The Price Premium for Organic Wines. Estimating a Hedonic Farm-Gate Price Equation

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The price premium for organic wines.
Estimating a hedonic farm-gate price equation*

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Abstract

Organic wines are increasingly produced and appreciated. Since organic production is more costly, a crucial question is whether they benefit from a price premium. We estimate hedonic price functions for Piedmont organic and conventional wines. We use data on the production side in addition to variables of interest for consumers. Our results show that, along with characteristics of interest to consumers, some farm and producer characteristics not directly relevant for consumers do significantly affect wine prices. We find that organic wine tends to obtain higher prices than conventional wine. The price premium is not simply an addition to other price components, but organic quality modifies the impact of the other variables on price. (JEL classification**:** C21, D49, L11, Q12)

I. Introduction

Organic production techniques are an increasing, though minor so far, part of agriculture. The growth of organic production is also favoured by the European Common Agricultural Policy, based on the consideration that it is more environment-friendly. On the consumers' side, organic products are increasingly consumed, both on the basis of environmental concerns and on their reputation of being healthier and tastier (AC Nielsen, 2005). Agricultural area under organic production has grown in Europe (EU-15) from 2.3 million hectares in 1998 to 5.1 million hectares in 2003 to 7.8 million hectares in 2008 (Rohner-Thielen, 2010). In Italy the area under organic production was 13,000 hectares in 1990 and reached 1,106,000 hectares in 2009.

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Among organic products, organic wine[1] is also growing. Organic grape area in Italy grew from 27 thousand hectares in 1998 to 42 thousand hectares in 2009. Nevertheless, this is still a small part of overall wine-growing. In Piedmont (Italy), the region of our investigation, organic vineyards in 2006 covered around 1400 hectares and organic wines accounted for about 2 percent of the regional wine sales (Corsi, 2007). Overall, the market for organic wines is still thin, and not all organic wines are sold as such. Though, the trend in consumption and production is ascending.

In general, organic products are considered healthier and more environmentally friendly by consumers, so that they may command higher prices. Though, for organic wine things are somewhat different. Indeed, it has some characteristics of interest for consumers in common with the other organic products (in particular, absence of chemicals in the grape production and, hence, a healthier image, and the response to environmental concerns). On the other side, quality is crucial for wine appreciation by consumers, and from this point of view, so far organic wine has not a sound reputation in terms of quality.

From the production point of view, organic techniques are usually more costly than conventional ones, which would in turn command higher selling prices. Though, since equilibrium price obviously results from both supply and demand factors, it is important to assess whether organic quality may raise wine price, ceteris paribus.

The literature on the determinants of wine prices is becoming quite large, and suggests that several attributes can affect price. They can be grouped into characteristics that are under control of the wineries and those that are exogenous (San Martin, Brümmer and Troncoso 2007). Among the latter, weather conditions are

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[1] Organic production within the EU is regulated by EU (EC) Reg. 2092/91, later substituted for by (EC) Reg.834/2007, which has been enforced as of 1st January 2009. On the basis of these regulations, only agricultural products following the prescribed production rules, and undergoing a certification process, can be sold as "organic". Organic products marketed without the certification are to be considered as conventional. We use the term "organic wine" for brevity. The correct term should have been "wine from organic grapes". While organic grape growing was regulated by the EU and, hence, organic grape was legally defined at the time of the survey, organic wine-making was not until very recently ((EC) Reg. 89/2008 and Commission Implementing Reg. 203/2012). Hence, in strict legal terms the name "organic wine" should not have been used.

important determinants of wine price (Ashenfelter, Ashmore and Lalonde 1995; Ashenfelter 2008; Di Vittorio and Ginsburgh, 2002; Wood and Anderson, 2002), though the influence of weather conditions on price is probably stronger for high quality wines. Gergaud and Ginsburgh (2008) also discuss the relative importance of natural conditions and of technology in determining wine prices. The largest part of the literature, nevertheless, is focussed on the consumer side, and basically explores the variables that can affect consumers' willingness to pay for particular characteristics. Most of these variables stem from the experience good (and possibly, credence good) nature of wine, including sensory quality, appellations, experts' ratings (Nerlove, 1995; Combris, Lecocq and Visser 1997; Landon and Smith, 1997; Lecocq and Visser 2006; Oczkowski 2001; Schamel 2006; Benfratello *et al.*, 2009; among others).

According to the theoretical foundations of hedonic pricing (Rosen, 1974), an hedonic price stems both from consumers' marginal willingness to pay for the characteristics *and* from marginal cost for producing it. Identification of the structural demand functions for the characteristics is nevertheless difficult, and requires stringent assumptions (see Mendelsohn, 1985 for a discussion). Moreover, the assumptions underlying Rosen's theory are rather stringent. First, it refers to a single purchase. While this is appropriate for durable consumer goods, wine certainly does not belong to this category. Second, a competitive market is assumed. The latter condition is questionable in wine markets, where product differentiation is the rule. Third, it implicitly assumes direct trade between sellers and buyers, while different marketing margins among different operators are most probably the rule in the wine market. Accordingly, to the best of our knowledge no paper has attempted to estimate demand functions for wine characteristics. Rather, hedonic price functions in the previous literature are to be interpreted as estimates of empirical relationships between wine prices and certain variables that are assumed to influence it, not necessarily implying the equality between the marginal willingness to pay and the marginal cost. For instance, while several papers show evidence of the influence of wine experts' ratings on wine prices (e.g., Hadj Ali et al., 2008; Gibbs et al., 2009), on the producer' side there exists nothing like the marginal cost for producing the experts' ratings, unless it is loosely interpreted as the cost for reaching the quality desired by the experts.

