	β_1	$\beta_1(X_1/Y)$
$\theta = \lambda = 0$	Logarithmic (Log-Log)	$\ln Y = \alpha + \beta_1 \ln X_1$	$\beta_1(Y/X_1)$	β_1
$\theta = 0, \lambda = 1$	Semi-logarithmic (Log – Lin)	$\ln Y = \alpha + \beta_1 X_1$	$\beta_1 Y$	$\beta_1 X_1$
$\theta = 1, \lambda = 0$	Semi-logarithmic (Lin – Log)	$Y = \alpha + \beta_1 \ln X_1$	β_1/X_1	β_1/Y

Note: (*) λ value is the same for all transformed dependent variables of the estimated model
Sources: León (2016), Griffith *et al.* (1997)

Table I.
Functional forms customarily used

Name	Meaning	Unit
YEARRANKING	*Year in which the wine was ranked*	*Year (2003-2016)*
POSITION	*Position in the ranking (1 to 100)*	*Unit*
VINTAGE	*Vintage year*	*Year*
NAME	*Wine denomination*	*Qualitative*
PRICE	Price in US dollars of 2010	Constant prices deflected with USCPI
POINTS	Points awarded by the specialized publication	Points (90 to 100)
PRODUCT	Production of each wine	Cases (produced in or imported to the US)
RELEASE	Years between the vintage year and the one suggested to start drinking	Years
STORAGE	Years between the vintage year and latest storage suggested year	Years
STORAGERANKING	Years between the ranking year and latest storage suggested year	Years
RELEASERANKING	Years between the release year and the ranking one	Years
VINTAGERANKING	Years between the vintage year and the ranking one	Years
STORAGERELEASE	Years remaining to storage from the release year	years
EURO	*European (the variable assumes value 1, else assumes value 0)*	Dummy
VARIETAL	*Varietal (the variable assumes value 1, for blends assumes value 0)*	Dummy
LIGHTW	*Light White (the variable assumes value 1, else assumes value 0)*	*Dummy*
RICHW	*Rich Whites (the variable assumes value 1, else assumes value 0)*	*Dummy*
ELERED	*Elegant Reds (the value assumes value 1, else assumes value 0)*	*Dummy*
BIGRED	*Big Reds (the value assumes value 1, else assumes value 0)*	*Dummy*
ROSÉ	*Rosé (the value assumes value 1, else assumes value 0)*	*Dummy*
SPARKLING	*Sparkling (the value assumes value 1, else assumes value 0)*	*Dummy*
COUNTRY	Country of origin	17 Country dummies
REGION	Region of origin	258 Region dummies
WINERY	Winery	780 Winery dummies
GRAPE	Identification for each varietal or blend	53 Varietal or blend dummies

Source: Own Elaboration on Wine Spectator's Top 100 Annual Rankings

Table II.
Database variables description

(3) Individual dummies, identifying whether the wine is a varietal grape or a blend, whether it belongs to one broad category and whether it is European or not.

(4) Dummies for each individual country, grape, region and winery.

Table III shows the descriptive statistics for the quantitative variables and the number of observations and average of the individual dummies. The latter illustrates the proportion of the observations which constitute each category. Thus, 52 per cent of the sample are

Variable	Observations	Mean	SD	Minimum	Maximum
PRICE	1,400	45.72	38.51	8.13	535.00
POINTS	1,400	92.88	2.21	90	100
PRODUCT	1,394	10,689	23,659	15	3,17,592
RELEASE	1,376	3.65	2.37	0	29
STORAGE	1,226	10.44	6.23	0	49
STORAGERANKING	1,249	7.65	5.74	0	46
RELEASERANKING	1,399	0.86	1.72	0	26
VINTAGERANKING	1,377	2.77	1.42	0	19
STORAGERELEASE	1,249	7.11	5.06	0	35
EURO	*1,400*	*0.5221*		*0*	*1*
VARIETAL	*1,400*	*0.6529*		0	1
LIGHTW	*1,400*	*0.1893*		*0*	*1*
RICHW	*1,400*	*0.0450*		*0*	*1*
ELERED	*1,400*	*0.1679*		*0*	*1*
BIGRED	*1,400*	*0.5707*		*0*	*1*
ROSÉ	*1,400*	*0.0042*		*0*	*1*
SPARKLING	*1,400*	*0.0229*		*0*	*1*

