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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. Because 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 to 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; organic quality modifies the impact of the other variables on price. (JEL Classification: C21, D49, L11, Q12)

Keywords: Organic wine, hedonic price, price premium, Piedmont.

I. Introduction

Organic production techniques are an increasing, though so far minor, part of agriculture. The growth of organic production is also favored by the European Common Agricultural Policy, based on the consideration that it is more environmentally friendly. On the consumers' side, organic products are increasingly consumed, both on the basis of environmental concerns and on their reputation for being healthier and tastier (AC Nielsen, 2005; Torjusen et al., 2004). 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] in particular is growing. The area under cultivation with organic grapes in Italy grew from 27,000 hectares in 1998 to 42,000 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 1,400 hectares, and organic wines accounted for about 2 percent of regional wine sales (Corsi, 2007). Overall, the market for organic wines is still small, and not all organic wines are sold labeled as such. However, the trend in consumption and production is rising.

Organic products in general are considered healthier and more environmentally friendly by consumers, so they can command higher prices. But for organic wine, the situation is somewhat different. Indeed, it has some characteristics of interest to consumers in common with other organic products (in particular, the absence of chemicals in grape production and, hence, a healthier image, and the response to environmental concerns). At the same time, thus far organic wine has not gained a sound reputation in terms of quality, which is a crucial element in wine appreciation by consumers of view.

In terms of production, organic techniques are usually more costly than conventional ones, which in turn command higher selling prices. Because the equilibrium price obviously results from both supply and demand factors, it is important to assess whether organic quality raises wine prices, ceteris paribus.

The literature on the determinants of wine prices is large and suggests that several attributes can affect price. These determinants can be grouped into characteristics that are under the control of the wineries and those that are exogenous (San Martin and Brummer, 2007). Among the latter, weather conditions are important determinants of wine price (Ashenfelter 2008; Ashenfelter and Ashmore, 1995; Di Vittorio and Ginsburgh, 2002; Wood and Anderson, 2006), 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 majority of the literature, nevertheless, focuses 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, and experts' ratings

[1] Organic production within the EU is regulated by EU (EC) Reg. 2092/91, later replaced by (EC) Reg.834/2007, which entered into force as of January 1, 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 considered conventional. We use the term "organic wine" for brevity. The correct term should be "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.

(Benfratello et al., 2009; Combris, Lecocq and Visser, 1997; Landon and Smith, 1997; Lecocq and Visser, 2006a; Nerlove, 1995; Oczkowski, 2001; Schamel, 2006; and others).

According to the theoretical foundations of hedonic pricing (Rosen, 1974), a hedonic price stems both from consumers' marginal willingness to pay for the characteristics *and* from the marginal cost of producing it. Identification of the structural demand functions for the characteristics is nevertheless difficult and requires firm assumptions (for a discussion, see Mendelsohn, 1985). The assumptions underlying Rosen's theory are rather stringent. First, it assumes a single purchase. Although this is appropriate for durable consumer goods, wine certainly does not belong to this category. Second, a competitive market is assumed—a condition that 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 earlier literature are 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., Gibbs et al., 2009; Hadj Ali et al., 2008), on the producer side there exists nothing like the marginal cost of producing the experts' ratings, unless it is loosely interpreted as the cost of reaching the quality desired by the experts.

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 the marginal cost 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 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, for example, Gergaud and Ginsburgh (2008) and Ginsburgh, Monzak, and Monzak (2013), 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, which includes characteristics of the farms and of the wines as well as personal characteristics of the wine-makers, which might influence prices.

Unlike much of the current literature, our analysis concerns production prices rather than retail prices. When a hedonic function is estimated on consumer prices, the price predictions from the function can be used by consumers to identify bargains and expensive wines (Oczkowski, 1994). Because the function predicts the average wine price, given its characteristics, wines above the average predicted value are too expensive and those below it are a good value for the 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, and the reverse is true 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 to organic vs. conventional wine prices, and we test whether organic quality induces a structural change in the hedonic price equation.