Nevertheless, even in this less rigorous approach, there is no doubt that production conditions influence prices. In principle, it is therefore possible to estimate how prices are influenced by characteristics at the production level. These variables include those that influence marginal costs of producing specific characteristics, but also variables representing the ability of winemakers to exploit the most appropriate marketing chains, to gain reputation and to differentiate their products. In addition, symmetrically with estimation of hedonic equations at the consumer level, some variables reflect consumers' willingness to pay for particular wine characteristics. The most interesting issue is nevertheless whether variables of no interest to consumers affect production prices.

Hedonic prices for wine have seldom been estimated on the basis of production characteristics apart from natural endowments. Important exceptions are, e.g., Ginsburgh, Monzack and Monzack (2012) and Gergaud and Ginsburgh (2008), who include vine-raising and wine-making techniques among the explanatory variables. In this paper, hedonic farm-gate price equations are estimated for organic and conventional wines, exploiting information on the production side, that include characteristics of the farms and of the wines, but also personal characteristics of the wine-makers, that can possibly influence prices.

Unlike much of the current literature, our analysis concerns production prices rather than retail prices. When a hedonic function is estimated on consumers' prices, the price predictions from the function can be used by consumers to identify bargains and expensive wines (Oczkowski, 1994). Since the function predicts the average wine price, given its characteristics, wines above the average predicted value are too expensive, and below it are good value for money. Very much in the same spirit, our results could, at least in principle, be of interest in suggesting production strategies to prospective organic wine-growers. Wines priced above the average, given their characteristics and production conditions, are a good deal for wine-makers, the reverse for those below the average.

A second contribution concerns the methodology of estimation of hedonic functions. Costanigro *et al*. (2007) argue that wines in different price ranges are differentiated, and that separate estimation of hedonic equations for different price ranges is superior to estimation on pooled data. We consider that the same might apply for organic vs. conventional wine prices, and we test whether organic quality induces a structural change in the hedonic price equation.

We use a unique dataset based on a total survey of organic farms in Piedmont (Italy). Organic farmers, nevertheless, may also produce conventional products, and this is also the case for those who are wine-makers, which allows estimation of wine price equations differentiating the organic nature of wine. As the producers in the sample are all organic farmers (though not necessarily producers of organic wine), we have to consider the possibility that the producers belong to a self-selected group. We thus take into account this selection effect when estimating the price equations.

II. The Econometric Models

Following the standard hedonic price model (Rosen, 1974), we assume that the log price of one unit of wine is given by the following hedonic price equation:

(1) $\log P_i = X_i\beta + \varepsilon_i$

P_i is the price of one unit of wine (Euro/liter), X_i is a vector of explanatory variables that we expect may affect the price of wine, β is a vector of unknown coefficients and ε_i is white noise.

Two different models are estimated. The first one (unified model) assumes that explanatory variables affect the wine price in the same way, regardless of its organic or conventional nature, and that organic characteristic only shifts the price. The assumption of this model is that the organic nature of the wine simply adds a percentage change to the price. This model is therefore estimated on the whole sample, introducing a dummy variable for the organic characteristic. The second model (split model) assumes that the explanatory variables may affect the price for organic and for conventional wine differently. Accordingly, this model is estimated separately for organic and conventional wines, allowing for different coefficients in the equations of the organic and conventional wines. The two models can be represented as follows:

Unified model:

(2) $\log P_i = \alpha + X_i\beta + Z_i \gamma + \varepsilon_i$

Split model:

(3) $\log P_{oi} = \alpha_o + X_i\beta_o + \varepsilon_{io}$, $i \in$ organic wines

(4) $\log P_{ci} = \alpha_c + X_i\beta_c + \varepsilon_{ic}$, $i \in$ conventional wines

where Z_i is a dummy variable which takes the value 1 if the wine is organic, 0 otherwise, γ a parameter to be estimated, and the subscripts *o* and *c* refer to organic and conventional, respectively.

The first model is nested in the second one. This can be seen by considering that equation (2) can be written:

(5) $\log P_i = (\alpha_o + X_i\beta)\, Zi + (\alpha_c + X_i\beta)\,(1 - Z_i) + \varepsilon_i =$

$= \alpha_c + (\alpha_o - \alpha_c)\, Zi + X_i\beta + \varepsilon_i$

while equations (3) and (4) can be merged into:

(6) $\log P_i = (\alpha_o + X_i\beta_o)\, Zi + (\alpha_c + X_i\beta_c)\,(1 - Z_i) + \varepsilon_i$

The two models can then be confronted by testing the restriction that $\alpha = \alpha_c$ and $\gamma = (\alpha_o - \alpha_c)$.

As mentioned above, the winemakers in the sample are all - to a varying extent - organic producers. Thus we should expect that this selection may matter for the price of the wine. More specifically, the expected value of the log price given that the wine producer is an organic producer may in principle deviate from the unconditional expectation of the log price. To account for this self-selection effect we estimate the probability for on-farm winemakers of being organic producers, based on a larger data set.