Source: Own elaboration on Wine Spectator's Top 100 Annual Rankings

Table III.
Descriptive statistics of the sample

European wines, 65 per cent are varietals (35 per cent are blends), 57 per cent are "big reds" (799 out of 1,400), 17 per cent are "elegant reds" (235 out of 1,400), 19 per cent are "light whites", 5 per cent are "rich whites" (63 out of 1,400), 0.4 per cent are "rosé" (6 out of 1,400) and 2.3 per cent are "sparkling" (32 out of 1,400). Wines from 17 countries[2], 258 regions, 780 wineries and 53 different grapes (with 52 varietals plus blends) were included.

Thus, Model (4) of PRICE to be estimated includes the quantitative variables POINTS, PRODUCT, VINTAGE, RELEASE, STORAGE (and the variants of the latter two), dummies for type of wine (i.e. big red), European or not, varietal or not, and individual dummies for country, region, grape and winery in vector Z.

We adopted the following procedure:

- The search for the model (variables that explain prices, including the influence of countries, regions, grapes and wineries), under five different functional forms (linear, log-lin, lin-log, log-log and "mixed", which is explained below), the "mixed" model being the best functional form, according to the Ramsey test for specification (Stage A).
- Some influences were deemed collinear and were dropped. Also, all the variables whose t statistic was <1 were dropped and the model was re-estimated (Stage B).
- All variables whose significance was <10 per cent were dropped and the model was re-estimated (Stage C).

All variables whose significance was <5 per cent were dropped and the model was re-estimated, ultimately determining the final model (Stage D).

5. Results

Table IV, presents the final estimated model of Stage D. The preferable functional form is called "mixed", in the sense that it is a mix between log-log and log-lin. The four Box-Cox specifications did not accept any null hypothesis related to specification; they could not