We use a unique data set based on a total survey of organic farms in Piedmont (Italy). Organic farmers might 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:

$$\log P_i = X_i\beta + \varepsilon_i \tag{1}$$

P_i is the price of one unit of wine (euros/liter), X_i is a vector of explanatory variables that might 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 characteristics only shift 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 entire sample, introducing a dummy variable for the organic characteristic. The second model (split model) assumes that the explanatory variables can affect the price for organic and conventional wines 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:

$$\log P_i = \alpha + X_i\beta + Z_i\gamma + \varepsilon_i \tag{2}$$

Split model:

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

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

where Z_i is a dummy variable that equals 1 if the wine is organic and 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:

$$\begin{aligned} \log P_i \quad &= (\alpha_o + X_i\beta)Z_i + (\alpha_c + X_i\beta)\ (1 - Z_i) + \varepsilon_i \\ &= \alpha_c + (\alpha_o - \alpha_c)\ Z_i + X_i\beta + \varepsilon_i \end{aligned} \tag{5}$$

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

$$\log P_i \quad = (\alpha_o + X_i\beta_o)Z_i + (\alpha_c + X_i\beta_c)\ (1 - Z_i) + \varepsilon_i \tag{6}$$

The validity of the two models can then be tested with the restriction that $\alpha = \alpha_c$ and $\gamma = (\alpha_o - \alpha_c)$.

As mentioned above, the winemakers in the sample are all—to various extents—organic producers. Thus we should expect that this selection can 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 can in principle deviate from the unconditional expectation of the log price. To account for this self-selection effect, we estimate the probability that on-farm winemakers are 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 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 Φ(.) the corresponding cumulated probability distribution. It can then be shown (using equation (1)) that E[logP_i| organic producer] = $X_i\beta + \mu\lambda_1$ (Heckman 1979) In this way a hedonic price equation can be estimated that accounts for self-selection.

If economic incentives matter in the choice of being an organic producer or not, we would expect that E[logP_i| organic producer] > E[logP_i], that is $X_i\beta + \mu\lambda_1 > X_i\beta$. This means that we expect $\mu > 0$.

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

III. Data

Data for the estimation of the hedonic price equations are drawn from a total survey, funded by the Piedmont Region, of all organic farms on the regional official list of organic farms. At the time of the survey (2006), 1,655 organic farms were operating in Piedmont (1.4 percent of the number of farms recorded at the Agricultural Census in 2000). Piedmont (located in northwestern 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 farms that processed wine on the farm. After elimination of observations with values that were either missing or not usable for the estimates, a total of 171 farms resulted, for a total of 389 wines produced: The number of wines produced on each farm ranges from 1 to 8. Wines (classified by variety and appellation, if any) could be organic or conventional, because not all organic farms only produce organic products or because wine-makers choose not to certify their wine as organic.[2] Organic wines numbered 304 and conventional ones 85, and this allows observation of production prices according to whether they were organic or conventional characteristic. Quantities and average prices were surveyed for both conventional and organic wines. The average price is 3.525 euros (Table 1). Prices exhibit a non-negligible variation, the minimum being 40 cents and the

[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 is that some farmers are only interested in the subsidies provided by the EU for organic farming. A second and related reason may be that, because certification is needed to sell a product as organic, the certification costs for them are too high relative to the price premium they could realize. 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.

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 (euros/liter)	3.525	2.551				
Organic wine price (euros/liter)			3.527	2.528		
Conventional wine price (euros/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 in 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

maximum 21 euros per liter.[3] The average price of organic wine, regardless of its destination, is 3.527 euros, while for conventional wine the price is only slightly lower (3.518 euros). On the basis of these data only, not controlling for explanatory variables, organic wine does not seem to benefit from a price premium relative to conventional wine.

Characteristics of each wine comprise two different appellation levels (DOC, Denominazione di Origine Controllata, or Controlled Designation of Origin, and DOCG, Denominazione di Origine Controllata e Garantita, or 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

[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 euros/liter. Organic wine prices ranged from 0.80 to 21.00 euros/liter, and the quartiles were 5.85, 10.90, and 15.95 euros/liter.

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 have different levels of 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.

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 in growing them, responsiveness to weather and pests, and wine-making processes. Hence, different varieties might have different production costs but, again, different prices can 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). Although our survey did not report production costs, organic wine-growing and wine-making are usually considered more costly than conventional methods. Delmas, Doctori-Blas, and Shuster (2008) report that wine-growing costs in California are 10 to 15 percent higher for organic than for conventional grapes. But, again, the price premium for organic wine might also reflect consumer preferences.[4]

By contrast, some farm and operator characteristics reflect production costs and farmers' skills and apparently have no impact on consumer 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 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 market power, they can be interpreted as indicators of their ability to set prices at the desired level, for example, by choosing the appropriate marketing channel or by raising the reputation of their wine. Farm operator characteristics refer to their human capital. Age is an indicator of skills acquired through experience. Education, another indicator of human capital, was recorded as the maximum degree attained. This was