Let $\Phi(Y_i\delta)$ be the probability that a winemaker is an organic producer, where Y_i is a vector of explanatory variables and δ is a vector of coefficients to be estimated. $[1-\Phi(Y_i\delta)]$ is the probability that a winemaker is not an organic producer. We estimate a probit model of the probability of being an organic producer. Based on the estimates of the probit we can compute a variable denoted λ_i, which is given as $\lambda_i = \varphi(Y_i\delta)/\Phi(Y_i\delta)$. Here $\varphi(.)$ is the density in the normal probability distribution, and $\Phi(.)$ the corresponding cumulated probability distribution. It can then be shown (using equation (1)) that $E[\log P_i|$ organic producer$]= X_i\beta+\mu\lambda_\iota$ (Heckman, 1979). In this way an hedonic price equation can be estimated where the self-selection is accounted for.

If economic incentives matter in the choice of being an organic producer or not, we would expect that $E[\log P_i|$ organic producer$]>E[\log P_i]$, that is $X_i\beta+\mu\lambda_\iota > X_i\beta$. This means that we expect $\mu>0$.

The asymptotic covariance matrix is biased, and must be corrected according to the formulas given by Heckman, 1979 and Greene, 1981.

III. Data

Data for the estimation of the hedonic price equations are drawn from a total survey, funded by Piedmont Region, of all organic farms enrolled in the regional official list of organic farms. At the time of the survey (2006), 1655 organic farms were operating in the Region (1.4 percent of the total number of farms recorded at the Agricultural Census in 2000). Piedmont (located in the North-West of Italy) is well-known for wine production, and some of its wines (e.g., Barolo and Barbaresco) have a worldwide reputation.

The questionnaire included data about farm and operator characteristics, and data about plant and animal products produced by the farms (area or number, yields, price by destination), including products processed on the farm. Data for this analysis were obtained by selecting those farms that processed wine on the farm. After elimination of observations with missing values or not usable for the estimates, a total of 171 farms resulted, for a total of 389 wines produced: the number of wines produced in each farm ranges from 1 to 8. Wines (classified by variety and appellation, if any) could be organic or conventional, since not all organic farms only produce organic products, or because wine-makers choose not to certify their wine as organic[2]. Organic wines were 304, and conventional ones were 85, and this allows observation of production prices also according to their organic or conventional characteristic. Quantities and average prices were surveyed for both conventional and organic wines. The average price is 3.525 Euro (Table 1). Prices exhibit a non-negligible variation, the minimum being 40 cents and the maximum 21 Euro per liter[3]. The average price of organic wine, regardless of its destination, is 3.527 Euro, while for conventional wine the price is only slightly lower (3.518 Euro). On the basis of these data only, not controlling for explanatory variables, organic wine does not seem to benefit of a price premium relative to conventional wine.

Characteristics of each wine comprise: two different appellation levels (DOC, Denominazione di Origine Controllata – Controlled Designation of Origin, and DOCG, Denominazione di Origine Controllata e Garantita - Controlled and Guaranteed Designation of Origin, the latter implying more stringent controls and qualification), represented by dummy variables; the variety, also represented by dummy variables (the reference is wines without a defined variety, or varieties comprising very few cases); and the organic quality. Fulfilling production rules, including a limitation in yields, is required to attribute an appellation to a wine; hence, using an appellation affects production costs. Nevertheless, appellations also

[2] We do not have a precise and direct explanation as to why some organic farmers sell their product as conventional, and we can only speculate. One reason can be that some farmers are only interested in the subsidies provided by the EU to organic farming. A second and related reason may be that, since for selling as organic certification is needed, the certification costs for them are too high relative to the price premium they could get. A third possible reason is that they could not find a specific market outlet for organic wine. Regardless, selling wines as organic entails certification costs (certification is provided by private certification bodies against a payment), which makes costs different between these choices.

[3] The first, second, and third quartiles were 3.80, 7.20, and 10.6 for conventional wine, with a minimum of 0.40 and a maximum of 14.00 Euro/liter. Organic wine prices ranged from 0.80 to 21.00 Euro/liter, and the quartiles were 5.85, 10.90, and 15.95 Euro/liter.

have different attractiveness for consumers as signals of quality, and the effect of appellations therefore also reflects consumers' appreciation. About 77 percent of wines in the sample belong to a DOC, and a further 6 percent to a DOCG.

Table 1. Summary statistics of wine observations, Piedmont, 2006.

	Total (389 obs.)		Organic (304 obs.)		Conventional (85 obs.)	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Average wine price (Euro/ liter)	3.525	2.551				
Organic wine price (Euro/liter)			3.527	2.528		
Conventional wine price (Euro/liter)					3.518	2.647
DOC (1,0)	0.766	0.424	0.750	0.434	0.824	0.383
DOCG (1,0)	0.062	0.241	0.059	0.236	0.071	0.258
Arneis (1,0)	0.015	0.123	0.013	0.114	0.024	0.152
Bonarda (1,0)	0.013	0.113	0.013	0.114	0.012	0.108
Cortese (1,0)	0.028	0.166	0.030	0.170	0.024	0.152
Chardonnay (1,0)	0.051	0.221	0.046	0.210	0.071	0.258
Grignolino (1,0)	0.028	0.166	0.030	0.170	0.024	0.152
Freisa (1,0)	0.036	0.187	0.026	0.160	0.071	0.258
Moscato (1,0)	0.021	0.142	0.023	0.150	0.012	0.108
Barbera (1,0)	0.234	0.424	0.224	0.417	0.271	0.447
Dolcetto (1,0)	0.183	0.387	0.197	0.399	0.129	0.338
Nebbiolo (1,0)	0.069	0.254	0.069	0.254	0.071	0.258
Wine area relative to total agricultural area	0.636	0.373	0.607	0.388	0.736	0.296
Operator's age	48.9	12.9	49.1	13.1	48.2	12.3
Attendance to professional courses (0, 1)	0.689	0.464	0.681	0.467	0.718	0.453
Years of general education	11.3	3.6	11.4	3.4	11.3	4.2
Agricultural education (1,0)	0.141	0.349	0.105	0.307	0.271	0.447
Organic wine (1,0)	0.781	0.414	1	0	0	0