Observations	1222				
R^2	0.9214				
Root MSE	0.2191				
Core Variables	*Coeff.*	*Wineries (cont.)*	*Coeff.*	*Wineries (cont.)*	*Coeff.*
log points	14.1033*	Joseph Drouhin	0.9165*	Giuseppe Rinaldi	0.1962*
log product	–0.0605*	Cirq	0.9054*	Loring	0.1812*
varietal	–0.3777*	Clarendon Hills	0.8830*	Margerum	0.1742*
elegant red	–0.1611*	L'Ecole	0.8424*	Jolie-Pitt & Perrin	0.1708*
big red	–0.1065**	La Chablisienne	0.8320*	Leasingham	0.1563**
storage	0.0121*	Boars' View	0.8188*	Alain Graillot	0.1357**
constant	–59.7366*	La Rioja Alta	0.8133*	Feudo di Santa Croce	0.1250*
Countries	*Coeff.*	Lisini	0.8038*	Marcassin	0.1238*
Spain	0.3739*	Continuum	0.7892*	JC Cellars	0.0826**
France	–0.1811*	Didier Dagueneau	0.7749*	Domaine Gilles Noblet	0.0385*
Greece	–0.1906**	Caymus	0.7716*	De Martino	–0.0953*
Australia	–0.4217*	Masi	0.7548*	Joseph Swan	–0.1181*
Portugal	–0.4258*	Brancaia	0.7495*	Luigi Bosca	–0.1332*
Grapes	*Coeff.*	Achával-Ferrer	0.7340*	Gérard Bertrand	–0.1350*
Nero d'Avola	0.9180*	Johannishof	0.7199*	Luca	–0.1457*
Carmenère	0.8608*	Château Lagrézette	0.7025*	Epoch	–0.1537*
Aglianico	0.6043*	Hewitt	0.6760*	Château Brown	–0.1716*
Pinot Noir	0.5237*	K	0.6735*	Elio Grasso	–0.1726*
Nerello Masca	0.5181*	H. Dönnhoff	0.6645*	Claude Riffault	–0.1728*
Tannat	0.5025*	J.J. Vincent & Fils	0.6497*	J.F. Gonon	–0.1739**
Semillon	0.4877*	Les Verrières de Montagnac	0.6479*	Argyle	–0.1740**
Cabernet Sauvignon	0.4521*	Honig	0.6407*	Bertrand Stehelin	–0.1814*
Viognier	0.4434*	Finca Allende	0.6340*	Mas du Soleilla	–0.1825*
Pinotage	0.4223*	Grosset	0.6251*	Heath Wines	–0.1864*
Merlot	0.4077*	La Marca	0.6235*	Kumeu River	–0.1873**
Syrah	0.3626*	John Duval	0.6128*	A to Z Wineworks	–0.1928*
Falanghina	0.3098*	João Portugal Ramos	0.6123*	Coltibuono	–0.2018*
Malbec	0.2999*	Bodegas Muga	0.6106*	Acrobat	–0.2070*
Zinfandel	0.2460*	Bodegas Beronia	0.5900*	J. & F. Lurton	–0.2076*
Cabernet Franc	0.2407*	Celler Laurona	0.5839*	Maysara	–0.2091*
Corvina	0.1994*	Lagier Meredith	0.5761*	Can Blau	–0.2159*
Sangiovese	0.1987*	Il Poggione	0.5681*	King Estate	–0.2178*
Chardonnay	0.1418*	Bodegas Dinastía Vivanco	0.5641*	Louis Latour	–0.2212*
Godello	–0.2396*	Alban	0.5579*	Alois Lageder	–0.2255*
Viura	–0.3381*	Château Ste. Michelle-Dr. Loosen	0.5526*	Montecillo	–0.2291**
Regions of Origin	*Coeff.*	Josef Leitz	0.5525*	Domaine de Nizas	–0.2293*
Puligny-Montrachet (France)	1.2400*	Aubert	0.5513*	Domaine La Monardière	–0.2299*
Clos de Tart (France)	1.1898*	Bodegas Sierra Cantabria	0.5372*	Gramercy	–0.2340*
St. Julien (France)	1.1397*	Castello Banfi	0.5337*	La Massa	–0.2409*
Corton-Charlemagne (France)	1.1094*	Mamete Prevostini	0.5188**	Domaine de la Solitude	–0.2433*
Bordeaux (France)	1.0487*	Firriato	0.5167*	Matthews Claret	–0.2434*

(*continued*)

Table IV.
The estimated model ("mixed" functional form). Incidence on prices (dependent variable) of core independent variables, countries, grapes, regions of origin and winery

