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Perceived Value of Precision Agriculture in the Vineyard: Combining the van Westendorp Pricing Analysis and Experimental Auctions

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Abstract

The wine market is increasingly sensitive to sustainability issues, thus calling for the use of environment-friendly productive processes. What is the willingness of consumers to pay for such products? This work aims to investigate how consumers perceive the value of a "precision viticulture" with respect to Italian wine "Falanghina del Sannio" using a mix of hypothetical and real scenarios, that is, the *hypothetical* van Westendorp's Price Sensitivity Meter (PSM) and *real* experimental auctions employing the Becker-deGroot-Marschak (BDM) mechanisms. The value of the attribute "precision viticulture" ranges between 19.86% and 24.51% (optimally 22.20%) of the total value of a hypothetical sustainable bottle of wine. In particular the attribute "precision viticulture" would maximize revenue if priced 2 Euros. A 1% increase in the price of the new wine associated with "precision viticulture" would lead to a 2.26% reduction in the quantity demanded. Finally, results suggest

that the higher the value of a regular bottle of wine, the higher the consumer's WTP for the "precision viticulture" attribute.

Keywords: Becker-deGroot-Marschak experimental auction; Falanghina del Sannio; precision viticulture; van Westendorp's price sensitivity meter; Italian wine

1. Introduction

The wine sector plays a leading role in the Italian and European agri-food in terms of sales volume, revenues and excellence in product quality (Nazzaro *et al*., 2022; Pomarici and Sardone, 2020). At the same time, the wine sector is largely responsible for greenhouse gas (GHG) emissions (Recchia *et al*., 2018; Sarri *et al*., 2020). For this reason, the wine sector has embarked in an innovative path of changes affecting production processes, which are becoming increasingly smart and green (Fiore *et al*., 2017; Dries *et al*., 2013). Wineries have changed their investment priorities, focusing on precision and smart agriculture (Giuliani *et al*., 2011). In particular, they rely on the use of information and communication technologies, such as Big Data and Analytics, in order to explore the variability of data and use it to deal with changes in the agricultural scenario (Lasso and Corrales, 2018). Such techniques are usually employed to measure and control variables such as temperature, water, and soil nutrients (Shafi *et al*., 2019), and to manage the proper use of herbicides, fertilizers, and other variables related to agricultural production, in order to achieve rational use of economic, human and natural resources (Bhakta *et al*., 2019; Giraldo *et al*., 2017).

Literature highlights that conveying information on sustainable production processes can positively affect consumer preferences and their willingness to pay (Lanfranchi *et al.*, 2019; Stanco and Lerro, 2020; Vecchio *et al.*, 2023). More deeply, previous studies focused on European and US consumers find a greater willingness to pay for sustainable wines (Sogari *et al.*, 2016; Pomarici *et al.*, 2016; Schäufele and Hamm, 2017). However, many of them exclusively analyse consumer preferences in hypothetical scenarios, raising questions about consumer behaviour in real scenarios.

In light of the above, this work aims to investigate how consumers perceive the value of a sustainable innovation in wine sector employing a mix of hypothetical and real scenarios. Consumers have been asked their willingness-to-pay (WTP) for upgrading a regular bottle of "Falanghina del Sannio", an Italian wine, to an equivalent one from the same winemaker, with the same brand, from the same grape variety, cultivated in the same geographical area, but employing a "precision viticulture" system in the vineyard. The regular wine has been valued using the van Westendorp's (1976) *hypothetical* Price Sensitivity Meter (PSM). The attribute "precision viticulture" has been measured using *real* experimental auctions with Becker-deGroot-Marschak (BDM) (Becker *et al.*, 1964) mechanisms, allowing to measure its demand curve and the optimal price which maximizes revenues. The elasticity of the new bottle of wine, obtained as the composite of the values of the regular wine and the attribute "precision viticulture", has been calculated. Finally, the relationship between the attribute "precision viticulture" and the value of the regular bottle of wine has been econometrically investigated.

The work is organized as follows: Section 2 contains a description of data and methods employed in the article; Section 3 shows the results; Section 4, finally, presents the conclusions.

