An hedonic approach applied to scanner data on cured ham purchases in Spain

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Abstract— **A quantity-dependent hedonic model is used to study consumers' actual purchases of cured ham, recorded through scanner in Spain, between April 2003 and March 2004. A Zero Inflated Negative Binomial (ZIB) model is applied because of the high proportion of zero purchase-values and the finding of overdispersion in the data. Ham characteristics are used as explanatory variables, such as breed, origin, EU Quality Certification squemes (PDO, PGI, STG), type of brand (producer's and distributor's), sale format (whole leg, vacuum packaged, on request), ripening period and price. Monthly dummies variables are also added to capture a possible seasonal effect. The results show that the distributor's brand, the whole leg sale format, the origin Teruel and its certification through a PDO are the main attributes affecting cured ham purchases. The Quality Certification has a significant effect when added to a locally produced ham (PDO Teruel), while in general, it has a negative impact. Vacuum packages and ripening period, have a negative impact on the quantity purchased. The positive impact of the attributes on cured ham purchases are reinforced when attached with Iberian ham, especially in the case of a distributor's brand and a whole leg sale format. In addition, the negative impact of the vacuum packages is mitigated when the breed of the ham is Iberian.**

Keywords— **hedonic analysis, consumers, zero inflated negative binomial**

I. INTRODUCTION

Research in hedonic prices have been fuelled by the theory of Lancaster's demand of characteristics [1] and Rosen's modelling of hedonic functions [2]. Lancaster's theory states that consumers do not obtain utility directly from the goods that they consume but from the combination of characteristics that the goods possess, whilst Rosen's approach, allows to estimate the implicit price for each of these characteristics. The hedonic price approach has been employed in a wide set of economic disciplines, whilst applications in agro-food products, have focused mainly on wine (e.g. [3], [4] and [5]).

Hedonic analysis in the food consumption field have used stated purchases through surveys [6]; information on product labels exposed on the shelves of retail outlets [7]; or in the case of wines, information provided by specialised guides [5]. Nevertheless, when interest lies on consumers' preferences, data based on their actual purchases maybe more reliable.

In this paper, we focus on actual purchases of cured ham in a northern city of Spain (Zaragoza), located in the same region as one well known producing area (Teruel), in which a Protected Designation of Origin (PDO) has been in place since 1985 (PDO 'Jamón de Teruel'). We use a scanner database provided by one of the main hypermarkets chain in the country. As in [3] and [4], we consider that consumers reveal their preferences through the quantity purchased at a given price, and accordingly, a quantity dependent specification is used. Moreover, given the nature of data, an array of count models (Poisson, Negative Binomial) are considered, and in particular, zero inflated versions are analyzed because of the high proportion of zero purchase records.

From an empirical perspective, this is the first attempt to estimate a hedonic function for cured ham. The broad customary basis and long tradition in production, has made of Spain the most important producing and consuming country in the world, whilst exports to specific markets, such as USA, China or Japan, have started to boost recently following the exports ban lift. Quality Certifications that protect the specificities of Spanish cured ham linked to methods of production, rearing, breeds and origin, have been in place since the mid-eighties. In this paper we try to assess the relevance of these Quality Certifications with special focus on the local origin (Teruel) and its certification (PDO 'Jamón de Teruel') as triggers for purchase, and the estimation of their implicit economic value.

II. THE DATA

This paper uses scanner data on actual purchases of cured ham, recorded by one of the main retail chains in Spain. This database records only actual purchases paid with the retailer's loyalty card in two hypermarkets located in Zaragoza. A total of 5640 customers are identified, who have purchased cured ham at least once during the analysed period, between April 2003 and March 2004. The raw data contains 19384 observations or purchase acts. Due to the restrictions imposed by the Law of personal data protection in Spain, customers' sociodemographic characteristics are not available. The choice set is composed by 73 references, which correspond to 57 different commercial brands [1]. Daily purchases of each reference are summed up to obtain

[1] The range of prices for one commercial brand can be very wide, depending on the sale format (whole leg, sliced and packaged, etc...). In order to gain a certain level of homogeneity the brand is split into "references" defined by the combination of brand and format.

weekly purchased quantities and purchase values. Then, we aggregate the quantities purchased (in grams) for each reference across all the customers included in the database. Therefore, we have a total of 3869 observations (53 weeks × 73 references). Available characteristics are: breed (Iberian or white); Quality Certification (presence or absence); type of brand (producer's, distributor's or non-identified); sale format (whole leg, vacuum or modified atmosphere packaged ham, or other formats (including, mainly, on request)); the presence of indication of a period of ripening after the curing process (through the mentions of '*Reserva*' or '*Bodega*' on the reference information); origin (Teruel or other places in Spain); and price, which is obtained by dividing the value against the quantity, therefore it is more a unit value than a transaction price. In Table 1 a basic description of data is presented.