In Piedmont, most wines are made from specific varieties and are not assembled. The most frequent varieties in our sample are Barbera (23 percent) and Dolcetto (18 percent); Nebbiolo accounts for almost 7 percent. Varieties may differ as to the yields, care needed for growing them, responsiveness to weather and pest attacks, and wine-making processes. Hence, different varieties may imply different production costs but, again, different prices may also reflect different consumers' appreciation and willingness to pay. The same applies to the organic rather than conventional method (78 percent of our sample is organic wine). Though our survey did not report production costs, organic wine-growing and wine-making are usually considered more costly than conventional ones. Delmas, Doctori-Blas and Shuster (2008) report that organic wine-growing costs in California are 10 to 15 percent higher than for conventional grapes. But, again, the price premium for organic wine may also reflect consumers' preferences[4].

By contrast, some farm and operators' characteristics reflect production costs and farmers' skills and apparently have no impact on consumers' preferences. Nevertheless, in a competitive market hedonic prices theoretically are simultaneously determined by marginal costs and marginal willingness to pay. Therefore, these farm and operator's characteristics might be interpreted as determinants of unobservable wine quality that has some cost for the producer and for which consumers are willing to pay. Alternatively, if wine-makers have some market power, they can be interpreted as indicators of their ability to set prices at the desired level, e.g., by choosing the appropriate marketing channel or by raising their wine reputation. Farm operators' characteristics refer to their human capital. Age is an indicator of skills acquired through experience. Education is another indicator of human capital, and was recorded as the maximum degree attained. This was translated into years of schooling, assuming that the regular number of schooling years was followed. A dummy variable indicates if the high school diploma or the university degree were in the agricultural field. A further dummy variable indicates whether the farm operator

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[4] In our sample a little more than 6 percent of the wines were listed in Gambero Rosso guidebook. This is a famous wine guidebook, rating wines across all Italian regions. Inclusion in Gambero Rosso is highly prestigious, and is a strong quality signal. In several hedonic function estimates, inclusion in prestigious guidebooks, or their ratings, are included among the explanatory variables. Nevertheless, we estimated a probit model of inclusion in Gambero Rosso guidebook as a function of other variables (varieties, appellations, wine quantity), in the same spirit of Landon and Smith (1997) who model wine ratings as a function of objective wine characteristics. Since the model was overall significant, to avoid multicollinearity problems with other explanatory variables we excluded the entry of the wine in the Gambero Rosso among the explanatory variables. The results of the model including this variable are nevertheless not much different from the ones presented here. They are available from the authors upon request.

had followed a professional agricultural course in the last three years. All these characteristics are hypothesized to affect wine prices, though the direction may be a priori unclear: skills acquired through working experience or formal education may translate into higher efficiency and, hence, lower production costs, though this would not necessarily reduce selling prices. On the other hand, farmers can acquire through education and experience the capacity to improve the quality of their wines and, possibly, greater marketing skills, and hence they can get higher prices through accumulation of reputation or through the choice of the appropriate marketing channels.

An important production characteristic is the degree of farm specialization in wine-growing[5]. This variable tries to capture the effects of the production mix, since organic farms typically comprise different crops and animal husbandry. A mixed type of farming is consistent with the spirit of organic farming, which in principle should try to close the biological circle within the farm through the utilization of manure. On the other hand, specialization can offer greater opportunities in terms of operating and marketing skills. Specialization is measured as the share of grapes on total utilized agricultural area. Long-term investment needed for the grape plant make this variable to a large extent exogenous to short-term prices. The average is 64 percent.

We did not include weather variables among the explanatory variables, since our database is cross-sectional, and concerns one region, so weather conditions in the reference year are quite homogeneous, and we can disregard them[6].

Data for estimating the participation to organic farming needed to correct for self-selection were drawn from a random sample of 10,000 individual farm records of the

[5] We also had information on the quantity of wine produced. This variable is often included in hedonic function estimation from consumer prices, representing the attractiveness for consumers of small production wines -"snob effects"- or the greater visibility of large production wines (Landon and Smith, 1997; Costanigro et al., 2007; San Martin et al., 2007). The same variable might capture economies of scale in wine-growing and wine-making influencing production costs and, hence, selling prices. Though, endogeneity might be a concern for this variable. Unfortunately, we had no good instrumental variables, so we estimated all models in double form, including or excluding this variable. The results, nevertheless, were almost identical, and formal tests of the restriction of the quantity parameter to zero never rejected it. We therefore decided to drop this variable.

[6] Lecoq and Visser (2006) find that Bordeaux wine estimates based on detailed local weather data are very similar to the estimates based on one regional weather station data. This comforts us in not including weather data in our cross-section model.