2. Materials and Methods

A behavioral experiment took place between June 2023 and December 2023 and consisted of two steps. First, people answered an online questionnaire administered via email concerning their socio-demographic profiles. They were then invited to the Food, Agriculture, and Resource Economics Laboratory (FARE-Lab, https://site.unibo.it/fare-lab/it) of the University of Bologna to carry out two tasks. They answered a second questionnaire to evaluate a regular bottle of wine via PSM. They then participated in an experimental auction *with endowment* based on the BDM mechanism to assess the willingness-to-pay (WTP) for exchanging the regular bottle of wine with a new one produced via "precision viticulture". The attribute "precision viticulture" has been evaluated *ceteris paribus* using the experimental auction. The auctions were conducted in a laboratory environment rather than "in the field" to exercise maximum control over the experiment. Once the experiment was concluded, the data obtained were analyzed with statistical methods to assess the weight of the "precision viticulture" attribute over the value of the regular product.

Furthermore, some characteristics that determine a significant variation in the WTP for the "precision viticulture" attribute were statistically analysed. The online questionnaire and the laboratory experiment were carried out using Qualtrics software (https://www.qualtrics.com). The programs used for the statistical elaboration of the answers are Julia 1.10.0 (Bezanson, 2017) and STATA 17 (https://www.stata.com).

2.1. Participants

Some participants were drawn from the pool of people who regularly shop at the University of Bologna's experimental farm (A.U.B. Azienda Agraria – UniBo), which sells local fruits, vegetables, jams and wines. Others were recruited in person by sponsoring the event and distributing flyers in shops and shopping centers. This procedure resulted in an initial sample of 168 participants reduced to 159 units due to logical inconsistencies in the answers concerning PSM analysis (details provided in Section 2.2). The socio-demographic characteristics of the sample are presented in Table 1.

Table 1: Sample characteristics

Data collected	**N**	**%**
Gender		
Male	58	36.48
Female	101	63.52
Age group (years)		
18-24	22	13.84
24-34	23	14.47

35-44	21	13.21
45-54	46	28.93
55-64	35	22.01
≥65	12	7.55
Educational level		
No	–	–
Primary school	–	–
Middle school	3	1.89
High school	44	27.67
University (bachelor and/or master)	54	33.96
Post-graduate (e.g., PhD)	58	36.48
Occupational status		
Unemployed	1	0.63
Student	31	19.50
Paid worker	110	69.18
Self-employed worker	6	3.77
Retired	11	6.92
Wealth		
Low (economic problems)	9	5.66
Middle	107	67.30
High (no economic problems)	43	27.04

2.2. Van Westendorp's Price Sensitivity Meter

The van Westendorp's PSM is a method for deriving the range of prices for a – usually new – product (Paczowski, 2018). The method is direct and hypothetical (Kloss and Kunter, 2016) in that each participant directly answers four questions concerning the price of a product without having to purchase it. These questions are:

1. *Too cheap*: At what price would the product become so cheap that you would start questioning its quality and, thus, refraining from purchasing it?
2. *Cheap*: At which price do you consider the product cheap but still a good deal?
3. *Expensive*: At which price would you consider the product expensive, but would you still buy it?
4. *Too expensive*: Above what price would the product become too expensive to purchase?

The answers to the above-mentioned questions provide four different price variables, which are considered valid for each individual if they follow the logical rule of consistency: too cheap ≤ cheap ≤ expensive ≤ too expensive (Paczkowski, 2018). Observations entailing illogical answers are dropped from the dataset. The cumulative

frequency distributions of each price are, thus, obtained, and their pairwise intersections are used to identify four crucial points:

1. the optimal price point (OPP), i.e., the point at which the percentage of individuals rating the product "too cheap" equals the percentage of those rating the product "too expensive";
2. the point the indifference price point (IDP), i.e., the point at which the percentage of individuals rating the product "cheap" equals the percentage of those rating the product "expensive";
3. the point of marginal cheapness (PMC), i.e., the point at which the percentage of individuals rating the product "too cheap" equals the percentage of those rating the product "expensive";
4. the point of marginal expensiveness (PME) i.e., the point at which the percentage of individuals rating the product "cheap" equals the percentage of those rating the product "too expensive".