Côte-Rôtie (France)	0.9298*	Golan Heights Winery	0.5167*	Jermann	–0.2606*
Pauillac (France)	0.9231*	Marqués de Griñon	0.5159*	Mocali Brunello	–0.2630*
Colli della Toscana (Italy)	0.7493*	Hahn	0.5153*	Marchesi di Barolo	–0.2648*
Collines Rhodaniennes (France)	0.6818*	Barossa Valley Estate	0.5015*	Kim Crawford	–0.2659*
Margaret River (Australia)	0.5725*	Herman Story	0.4875*	Loosen Bros.	–0.2907*
Constantia Valley (South Africa)	0.5688*	DeLille D2	0.4790*	Cuvée du Vatican	–0.2967*
Sancerre (France)	0.5616*	Andrew Will	0.4787*	Le Macchiole	–0.2984*
Chassagne-Montrachet (France)	0.5577*	Massolino	0.4785*	Limerick Lane	–0.3003*
Médoc (France)	0.5422*	I Greppi	0.4745*	Bodegas Godeval	–0.3040*
Pouilly-Fuissé (France)	0.4846*	Moccagatta	0.4703*	Mommessin	–0.3102*
Cornas (France)	0.4758*	Marqués de Murrieta	0.4694*	La Valentina	–0.3201*
Puente Alto (Chile)	0.4649*	CVNE	0.4673*	Collosorbo	–0.3254*
St. Joseph (France)	0.4219*	Louis Roederer	0.4537*	M. Chapoutier	–0.3264*
St. Emilion (France)	0.4217*	Château Smith-Haut-Lafitte	0.4532*	Alexana	–0.3266*
Savennières (France)	0.4167*	Gunderloch	0.4440*	Morgan	–0.3296*
Châteauneuf-du-Pape (France)	0.4013*	Kongsgaard	0.4421*	Kono	–0.3299*
St. Aubin (France)	0.4001*	François Pelissié	0.4416*	Josmeyer	–0.3307*
Brunello di Montalcino (Italy)	0.3855*	Landmark	0.4326*	Arnaldo Caprai	–0.3362*
Coonawarra (Australia)	0.3834*	Mastroberardino	0.4297*	Godelia	–0.3402*
Westhofener (Germany)	0.3824*	Hartford Family	0.4171*	Iron Horse	–0.3433*
Chablis (France)	0.2980*	Lewis	0.4166*	Château La Roque	–0.3462*
Champagne (France)	0.2953*	Luce della Vite	0.4143*	Château de Lascaux	–0.3483*
Côtes du Jura (France)	0.2805*	Louis Chèze	0.4045*	Bodegas Cepa 21	–0.3495*
Barbaresco (Italy)	0.2243**	Darioush	0.4003*	Michele Chiarlo	–0.3521*
Chalone (France)	0.1565*	Hall	0.3970*	Lagar de Fornelos	–0.3547*
Stellenbosch (South Africa)	0.1429*	Krug	0.3970*	Fratelli Revello	–0.3554*
Carneros (USA)	–0.1327*	Monte Antico	0.3889*	La Serena	–0.3584*
Sonoma County (USA)	–0.1388**	Arcanum	0.3883*	Matetic	–0.3612*
Dry Creek Valley (USA)	–0.1504**	Masciarelli	0.3867*	Amavi	–0.3617*
Tavel (France)	–0.1509*	Lewis Cellars	0.3813*	Concha y Toro	–0.3623*
Pfalz (Germany)	–0.1578*	Argiano	0.3805*	Belle Vallée	–0.3652*
Russian River Valley (USA)	–0.1659*	Les Vins de Vienne	0.3780*	Heidsieck Monopole	–0.3663*
South Australia (Australia)	–0.1821*	Hijos de Antonio Barceló	0.3758*	Kanonkop	–0.3704*
Etna (Italy)	–0.1911*	Bodega Catena Zapata	0.3743*	Finca Luzón	–0.3791*
Mendocino (USA)	–0.2037*	Giuseppe Mascarello & Figlio	0.3715*	Condado de Haza	–0.3793*
Mendoza (Argentina)	–0.2209*	Cloudy Bay	0.3645*	Knoll	–0.3802*
Bierzo (Spain)	–0.2285*	Lapostolle	0.3566*	Lingenfelder	–0.3829*
Bolgheri (Italy)	–0.2470*	Château Figeac	0.3538*	Lucien Crochet	–0.3927*

(*continued*)

Table IV.