2000 Agricultural Census in Piedmont, since overall regional data for the year of the survey in 2006 were not available. We assume that the effect of the explanatory variables on the probability of organic farming was not different in 2000 relative to 2006. The Census included information on whether wine was made on the farm, and whether the farm produced organic products. On-farm winemakers in the sample were 1443, i.e., 14.4 percent of the total. Among them, those who had some organic production (not necessarily wine) were 1.3 percent, a percentage that mirrors the general percentage of organic farms in the region. Other information used in the estimation of the probability of producing organic wine were the location (mountains, hills or plains), farm size (hectares), and some operator's characteristics (age and attendance to professional courses). A commonly held consideration is that while location in the mountains and in the hills is a disadvantage for farming, due to lower yields and more difficult mechanization, organic farming could relieve the disadvantage, due to lower emphasis on yields and to easier abidance of the rules of organic farming in these areas. Organic farming is also said to be more favourable to small farms, due to higher labour intensity, though this reputation is disputed. Finally, organic farming is a relatively new technique, so younger farmers might be more inclined to adopt it, since they have a longer life span to exploit acquired skills. Also, attending professional courses might facilitate the adoption of organic farming. All these variables are assumed to influence the choice of wine-makers to have some organic production. The descriptive statistics are presented in Table 2.

Table 2. Summary statistics of on-farm winemakers, Piedmont 2000 (1443 obs.)

	Mean	Std.Dev.
Location: Plains (0, 1)	0.119	0.323
Location: Mountains (0, 1)	0.032	0.176
Farm area (ha)	6.24	11.62
Operator's age	58.8	14
Attendance to professional courses (0, 1)	0.089	0.285
Organic production (0, 1)	0.013	0.114

Source: Agricultural Census, 2000

IV. Results and Discussion

The binomial probit model assumes that a wine-making farm is organic depending on a set of variables of which some are not among the explanatory variables in the hedonic price equations[7]. The results of the probit model are shown in Table 3. From that table we observe that the farm being located in the mountains contributes positively and significantly to the probability that the wine producer is an organic farmer. Moreover, the larger the farm, the higher is the probability that the winemaker is an organic farmer. This contrasts with the often held view that organic farms are small and marginal farms, but a comparison between organic farm characteristics and overall farm characteristics (Corsi, 2007) shows that in reality this is not the case: the average size of organic farms is larger than the overall average size. Age has a significant and negative impact on the probability that the wine farm operator is an organic producer, which reflects the fact that younger people are more willing to adopt a new technique like organic farming, given their longer time horizon for the investment in human capital. Indeed, organic farmers probably require more professional skills than conventional farmers, also because they need to gather technical information less available than the one needed for conventional agriculture. This is also reflected by the significantly higher likelihood that a wine-maker farmer is an organic producer if he/she has attended a professional course.

Based on the estimates in table 3 we computed the variable denoted λ_i, the inverse Mills ratio, and included it in the hedonic price equation to correct for self-selection. The asymptotic covariance matrices have been corrected for the inclusion of the selection variable (Heckman, 1979; Greene, 1981).

Table 4 gives the results of regressing the log price of wine for the full sample of 389 observations in Piedmont against the explanatory variables described above (unified model). While for continuous variables the coefficients, multiplied by 100, are to be interpreted as the percentage change in the price for a unit change in the

[7] We experimented different specifications of the participation equation and of the wine price equations, since several variables were good candidates for both. The final specification is quite robust to the inclusion of other variables. In particular, we found that location (mountains, plains) and farm size were never significant for wine prices, and that gender was never significant in both.

explanatory variable, the percentage effect of a change of a dummy explanatory variable from 0 to 1, shown in the column "Price premium", is equal to 100·[exp(*c*) – 1], where *c* is the relevant coefficient (Halvorsen and Palmquist, 1980).

Table 3. Estimate of the probability of being organic producer among winemakers in Piedmont 2000 (binomial probit).

Variables	Estimates	t-values
Constant	-1.608	-3.999
Location: Dummy for plains	-0.422	-0.97
Location: Dummy for mountain	0.917	2.858
Area of the farm	0.01	2.009
Operator's age	-0.015	-2.172
Attendance to professional courses	0.567	2.435
No of observations	1443	
Log-likelihood	-88.1281	
Prob[ChiSqd > value] =	0.0001	
McFadden's Pseudo R^2	0.1287	
Akaike's I.C.	0.13046	
Correct predictions	98.70%	

We note that the selection effect is significant and positive, which means that the expected price of wines, conditional on the winemaker being an organic wine producer, exceeds the unconditional expectation of the price of such wines.

Second, we note that the appellation system matters for the price. A DOC appellation, relative to no appellation (table wines), raises the price by about 38 percent. The DOCG classification raises the price by further 14 percent. We consider these effects to reflect both costs needed for producing high quality wines, and consumers' willingness to pay for high quality wine, based on the appellation quality signal.

The only variety with a significant positive premium is Nebbiolo. This is an expected result, since it is the grape variety from which the most prestigious wines are made (such as Barbaresco and Barolo). The price premium is as high as 71.5 percent.

Table 4. Estimate of log price of wine in Piedmont, 2006 with a dummy for organic produced wine.