2.3. Becker-DeGroot-Marschak experimental auction

The BDM auction has two precise characteristics: each participant competes with the computer – rather than against other participants – to obtain a specific product; each participant who places a bid higher than the drawn price will pay the price offered by the computer and will win the product. In other words, what is offered is independent of what is paid. This makes BDM auctions incentive compatible. The experiment is within-subject, meaning each participant is subject to the same experimental conditions. In other words, the experiment is repeated in the same format for each participant. The auction exploits an *endowment* mechanism: the individual participant, who has previously been donated a standard product (i.e. one with characteristics that satisfy the basic market expectations for the product itself), is questioned on his/her WTP for exchange it for a new product with an additional and innovative feature. Precisely for this experiment, the participant was asked how much he or she would pay to exchange a regular bottle of wine produced with standard winemaking techniques (the endowment) for an upgraded wine from "precision viticulture". It is worth underlining that the two products are identical (brand, grape variety, alcohol content, production area) apart from the "precision viticulture" attribute, which is the subject of evaluation. In order to encourage participation, participants were offered a voucher of 15.00 euros to spend on the products of the experimental farm of the University of Bologna (A.U.B.). At the end of the auction, if the participant made a bid higher than the drawn price, she/he won the bottle of wine with the "precision viticulture" attribute, effectively paying the price drawn at random by the computer.

2.4. Procedure

The detailed procedure used to experiment is described step-by-step in algorithmic fashion as follows.

- Recruitment of participants via distribution of flyers, posters and email invitations;
- Participants answered the socio-demographic survey provided via email. They are then invited to book a slot for the laboratory experiment according to their time preference;
- Upon entering the laboratory, each participant is informed by the experimenter about the characteristics and purposes of the experiment;
- The participant is given a regular bottle of wine as an *endowment*. Each participant evaluates the regular bottle of wine, answering the four questions the van Westendorp's PSM framework requires.

- The participant then evaluates the “precision viticulture” attribute through the BDM experimental auction.

3. Results and Discussion

The WTP for “precision viticulture” is analysed for upgrading a bottle of Italian wine to an equivalent one from the same winemaker, with the same brand, coming from the same grape variety, cultivated in the same geographic area, but using a precision farming system in the vineyard.

On this premise, the analyses in this article are based on the assumption that the hypothetical value for a new bottle of wine from “precision viticulture” is obtained as the sum of the values given to the regular bottle of wine using van Westendorp’s PSM and the value of the attribute “precision viticulture” elicited via BDM experimental auction mechanism.

3.1. Descriptive statistics

Table 2 provides some descriptive statistics, i.e., mean, median, minimum value, maximum value and standard deviation, concerning the variable used throughout the article. These are the willingness to pay for the attribute “precision viticulture” (WTP) and the answers to questions “Too cheap”, “Cheap”, “Expensive”, and “Too expensive” relative to van Westendorp’s PMS analysis. All of them share Euro as their unit of measure.