Marlborough (New Zealand)	–0.2567*	Franciscan Oakville Estate	0.3533*	Langmeil	–0.3944*
Rheinhessen (Germany)	–0.2658*	Bartolo Mascarello	0.3521*	Matua	–0.4040*
Priorat (Spain)	–0.2739*	Bodegas Bilbainas	0.3501*	Livio Felluga	–0.4050*
Nardò (Italy)	–0.2801*	Le Vieux Donjon	0.3481*	Bodegas Emilio Moro	–0.4073*
Mosel (Germany)	–0.2816*	Lemos & van Zeller	0.3469*	Fairview Goats do Roam In Villages	–0.4115*
Luján de Cuyo (Argentina)	–0.2888*	Jean Perrier & Fils	0.3462*	Merus	–0.4128*
Sonoma Coast (USA)	–0.2897*	Boutari	0.3445*	Cardwell Hill	–0.4131*
Horse Heaven Hills (USA)	–0.3096**	Cortes de Cima	0.3441*	Jules Taylor	–0.4140*
Primitivo di Manduria (Italy)	–0.3187*	Bouchard Père & Fils	0.3416*	Domaine Clusel-Roch	–0.4144*
Salta (Argentina)	–0.3190*	Koutsoyiannopoulos	0.3414*	Brewer-Clifton	–0.4197*
Choapa Valley (Chile)	–0.3333*	Inama	0.3360**	Château Maris	–0.4211*
Uco Valley (Argentina)	–0.3344**	Maybach	0.3340*	Fournier Père & Fils	–0.4250*
Chehalem Mountains Margo (USA)	–0.3431*	Markus Molitor	0.3323*	Kosta Browne	–0.4278*
Red Mountain (USA)	–0.3503*	Jean-François Ganevat	0.3322**	Leeuwin	–0.4289*
Judean Hills (Israel)	–0.3549*	Leviathan	0.3319*	Buehler	–0.4334**
Cahors (France)	–0.3664*	Galil Mountain Yiron	0.3311*	Merry Edwards	–0.4342**
Columbia Valley (USA)	–0.3949*	Heartland	0.3309*	Domaine La Roquète	–0.4356*
Galilee (Israel)	–0.4250*	Dakota Shy	0.3259*	Adegas Morgadío	–0.4451*
Edna Valley (USA)	–0.4460*	Klein Constantia	0.3180*	Château de Flaugergues	–0.4475*
Yakima Valley (USA)	–0.4614*	Altos de Medrano	0.3149*	Château Léoville Barton	–0.4501*
Maremma (Italy)	–0.4815*	Lemelson	0.3121*	Januik	–0.4511*
Sicilia (Italy)	–0.4935*	Marchesi de' Frescobaldi	0.3072*	Clos du Mont-Olivet	–0.4577*
Veneto (Italy)	–0.5016*	Georges Duboeuf	0.3040*	M. Marengo	–0.4700*
Marsannay (France)	–0.5047*	Montus Bouscassé	0.2998*	Domaine de Beaurenard	–0.4862*
Sonoma Valley (USA)	–0.5155*	M. Lapierre	0.2992*	Château La Sauvageonne	–0.4871*
Irpinia (Italy)	–0.5340*	Forefathers	0.2900*	Cougar Crest	–0.4997*
Dominio de Valdepusa (Spain)	–0.5595*	Meiomi	0.2825*	Alain Jaume	–0.5015*
Morgon (France)	–0.5753*	Louis Jadot	0.2823*	Montirius	–0.5140*
Côtes du Roussillon-Villages (France)	–0.5777*	Jean-Paul & Jean-Luc Jamet	0.2820*	Château Climens	–0.5233*
McMin.ille (USA)	–0.6124*	Lucia	0.2791*	Dominio de Atauta	–0.5300*
Santa Barbara (USA)	–0.6226*	LAN	0.2781*	Cabriz	–0.5542*
Washington (USA)	–0.6281*	Bodegas Palacio	0.2780*	Cavit	–0.5544*
Tokaji (Hungary)	–0.6336*	Joh. Jos. Prüm	0.2642*	Korbel	–0.5617*
Rheingau (Germany)	–0.6498*	Marquis Philips	0.2641*	Campogiovanni	–0.5730*
Maipo Valley (Chile)	–0.7098*	Joseph Phelps	0.2594*	Bodegas Borsao	–0.5832*
Toscana (Italy)	–0.7147*	Hourglass	0.2590*	Monasterio	–0.5844*
Hemel-en-Aarde Valley (South Africa)	–0.7454*	Babich	0.2562*	Big Table Farm	–0.5850*