Variables	Estimates of coefficients	t-values	Price premium (%)
Constant	-1.574***	-2.755	
DOC (1,0)	0.321**	2.239	37.9
DOCG (1,0)	0.416*	1.76	51.6
Arneis (1,0)	0.03	0.083	3
Bonarda (1,0)	-0.265	-0.732	-23.3
Cortese (1,0)	-0.429	-1.62	-34.9
Chardonnay (1,0)	0.008	0.038	0.8
Grignolino (1,0)	-0.169	-0.658	-15.5
Freisa (1,0)	0.107	0.455	11.2
Moscato (1,0)	0.014	0.042	1.4
Barbera (1,0)	-0.025	-0.185	-2.5
Dolcetto (1,0)	0.031	0.217	3.1
Nebbiolo (1,0)	0.539***	2.916	71.5
Wine area relative to total agricultural area	0.413***	3.189	41.3
Age of producer, years	0.004	0.675	0.4
Professional course (1,0)	0.158	0.888	17.1
Years of general education	0.052***	4.148	5.2
Agricultural education(1,0)	0.09	0.692	9.4
Organic produced wine (1,0)	0.239**	2.422	27
Lambda[1]	0.442*	1.696	
No of observations	389		
Adjusted R square	0.354		
F[19, 369]	12.17		

[1] Lambda is a selection variable and equals the inverse Mills ratio [$\phi(x)/\Phi(x)$] and is computed based on the estimates given in Table 3.

***, **, * = significant at the 1%, 5%, and 10%, respectively

The coefficients of the other varieties are not significant, which implies that their price does not significantly differ from the reference wines without a defined variety.

The more specialized the producer is in producing wine (in terms of the share of total agricultural area devoted to grape production), the higher is the price of his wine. The price increase is close to 0.4 percent for each additional 1 percent of agricultural area devoted to wine-growing. This result can be interpreted both in terms of better quality (and hence, higher prices) of specialized farmers, and in better marketing skills of farmers devoting specifically to wine-growing[8].

The age of the wine producer is not significant. Also the effect of a specialized education in agriculture has not a significant impact on the price of the wine produced. Probably this kind of education is not specific to wine-making and does not add specific skills in this field. The level of general education, however, has a positive impact, with about a 5 percent price increase for every extra year of general education. This may in part be due to a general better insight linked to education, and possibly to family background characteristics. The higher the education level of the wine producer, the better he/she is in wine-growing and wine-making, and in a better situation he/she is for exploiting marketing opportunities. Moreover, the higher his/her education, the better off his/her family tends to be, which probably reflects more profitable vineyards. The better off the family is, the better is the possibility to buy the best slots for making wine.

Of great interest for us is the finding that organic wine - all other things equal- obtains a higher price in the market than conventional wine. Under the assumption of the unified model, i.e., that organic quality raises the price but does not change the impact of the other variables on wine price, we find that keeping under control all other variables the price premium, which did not seem to exist only considering average price data, is actually sizeable, 27 percent.

Though, as already mentioned, an alternative model can be estimated. The second model assumes that organic quality implies different impacts of the other variables on wine price relative to conventional quality. The two models can be

[8] Of course it might also be that the higher the price the farmer can obtain from his wine the more of the total area is devoted to wine-growing. If so, there should be an endogeneity problem, but tests do not indicate this. We regressed the residuals of the price equations on the share of grape area over total area, and never found significant values.

confronted by testing the restriction that $\alpha = \alpha_c$ and $\gamma = (\alpha_o - \alpha_c)$. A likelihood ratio test strongly rejects the hypothesis. The relevant chi-square test is 38.93 with 2 d.f. The conclusion is therefore that organic and conventional wine prices are differently affected by the explanatory variables[9]. Tables 5 and 6 present the estimates of the split model.

Table 5. Estimate of log price of organic wine in Piedmont, 2006

Variables	Estimates of coefficients	t-values	Price premium (%)
Constant	-1.118**	-2.122	
DOC (1,0)	0.331**	2.318	39.2
DOCG (1,0)	0.389*	1.658	47.6
Arneis (1,0)	-0.02	-0.053	-1.9
Bonarda (1,0)	-0.219	-0.613	-19.6
Cortese (1,0)	-0.248	-0.938	-21.9
Chardonnay (1,0)	0.038	0.177	3.8
Grignolino (1,0)	-0.106	-0.418	-10.1
Freisa (1,0)	0.211	0.793	23.6
Moscato (1,0)	0.007	0.023	0.7
Barbera (1,0)	0.051	0.368	5.2
Dolcetto (1,0)	0.051	0.358	5.2
Nebbiolo (1,0)	0.544***	2.963	72.3
Wine area relative to total agricultural area	0.304**	2.394	30.4
Age of producer, years	0.004	0.683	0.4
Professional course (1,0)	0.263	1.593	30
Years of general education	0.041	3.14	4.1
Agricultural education(1,0)	0.091***	0.648	9.5
Lambda[1]	0.384	1.616	
No of observations	304		
Adjusted R square	0.355		
F[18, 285]	10.28		

[1] Lambda is a selection variable and equals the inverse Mills ratio [$\phi(x)/\Phi(x)$] and is computed based on the estimates given in Table 3.

***, **, * = significant at the 1%, 5%, and 10%, respectively

[9] It is interesting to note that if we do not account for the selection effect, the unified model is not rejected. It should also be noted that the dummy variable for organic may suffer from an endogeneity problem; we regressed the squared residuals of the model on the dummy variable, and found it was significant. Unfortunately, we had no instruments for it. Overall, this reinforces the preference for the split model.