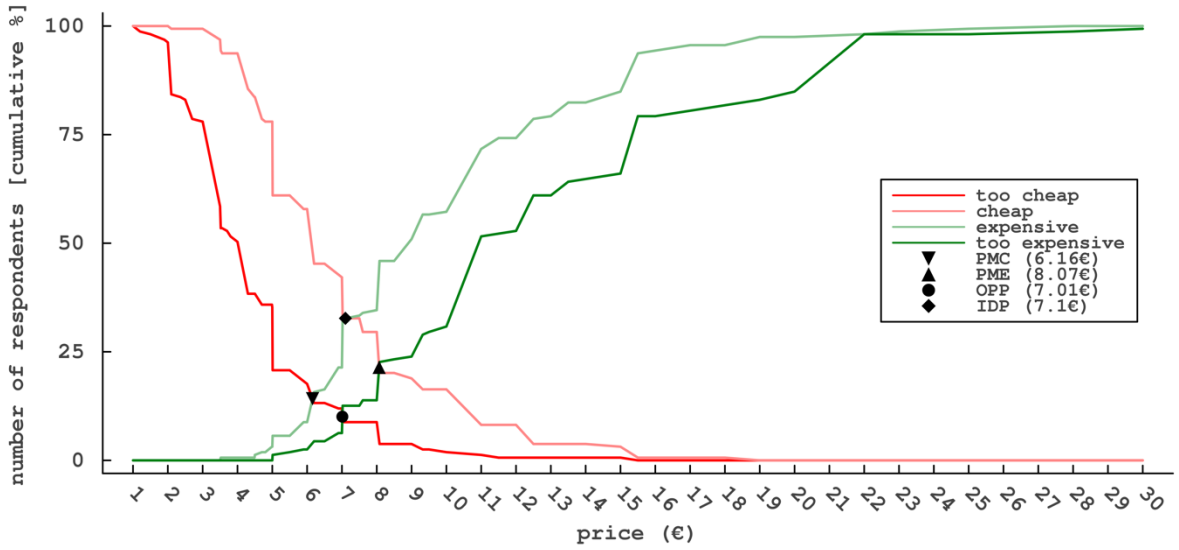
Table 2: Descriptive statistics

	WTP	Too cheap	Cheap	Expensive	Too expensive
mean	2.71	4.21	6.75	9.67	12.35
median	1.75	4	6	8.5	10
min	0	1	2	3.5	5
max	30	15	18	25	30
std. dev.	3.73	2.11	2.79	3.85	4.86
Obs.	159	159	159	159	159

3.2. Van Westendorp’s PSM analysis of regular wine bottle

These results are shown graphically in Figure 1, which maps the cumulative number of respondents (cumulative %) as a function of price. The red and light red lines are the cumulative frequencies relative to “Too Cheap” and “Cheap” answers, respectively. On the other hand, the green line and the light green line refer respectively to “Too Expensive” and “Expensive” answers.

Figure 1: van Westendorp's Price Sensitivity Meter for the regular bottle of wine.

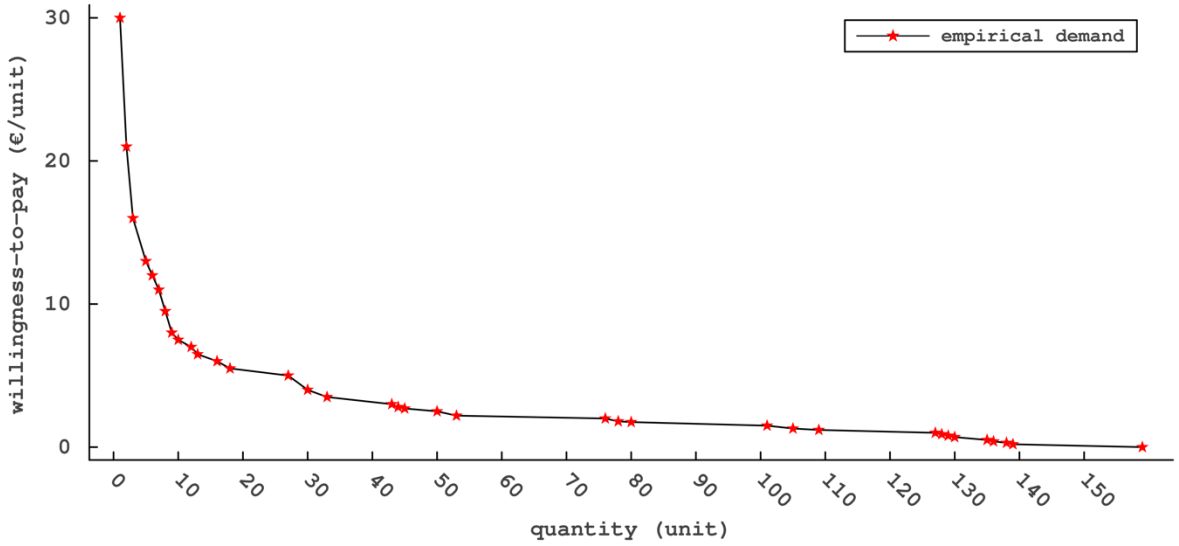


The results suggest that the value of the regular bottle of wine ranges from 6.16 Euros to 8.07 Euros. In particular, its optimal price is equal to 7.01 Euros.