Table IV. (*continued*)

Rioja (Spain)	–0.7561*	Château Larcis Ducasse	0.2558*	Intrinsic	–0.6016*
Aglianico del Vulture (Italy)	–0.8326*	Château de Haute-Serre	0.2554*	Bouza do Rei	–0.6112*
Almansa (Spain)	–0.8355*	Livio Sassetti	0.2506*	Bisquertt	–0.6120*
Jumilla (Spain)	–0.8355*	Altamura	0.2464*	Macarico	–0.6356*
Bolgheri Superiore (Italy)	–0.9974*	Marqués de Cáceres	0.2457*	Eberle	–0.6440*
Montsant (Spain)	–1.0529*	Ken Wright	0.2440*	Denner	–0.6638*
Wineries	*Coeff.*	Château Doisy-Védrines	0.2404*	Abadia Retuerta	–0.6691*
Konzelmann	2.0420*	Kistler	0.2390*	Hecht & Bannier	–0.7011*
Antinori	1.3325*	Hamilton Russell	0.2136*	Folonari	–0.7236*
Disznókóó	1.1166*	Mollydooker	0.2131*	Hidden Ridge	–0.7528*
Jean-Michel Stephan	1.1072*	Elderton	0.2100*	Château Coutet	–0.7807*
Jean-Louis Chave	1.0610*	Jean-Marc Brocard	0.2063*	Cono Sur	–0.7829*
Hermann J. Wiemer	1.0285*	Henri Bourgeois	0.2053*	Buite.erwachting	–0.8008*
Loimer	1.0037*	Château Lamartine	0.2031*	HdV	–0.8243*
Lavau	0.9798*	François Chidaine	0.2012*	Keplinger	–0.8375*
Branson Coach House	0.9664*	Jacob's Creek	0.2009*	Bodegas Resalte de Peñafiel	–1.0322*

Notes: $^{*}p < 0.01$; $^{**}p < 0.05$

Table IV.

provide any information. So, we used a Ramsey Regression Equation Specification Error Test (RESET) as a guide to determine the best functional form, which we called "mixed". The RESET tests whether non-linear combinations of the fitted values help explain the dependent variable. If non-linear combinations of the explanatory variables have any power to explain the dependent, the model is mis-specified. In a well-specified model, the null-hypothesis (whereby all coefficients in the non-linear combination are zero) cannot be rejected.

Intuitively, the "mixed" functional form is already suitable because the variables related to years (RELEASE, STORAGE, STORAGERANKING, RELEASERANKING, VINTAGERANKING and STORAGERELEASE) are better considered at their levels than in logarithms to capture the percentage influence on prices of one year of delay in release or one year more in cellar, etc.

The mixed model was estimated by ordinary least squares (OLS) with robust errors, given the great number of observations, and we applied a Ramsey test to check for problems of specification. We could not reject the *H0* of good specification.

The core variables which are significant in the final mixed model at 1 per cent are LPRODUCT (for a 1 per cent increase in PRODUCT, PRICE decreases 0.06 per cent approximately), LPOINTS (for a 1 per cent increase in POINTS, PRICE increases 14.1 per cent), ELERED (16 per cent points penalty on PRICE if the wine belongs to this category) and BIGRED (10 per cent points penalty on PRICE if the wine belongs to this category), VARIETAL (on average, 37.77 per cent points less PRICE than blends, all the rest being equal) and STORAGE (a one-year increase in time of STORAGE increases PRICE by 1.21 per cent points on average). With respect to COUNTRY, GRAPE, REGION and WINERY, the landscape is interesting.