Table 6. Estimate of log price of conventional wine in Piedmont, 2006

Variables	Estimates of coefficients	t-values	Price premium (%)
Constant	-2.168***	-4.116	
DOC (1,0)	0.246*	1.721	27.8
DOCG (1,0)	0.540**	2.303	71.6
Arneis (1,0)	-0.324	-0.882	-27.7
Bonarda (1,0)	-0.445	-1.248	-35.9
Cortese (1,0)	-0.870***	-3.293	-58.1
Chardonnay (1,0)	-0.014	-0.066	-1.4
Grignolino (1,0)	-0.133	-0.524	-12.5
Freisa (1,0)	-0.099	-0.37	-9.4
Moscato (1,0)	0.243	0.759	27.5
Barbera (1,0)	-0.253	-1.827	-22.3
Dolcetto (1,0)	-0.001	-0.008	-0.1
Nebbiolo (1,0)	0.562***	3.062	75.5
Wine area relative to total agricultural area	0.624***	4.914	62.4
Age of producer, years	0.002	0.464	0.2
Professional course (1,0)	-0.028	-0.168	-2.7
Years of general education	0.062***	4.744	6.2
Agricultural education(1,0)	-0.062	-0.441	-6.0
Lambda[1]	0.754***	3.176	
No of observations	85		
Adjusted R square	0.326		
F[18, 66]	3.26		

[1] Lambda is a selection variable and equals the inverse Mills ratio [$\phi(x)/\Phi(x)$] and is computed based on the estimates given in Table 3.
***, **, * = significant at the 1%, 5%, and 10%, respectively

The results of the split model for organic wine are to a large extent similar to the ones of the unified model. The selection effect is positive as above, but only marginally significant (the prob-value is 0.107) and positive. Appellations (DOC and DOCG) are both significant, and add to the price 39 and 48 percent respectively. Also the effect of Nebbiolo grape is similar to the one of the unified model (72 percent. The specialization effect is significant but lower (the price is 0.3 percent higher for each 1 percent increase in grapes over total area). General education is also significant, and each additional year adds about 4 percent to the price. The variable of attendance to professional courses is now highly significant, and raises the organic wine price by 30 percent, which could be taken as an effect of the higher professional skills required by organic farming.

For conventional wine price, the selection effect is positive, and significant. Thus also the expected price of conventional wine, conditional of being an organic producer, exceeds the unconditional expectation in the whole population of wine-makers. This indicate that there is economic incentive behind the decision to be an organic producer. Again, the appellation variables are significant and positive. A DOC adds about 28 percent to the price, and DOCG 72 percent. The former is weaker than for organic wines, while the latter is larger. Also the Nebbiolo grape variable coefficient is slightly larger than for organic wines. The specialization variable is positive and significant, and exhibits a much stronger effect than on organic wine price. Also general education, the other significant variable, has a positive effect on price, stronger than on organic wine price (6 percent). Somewhat surprising is that Cortese – a grape used to produce white wines- carries a significant and substantial negative price premium.

Since the unified model is rejected, one cannot claim that there is simply a price premium for organic wine as such. This is because the characteristics influence the price in different ways, depending on the wine being organic (table 5) or conventional (table 6). Nevertheless, the constant terms in the organic price equation is significantly higher than the constant term in the conventional price equation (a t test strongly rejects the hypothesis of a zero difference). Therefore, one can conclude that at the zero level of all other characteristics, the price of organic wine is higher than the price of conventional wine.

One may finally wonder whether wine-growers on the average “do the right choice” when they grow organic or conventional grapes and sell organic or conventional wine, given the characteristics of the farm and farmers. Given these characteristics the question thus is whether they would get a higher price if growing and selling organic wine rather than conventional wine. To answer this question, one can predict the average price organic wines would get and compare it to the average price the very same wines would get if they were grown and sold as conventional. Formally, one can test:

$$(7) \quad \bar{p}_{oo} > \bar{p}_{oc}$$

where $\bar{p}_{oo}$ is the average log price calculated with the organic price equation coefficients and the covariates of the organic wine observations, and $\bar{p}_{oc}$ is the average log price calculated with the conventional price equation coefficients and the covariates of the organic wine observations. That is:

$$(8) \quad \frac{1}{N_o}\sum_{i=1}^{N_o}\left[\alpha_o + X_{0i}\beta_o\right] > \frac{1}{N_o}\sum_{i=1}^{N_o}\left[\alpha_c + X_{0i}\beta_c\right]$$

where the summation is over $N_{0,}$ the number of organic wines.

Similarly, one might wonder whether those who made conventional wine would get higher prices had they made organic wine, given their characteristics. This can be tested formally as follows:

$$(9) \quad \bar{p}_{co} > \bar{p}_{cc}$$

where $\bar{p}_{co}$ is the average log price calculated with the organic price equation coefficients and the covariates of the conventional wine observations, and $\bar{p}_{cc}$ is the average log price calculated with the conventional price equation coefficients and the covariates of the conventional wine observations. That is:

$$(10) \quad \frac{1}{N_c}\sum_{i=1}^{N_c}\left[\alpha_o + X_{ci}\beta_o\right] > \frac{1}{N_c}\sum_{i=1}^{N_c}\left[\alpha_c + X_{ci}\beta_c\right]$$

where the summation is over N_c, the number of conventional wines.