Table 1. Data description

Characteristic	% of observations	% of purchased quantity	Average price (€/kg)
Price	100	---	19.42
White ham	71.23	93.06	12.05
Iberian ham	28.77	6.94	37.66
Distributor's brand	13.70	27.16	24.60
Iberian	4.11	0.22	57.27
White	9.59	26.93	10.60
Producer's brand	73.97	67.53	17.43
Iberian	20.55	6.70	32.44
White	53.42	60.83	11.65
Quality certification	9.59	6.19	16.36
PDO 'Jamón de Teruel'	6.85	5.35	17.02
Origin Teruel	10.96	8.87	17.71
Ripening indication	20.55	20.43	9.86
Format: Packages	27.40	18.27	20.56
Iberian	4.11	0.08	55.66
White	23.29	18.19	14.36
Format: Leg	38.36	55.96	11.25
Iberian	12.33	6.55	20.40
White	26.03	49.91	6.92
Format: On request	30.14	16.30	30.65
Iberian	12.33	0.30	48.93
White	17.81	16.00	17.98

Notes: the percentages of observations and quantities for Distributor and Producer's brands do not add to 100 as there is also a significant proportion of observations with a non-specific brand.

After the aggregation process, 49% of the observations are zero, being the most plausible explanation that the reference was not available for sale at that specific week. The average price is 19.42 €/kg. However, this figure conceals that Iberian ham is significantly more expensive than white ham, due to its specificities in terms of breed, feeding (mainly acorn and wild herbaceous plants), extensive rearing, and traditional processing methods. In the database, the average price for Iberian ham is about 38€/kg, whilst the mean price for white ham is 12€/kg. White ham purchases represent 71% of the observations and 93% of the total quantity purchased. It is important to remark that the location of the consumer does affect purchase and consumption habits. The region of Aragón, where the scanner data is recorded, counts with a long producing and consuming tradition of white breed ham, and accordingly, Iberian ham is consumed significantly less than in other parts of Spain (mainly the centre and the south).

Most observations carry a producer brand (74%). Branding allows the retailer to reach different market segments, offering different price/quality combinations. The scanner data shows a clear distinction of target markets. In the Iberian ham, the own distributor's brand is positioned at the top, with an average price of 57€ which is significantly higher than the average Iberian ham price, 38€, while in white ham, the central tendency is to offer varieties slightly cheaper (10€) than the white ham price mean (12€). Nevertheless, the market share for the Iberian distributor brand is less than 1%.

Around 10% of the observations and 7% of the purchased quantity correspond to references that carry a Quality Certification under schemes ruled by the EU: Protected Designation of Origin (PDO), Protected Geographical Identification (PGI) or Traditional Speciality Guaranteed (TSG). Importantly, most of these observations (70%) fall into the regional PDO '*Jamón de Teruel*'. Note however, that not all the product coming from Teruel carries the PDO (around 60%), while the prices for this local speciality are clearly superior to the average white ham price (17€/kg versus 10.6).

The description '*Reserva'* or '*Bodega'* which indicates the existence of a period of ripening after the curing process is found in 21% of the observations and quantity purchased along the year. These are traditional descriptors for Iberian ham and are regulated by the regulatory bodies of the PDO/PGI schemes [8], whilst still are found among non-origin-labelled hams.

Whole legs predominate over packaged formats (sliced or small pieces in vacuum or modified atmosphere): legs account for 38% of observations and 56% of the total purchased quantity (12% of observations and 7% of the total purchased quantity in the case of iberian ham), whilst packaged formats account for 27% and 18% of observations and quantity, respectively (4% and 0.08% if the breed is iberian). In the last years, however, packages in self-service have become more popular due to the search for convenience [9], and have overtaken the more traditional way of buying on request at the Delicatessen section (16% of the purchased quantity).

III. THE THEORETICAL MODEL

Our empirical application is based on the theoretical hedonic approach developed by Rosen, and further updated by Nerlove to the case where the supply of characteristics is perfectly elastic. Nerlove highlights that there is an identification problem in the price-dependent formulation, as observations on price and quantity of attributes are in general, jointly determined by demand and supply, and accordingly, the estimated coefficients or implicit prices for each attribute, will be reflecting not only consumers'

preferences and the economic value of that characteristic for consumers, but also supply factors, such as producing costs. Nerlove argues that, in a limited market, where prices are given, consumers will express their preferences purchasing a determined quantity of each good variety. In this case, the changes in the consumer demand do not affect the supply of the good and its characteristics, and the supply is perfectly elastic. Durham follow this advice, and applies it to a retail situation in which products are storable and prices are fixed at the sales level.