[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 spirit of Landon and Smith (1997) who model wine ratings as a function of objective wine characteristics. Because overall the model was 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.

translated into years of schooling, assuming that the normal number of years of schooling was followed. A dummy variable indicates whether the high school diploma or the university degree was in the agricultural field. A further dummy variable indicates whether the farm operator had taken a professional agricultural course in the previous three years. All these characteristics are hypothesized to affect wine prices, though the direction may be a priori unclear: Skills acquired through work experience or formal education might translate into higher efficiency and, hence, lower production costs, though this would not necessarily reduce selling prices. At the same time, 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 fetch 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 tries to close the biological circle within the farm through the use of manure. However, specialization can offer greater opportunities in terms of operating and marketing skills. Specialization is measured as the share of total utilized agricultural area planted in grapes. 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, because 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 in organic farming needed to correct for self-selection were drawn from a random sample of 10,000 individual farm records of the 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 the same in 2000 as it was in 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

[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—“the snob effect”—or the greater visibility of large production wines (Costanigro et al., 2007; Landon & Smith, 1997; San Martin et al., 2007). The same variable might capture economies of scale in wine-growing and wine-making that influence 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 (2006b) find that Bordeaux wine estimates based on detailed local weather data are similar to the estimates based on one regional weather station data. This comforts us in not including weather data in our cross-section model.

Table 2
Summary Statistics of On-Farm Winemakers, Piedmont 2000 (1,443 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 in professional courses (0, 1)	0.089	0.285
Organic production (0, 1)	0.013	0.114

Source: Agricultural Census, 2000.

numbered 1,443—that is, 14.4 percent of the total, of which, those who had some organic production (not necessarily wine) comprised 1.3 percent, a proportion that mirrors the general representation of organic farms in the region. Other variables used in the estimation of the probability of producing organic wine were the location (mountains, hills, or plains), farm size (hectares), and some operator characteristics (age and attendance in 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 adherence to the rules of organic farming in these areas. Organic farming is also said to be more favorable to small farms, due to higher labor intensity, though this reputation is disputed. Finally, organic farming is a relatively new technique, so younger farmers might be more inclined to adopt it, because 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.

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, which indicates that the farm's location 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 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

[7] We experimented different specifications of the participation equation and of the wine price equations, because 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.

Table 3

Estimate of the Probability of Being an 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 in professional courses	0.567	2.435
No. of observations	1,443	
Log-likelihood	–88.1281	
Prob[χ^2 > value] =	0.0001	
McFadden's Pseudo R^2	0.1287	
Akaike's I.C.	0.13046	
Correct predictions	98.70%	

overall farm characteristics (Corsi, 2007) shows that in reality this is not the case: Organic farms in Piedmont on average are larger than farms overall. 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 because they need to gather technical information that might be less prevalent than that needed for conventional agriculture. This is also reflected in 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 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 (Greene, 1981; Heckman, 1979).

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, should be interpreted as the percentage change in the price for a unit change in the explanatory variable, the percentage effect of a change of a dummy explanatory variable from 0 to 1, shown in the column "Price Premium," equals 100 [exp(c) – 1], where c is the relevant coefficient (Halvorsen and Palmquist, 1980).

We note that the selection effect is significant and positive, which means that the expected price of wines, conditional on the winemaker's 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 raises the price by about 38 percent, compared to no appellation

Table 4
Estimate of the Log Price of Wine in Piedmont, 2006, with a Dummy for Organically 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	3.0
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
Organically produced wine (1, 0)	0.239**	2.422	27
Lambda[1]	0.442*	1.696	
No. of observations	389		
Adjusted R^2	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 1%, 5%, and 10%, respectively.

(table wines). 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 because 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.

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 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 in terms of better quality (and hence, higher prices) of specialized farmers and better marketing skills of farmers devoting specifically to wine-growing.[8]

The age of the wine producer is not significant, nor does a specialized education in agriculture have 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 be due in part to a generally 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 at wine-growing and wine-making and the better a 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 greater the prospects for buying the best slots for making wine.

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

However, as already mentioned, an alternate 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 tested with the restriction that $\alpha = \alpha_c$ and $\gamma = \alpha_o - \alpha_c$. A likelihood ratio test strongly rejects the restriction implicit in the unified model. The relevant chi-square test is 38.93 with 2 degrees of freedom (d.f.). The conclusion is therefore that organic and conventional wine prices are affected differently by the explanatory variables.[9] Tables 5 and 6 present the estimates of the split model.