To calculate the predicted average log prices, we have employed Krinsky and Robb’s (1986) Monte Carlo simulation approach. We randomly drew (1000 draws) from the multivariate normal distribution with mean $(\hat{\alpha}, \hat{\beta})$, the means of the estimated coefficients, and variance-covariance matrix V, the relevant estimated variance-covariance matrices. For each draw of the coefficients we combined the draw of the coefficients with the individual observed values of the explanatory variables to calculate the log price for each observation. Then we took the average of the log prices over the observations and we repeated the procedure over the 1000 draws to obtain the average log prices. The results are given in table 7. The mean log price of organic wine, using the coefficients and variables related to organic wine, is predicted to be 1.083 Euro/liter. When using the coefficients of the conventional price equation, but the co-variates of organic wine, the mean log price is lower, 0.869. Thus these averages indicate that the organic "technology", as measured by the estimated coefficients, yields higher prices than the conventional "technology (eq (7) above).

Table 7. Price simulations of average log price per liter

Average log price	Mean
Log price| organic parameters and organic variables	1.083
Log price| conventional parameters and organic variables	0.845
Log price| conventional parameters and conventional variables	0.954
Log price| organic parameters and conventional variables	1.193

To test whether these prices are significantly different, we tested the one-sided significance of

$$H_0 : \bar{p}_{oo} - \bar{p}_{oc} \leq 0$$
$$H_1 : \bar{p}_{oo} - \bar{p}_{oc} > 0$$

using the methodology suggested by Poe, Giraud and Loomis (2005). We calculated the difference between all permutations of the random values of the average prices, and counted the number of the negative or null ones, which turned out to be 13.2

percent[10]. This indicates that, conditional on the characteristics of the wine and of the farm, organic produce wine tend to obtain higher price than if the wine were produced by a conventional "technology". In 86.8 percent of the cases the alternative hypothesis H_1 was true. However, this is a somewhat away from the 95 percent case, which often is required in such tests.

The mean log price of conventional wine, predicted with the parameters and the variables of making conventional wine, is 0.954 Euro/liter. When replacing the coefficients with those of the organic log price regression, we predict the mean log price to be 1.189. In this case, the test is on

$$H_0 : \bar{p}_{co} - \bar{p}_{cc} \leq 0$$
$$H_1 : \bar{p}_{co} - \bar{p}_{cc} > 0$$

and the probability of a negative or null difference is lower, i.e., 9.2 percent. Thus, though the difference is not highly significant, we can conclude that those farmers who actually produced conventional wine, given their characteristics, would on the average gain higher prices had they produced organic wine.

V. Conclusions

In this paper we estimated hedonic price functions for Piedmont organic and conventional wines. Unlike the current literature on the determinants of wine prices, we used data on the production characteristics in addition to data on characteristics of interest to consumers, and prices are at the farm-gate rather than at the consumer level. One question was whether and how farm and operator's characteristics apparently of no interest for consumers, but influencing production costs, affect wine prices. The second question was whether organic wine obtains a price premium relative to conventional wine.

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[10] The differences were calculated over the permutations of the 1000 average prices calculated from the random draws. The procedure is demanding in terms of computer time.

As expected the appellation of wines in the Piedmont region matters for the price of wine. And also as expected wines from the Nebbiolo grape are priced far better in the market than other grapes. Nevertheless, in addition to being characteristics affecting production costs, these are characteristics that may also affect consumers' evaluation of wines. Among the characteristics that apparently are of no interest to consumers, we found that human capital characteristics of the wine producer do affect the price. General education level of the wine producer has a positive impact on wine prices. Also, we found that specializing in wine relative to producing a broader specter of agricultural products has a significant positive impact on the price of wine obtained by the producer.

Finally, an important finding is that the way the wine is produced - organic or non-organic – affects the price obtained in the market. Organic quality does not simply add to the price, but modifies the impact of other variables. So, there is not simply a price premium in the sense of fixed amount added to the price by the organic quality, but organic quality interacts with other characteristics in determining the price. Nevertheless, at the zero level of all other characteristics, organic wine price is higher than conventional wine price. The overall conclusion is therefore that, though there is not simply a price premium in the sense of an addition to other price components, organic wines do command significantly higher prices.

We also found that those wine-growers who made conventional wine would obtain on the average higher prices had they grown organic grapes and made organic wine given farmers' and wines' characteristics. With a somewhat lower significance we find that those wine-growers who actually made organic wine obtained higher prices than what they would get had they grown conventional grapes and made conventional wine. The reason why some wine-makers choose to make conventional wine if the price they would get for organic wine would be higher is not investigated in our research. It might obviously depend on the production costs not compensating for the price premium, or might depend on the difficulty to find appropriate outlets for organic wine. This is left to further research.

The conclusion that parameters are different for organic and conventional wines functions also contributes to the question of structural changes in the estimated hedonic equations, conditional on some grouping of the wines. In most setting, wine characteristics are assumed to affect the price additively. For instance, a dummy for the color of the wine is often included among the explanatory variables, under the implicit assumption that the other characteristics affect the price in the same way regardless of the color. This setting has been questioned by Costanigro et al. (2007), who suggest that hedonic functions are different across price ranges. Our results support their view of different hedonic functions according to some grouping, since estimating separate functions for organic and conventional wines proved superior to the pooled estimation.

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