Spain is the only COUNTRY whose wines receive a plus in PRICE (37.4 per cent points on average); France, Greece, Australia and Portugal have penalties. There are 19 GRAPES which receive more than the average PRICE estimated by the model, Nero d'Avola being the

most overpriced (+92 per cent points), and two grapes that receive less than the average: Godello (–23.9 per cent points) and Viura (–33.81 per cent points). By REGION, the French are at the top of the overvalued, highlighting Puligny-Montrachet (+124 per cent points plus on PRICE). At the same time, they lost 18 per cent points on PRICE as France is its COUNTRY of origin. Finally, there are overvalued and undervalued WINERY (with respect to the model predicted PRICE): as shown in Table IV, the most overvalued is Konzelmann (+204 per cent points plus on PRICE) and the most undervalued is Bodegas Resalte de Peñafiel (–103 per cent points penalty on PRICE).

Thus, let us develop some application of the model's results in Table V to distill the main message of the paper. So far, the results could be summarized in the following equation:

$$\begin{aligned} log\,Price = &-59.7366 + 14.1033\,log\,points - 0.0605\,log\,product - 0.3777\,varietal \\ &- 0.1611\,elegant\,red - 0.1065\,big\,red + 0.0121\,storage + b1\,country \\ &+ b2\,grape + b3\,region + b4\,winery \end{aligned} \tag{7}$$

Where *bi* (i = 1 to 4) can be either positive, negative or zero percentage premiums or punishments to the latter four variables. The first seven terms of the right part of the equation are the core determinants of prices, and the four final terms "correct" that predicted price by particular circumstances.

We picked-up some assorted examples to show the potential of the model. The first is one Spanish wine where the predicted price by the core variables is 4 per cent the market one. In this case, the country effect is positive, adding 37 per cent, the grape is neutral – because it is not significant as explanation of price variance – the region is negative in 75 per cent and the winery adds almost 47 per cent to log price. Then, the combined effect is 8.5 per cent, which compared with the price and the predicted price of the core model, is indicating the possibility of improvement.

In the second example, an Australian wine has a price exceeding 5 per cent the core model prediction, while the combined effect of country and region are negative, the grape partially compensates, and the winery is neutral.

Third and fourth examples are from two wines whose price exceed the predicted one by the core model. In both cases, the country effect is neutral; the region effect is negative in the Argentine wine but neutral in the Chilean one and the winery effect is positive in the Argentine wine but negative in the Chilean producer. The room for improvement is 8 per cent for the Chilean wine.

The options of intervention are several and can be classified broadly in management (or individual) actions, collective action and policy actions. In the first case, supposing the individual producer does not count on government collaboration and/or on "allies" in the industry to promote collective action, the efforts would be purely individual, to highlight the valued characteristics of the wine and to avoid those features not so valuable. The second case is collective action, that is, more than one winery acting to promote – on behalf of common interests – the name and reputation of their grapes, regions and countries, perhaps benchmarking practices with successful experiences of other grapes, regions and countries. The third case, which can be induced bottom-up by collective action, or top-down by the policy makers themselves, is public policy from government to raise the reputation of their producers.

6. Conclusions

In hedonic price models, a specific (differentiated) good has a bundle of characteristics. From the wines in our sample, we know price and quantity produced; the points in a quality