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 ($p = 0.107$) and positive. Appellations (DOC and DOCG) are both significant and add 39 percent and 48 percent respectively to the price. Also the effect of Nebbiolo grape is similar to the one of the unified model (72 percent).

[8] Of course it might also be that the higher the price the farmer can ask for 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.

[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 that it was significant. Unfortunately, we had no instruments for it. Overall, this reinforces the preference for 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	
Number of observations	304		
Adjusted R^2	0.355		
F[18, 285]	10.28		

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

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 regarded as an effect of the higher professional skills required by organic farming.

For conventional wine price, the selection effect is positive and significant. Thus the expected price of conventional wine, conditional of being an organic producer, also exceeds the unconditional expectation in the entire population of wine-makers. This indicates that there is an economic incentive behind the decision to become 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. General education, the other significant variable, has a positive

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	
Number of observations	85		
Adjusted R^2	0.326		
F[18, 66]	3.26		

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

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.

Because 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 whether the wine grapes are grown organically (Table 5) or conventionally (Table 6). Nevertheless, the constant in the organic price equation is significantly higher than the constant 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 is higher for organic wine than for conventional wine.

One might wonder in the end whether on average wine-growers "make the right choice" by growing organic or conventional grapes and selling organic or conventional wine, given the characteristics of the farm and farmers. Given these characteristics, the question is thus whether they would get a higher price if they grew and sold organic wine rather than conventional wine. To answer this question, one can predict from the parameters of the organic wine model the average price organic wines would fetch and compare it to the average price predicted by the conventional wine model, that is, the average price the very same wines would have fetched if they used conventionally raised grapes. Formally, one can test:

$$\bar{\mathrm{p}}_{\mathrm{oo}} > \bar{\mathrm{p}}_{\mathrm{oc}} \tag{7}$$

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

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

where the summation is over $\mathrm{N_0}$, the number of organic wines.

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

$$\bar{\mathrm{p}}_{\mathrm{co}} > \bar{\mathrm{p}}_{\mathrm{cc}} \tag{9}$$

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

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

where the summation is over $\mathrm{N_c}$, 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 (1,000 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 repeated the procedure over the 1,000 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 euros/liter. When using the coefficients of the conventional price equation, but the covariates of organic wine, the mean log price is lower, 0.869

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	0.868
Log price| conventional parameters and conventional variables	0.954
Log price| organic parameters and conventional variables	1.189

euros/liter. Thus these averages indicate that the organic "technology," as measured by the estimated coefficients, yields higher prices than the conventional "technology" (Equation (7) above).

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, wine from organic produce tends to fetch a higher price than wine produced using conventional "technology." In 86.8 percent of the cases, the alternative hypothesis H_1 was true. However, this is far from 95 percent of cases, 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 euros/liter. When we replace 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, 9.2 percent. Thus, though the difference is not highly significant, we can conclude that farmers who produced conventional wine, given their characteristics, would on average have been able to charge higher prices if they had produced organic wine.

[10] The differences were calculated over the permutations of the 1,000 average prices calculated from the random draws. The procedure is demanding in terms of computer time.

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 that apparently are of no interest to consumers but influence production costs affect wine prices. The second question was whether organic wine can fetch a price premium relative to conventional wine.

As expected, the appellation of wines in the Piedmont region matters in the price of wine. And also as expected, wines from the Nebbiolo grape are priced far higher in the market than other grapes. Nevertheless, in addition to the fact that these characteristics affect production costs, they might 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. The 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 spectrum of agricultural products has a significant positive impact on the price of wine.

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 a fixed amount added to the price due to the organic quality; organic quality interacts with other characteristics in determining the price. Nevertheless, at the zero level of all other characteristics, organic wine is priced higher than conventional wine. 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 wine-growers who made conventional wine would on average be able to charge higher prices if they had grown organic grapes and made organic wine, given farmers' and wines' characteristics. With a somewhat lower significance, we find that wine-growers who made organic wine charged higher prices than they would have if they had grown conventional grapes and made conventional wine. The reason some wine-makers choose to make conventional wine even though they could charge higher prices for organic wine is not investigated in our research. It might obviously depend on the production costs, not compensating for the price premium, or on the difficulty of finding appropriate outlets for organic wine. This is left to further research.

The conclusion that parameters are different in equations for organic and conventional wines also contributes to the question of structural changes in the estimated hedonic equations, conditional on some grouping of the wines. In most settings, wine characteristics are assumed to add to the price. 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, because estimating separate functions for organic and conventional wines proved statistically superior to the pooled estimation.

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