3.3. Empirical demand and revenue analysis for the attribute

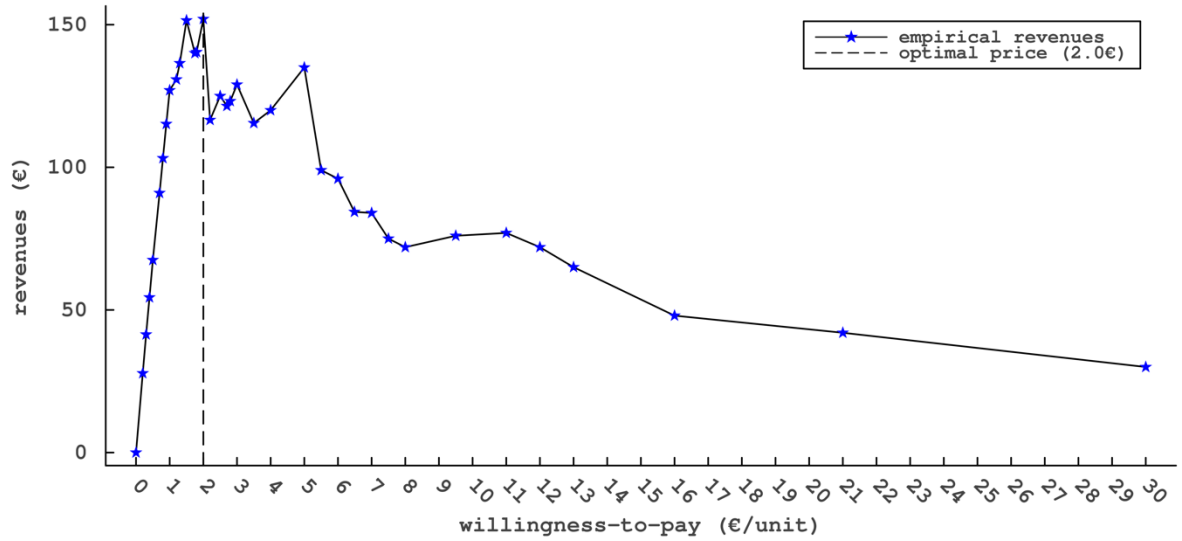
The empirical demand curve concerning the bids for exchanging the regular bottle of wine with that from "precision agriculture" is presented in Figure 2

Figure 2: Empirical demand for "precision viticulture"



The empirical demand curve presents a negative and downward-sloping behaviour. Figure 3 shows the value of the WTP, which maximises the potential revenue for the "precision viticulture" attribute. Concerning this sample, this is found to be equal to 2.0 Euros.

Figure 3: Empirical revenue for “precision viticulture”



Assuming the new bottle of wine as the composite of the regular bottle and the “precision viticulture attribute”, the latter attribute would weigh about 22.20% over the total value of the composite bottle. In general, the attribute “precision viticulture” would weigh between 19.86% and 24.51% of the total value of the upgraded bottle.

3.4. Mixing PSM and BDM: the elasticity of the new bottle of wine

Of interest is the computation of the elasticity of demand for a hypothetical bottle of wine from precision viticulture, that is, the composite of the regular bottle of wine and the attribute “precision viticulture”. This is achieved in terms of Equation 1, which shows a log-log model (natural logarithm) to estimate the *constant price elasticity of demand*, β, that is,

$$\ln(Q_{sw}) = \gamma + \beta \ln(P_{sw}) + \varepsilon \quad (1)$$

where Q_{bids} is the quantity demanded for the new bottle of wine and P_{bids} is its unit price. Parameters α and β are estimated employing 36 observations – 36 unique prices for 36 quantities – out of 159. In other words, duplicate prices were reduced to unique values. The estimation of Equation 1 via OLS generates estimates $\hat{\gamma}$ = 9.29 and $\hat{\beta}$ = −2.26. Both are significantly different from 0 at the 1% level. The R^2 is equal to 0.91, thus denoting a relatively high goodness-of-fit. The negative sign of $\hat{\beta}$ is coherent with price elasticity, thus denoting a downward-sloping behavior. In particular, a 1% increase in the price of the new wine from “precision viticulture” leads to a 2.26% reduction in the quantity demanded.

4. Conclusions

This study aims to investigate how consumers perceive “precision viticulture” by mixing the features of van Westendorp’s PSM analysis and those of experimental auctions based on the BDM mechanism. Van Westendorp’s PSM is used to provide the optimal value for a regular bottle of Italian wine “Falanghina del Sannio”, which is found to be equal to 7.01 Euro. The experimental auction assesses the consumers’ WTP to upgrade the regular bottle to a new one featuring “precision viticulture” ceteris paribus. The latter valuation is exploited to draw the empirical demand and the optimal price, i.e., the price maximising the empirical revenues of the attribute “precision viticulture”. Assuming the total value of the upgraded bottle of wine as the sum of the optimal value from van Westendorp’s PSM analysis and that of the attribute “precision viticulture” from BDM experimental auction, a price elasticity of −2.26% is calculated. These results provide valuable information that could stimulate the interest of wine producers in adopting sustainable farming techniques and serve as a valuable benchmark for pricing wines produced using precision farming systems in the vineyard.

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