Table V.
Some applications of the models' results

Wine and price in constant dollars	Predicted price according to core variables of the model	Country effect	Grape	Region	Winery	Combined effects (country + grape + region + winery) (%)
Cune Rioja Imperial Gran Reserva (US$58.97)	US$61.67 (4%)	Spain (+ 37.39%)	Tempranillo (Neutral)	Rioja (–75.61%)	CVNE (+46.73%)	+8.51
Penfolds Shiraz South Australia St. Henri (US$66.07)	US$63.13 (+5%)	Australia (–42.17%)	Syrah (+36.26%)	South Australia (–18.21%)	Penfolds (Neutral)	–24.12
Achával-Ferrer Malbec Mendoza Finca Bella Vista (US$113.97)	US$58.63 (+94% Premium)	Argentina (Neutral)	Malbec (+29.99%)	Mendoza (–22.09%)	Achával Ferrer (+73.4%)	+81.3
Concha y Toro Carmenère Peumo Terrunyo (US$41.67)	US$31.25 (+33%)	Chile (Neutral)	Carmenère (+86.08%)	Peumo (Neutral)	Concha y Toro (–36.33%)	+49.75

ranking; the grape (e.g. Cabernet Sauvignon) and its association with one broad classification of wines (e.g. "Big Reds"); the winery with a name and reputation in the industry; the production year, its date of release (time to begin drinking), its aging potential (if any); the producer region where the grapes were grown, a country with an old or new history as producer. Points as proxy for quality are elements consumers value because quantity, grapes and storage potential are aspects that are strongly related to costs, and thus to producers.

We estimated an econometric model of hedonic prices using a 14-year sample of the 100 top-rated wines by Wine Spectator for the American market between 2003 and 2016, totaling 1,400 observations. We ran several OLS variants of the basic model to find robustness in our results.

We found that the factors positively explaining (the log of) prices of top-quality wines are the (log of) points they obtained in the rating and the years of storage, and negatively the (log of) quantity produced, whether they are varietal, and their condition of being elegant reds or big reds.

We also detected countries, origins, grapes and wineries that are undervalued or overvalued when compared to the average price predicted by the model.

The findings are useful to understand the role of price explanatory variables, as well as for making policy and managerial decisions. In some cases, managerial choices could be conditioned by the policies or history; in other cases, there are clear synergies for policies that can raise the prestige of countries and regions (collective efforts) and their spillovers on the brand name reputation of individual wineries.

While literature on wine hedonic prices is rich, to our best knowledge, this contribution innovates in some respects: first, the sample is extended in time, observations and international reach (almost all productive countries are represented, while in general, previous literature concentrates in individual producers); second, the procedure we followed to find a proper functional form and to test the omission of variables; third, the implications that can be derived for management of individual wineries, for collective action of groups of wineries sharing a common geography, for policy makers interested in developing this market and for consumers, interested in a reasonable price/quality ratio. Probably, the main interest of this work is to show how to increase the prestige of countries and regions abroad and to increase their ranking internationally.

Our research faces some limitations: while the findings are useful to understand the role of price explanatory variables, as well as for making policy and managerial decisions, the proxy for "quality" in the study is not the only possible definition. As practical implications, the study shows that managerial choices could be conditioned by the policies or history. On the other hand, the study suggests that there is some room for collective action and public policies to improve regions' and countries' reputation. There are clear synergies for policies that can raise the prestige of countries and regions (collective efforts) and their spillovers on the brand name reputation of individual wineries. Some possible extensions of this article are to try to conciliate different expert's rankings, and to extend the analysis to middle-quality wines in search of robustness of findings.

Notes

1. Examples of light whites are Sauvignon Blanc, Pinot Grigio or not oaked Chardonnay; of rich whites, Burgundy, oaked Chardonnay, Chenin Blanc, Godello or Friuliano; of elegant reds, Pinot Noir, Barbera, Dolcetto or Sangiovese; of big reds, Cabernet Sauvignon, Tempranillo, Malbec, Shiraz or Douro; rosé wines are normally blends, and sparkling ones rarely distinguish grapes, with exceptions such as Prosecco.

2. The sample includes the following countries and their representation in parentheses: Argentina (44), Australia (95), Austria (19), Canada (2), Chile (40), France (287), Germany (30), Greece (9), Hungary (6), Israel (4), Italy (223), Macedonia (1), New Zealand (36), Portugal (48), South Africa (28), Spain (108) and the USA (420).

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