IV. THE EMPIRICAL MODEL

The Poisson model has been frequently applied for the study of count data. In our study, we try to explain the units (grams) of ham purchased weekly, for each reference/brand (q_i). The Poisson model has three main limitations: first, in the presence of zero inflation, that is, when the dataset contains a high frequency of zero values [10], it does not provide an accurate fit of the data; second, it tends to under-predict the probability of large counts [11]; and third, it relies on the assumption of equi-dispersion, that is, the variance and mean of the count data are equal, $Var(q_i) = E(q_i)$. When this is not the case, there is over-dispersion, and as a result, although the estimates are unbiased they are inefficient, leading to inflated t-statistics [12]. The negative binomial (NB) improves the Poisson performance in the case of over-dispersion, and assumes: $Var(q_i) = \lambda_i + \alpha \lambda_i^2$, with α being the dispersion parameter and λ_i the mean.

However, when count data contains an excess of zeros, the zero inflated counterparts of Poisson and Binomial models, Zero Inflated Poisson (ZIP) and Zero Inflated Binomial (ZIB), are recommended. Both, ZIP and ZIB have been applied to a variety of fields including bio-diversity, medicine, manufacturing defects [11] or economics [13]. However, their application into agricultural economics is still rare, and to our knowledge, only have been applied by [14] and [4]. Our data reveals that 49% of the observations contain zeros, and accordingly, the use of inflated models seems a logical methodological avenue.

The ZIB model handles over-dispersion by following a mixture of two states: one state leading to an excess of zeros, with probability p_i (i.e. probability of non-purchase); and the second state, with probability 1-p_i (i.e. probability of purchase), that follows a binomial distribution. According to this approach, zeros may arise from: a zero-process from which only the "true" zero values are observed (i.e. consumers choose not to purchase the specific reference of cured ham that week although it was available); or a negative binomial process that accounts for non-zero (i.e. actual purchases) and a proportion of zero "false" values (i.e. a specific reference is not purchased at the specific week because either, the reference was not available or there is an error in the data collection) [15]. The ZIB model defines the following count probabilities ([16]; [17]):

$$\Pr(q_i = 0) = p_i + (1 - p_i)\left[\frac{\theta}{\theta + \lambda_i}\right]^{\theta} \quad (1)$$

$$\Pr(q_i = q) = (1 - p_i)\frac{\Gamma(\theta + q_i)u_i^{\theta}(1 - u_i)^k}{q_i!\,\Gamma(\theta)} \quad (2)$$

$q>0$

Where θ is the inverse of the over-dispersion parameter α, $\theta = 1/\alpha$; $u_i = \theta/(\theta+\lambda_i)$ with λ_i the mean, and the expression $\frac{\Gamma(\theta + q_i)u_i^{\theta}(1 - u_i)^k}{q_i!\Gamma(\theta)}$ is the negative binomial probability distribution.

Both the probability of being in the true-zero or inflated zero state (p_i) and the mean of the purchase state (λ_i), can be modelled as a function of the covariates or explanatory variables of both states (X_1 and X_2) [11], as follows:

ZIB: $\log(\lambda_i) = X_1\beta$ and $\text{logit}(p_i) = X_2\eta$ (3)

ZIB(τ): $\log(\lambda_i) = X_1\beta$ and $\text{logit}(p_i) = -\tau X_2\eta$ (4)

being $p_i = 1/(1+\lambda_i^{\tau})$

When the covariate vectors are related by the parameter τ, as in (4), the model ZIB is denoted ZIB(τ). In our dataset, after aggregating over individual purchases, it is more likely that a zero purchase outcome for a specific reference and week is the result of a false zero (eg. due to lack of availability of the reference) rather than a true zero (eg. a deliberate non-choice), an accordingly, a ZIB(τ) model seems more suitable as recommended by Martin *et al*. Besides, we use only one set of covariates (X_1=X_2), that account for ham's attributes reported in Table 1. Accordingly, we are assuming that the same variables explain both, purchase and non-purchase (given the nature of our dataset, we cannot isolate the factors that affect each of these outcomes); besides, this assumption simplifies the interpretation of the coefficients.

V. RESULTS

In the estimation, we use as the dependent variable ($q_i \geq 0$) the quantity purchased of a specific reference (73 references) in each week (52 weeks) measured in grams (in order to have integer values). As explanatory variables, we include Price (€/g); and an array of dummy variables to account for specific characteristics: Dist and Prod equal 1 when the reference is Distributor's and Producer's brand, respectively, and 0 otherwise; Leg and Pac equal 1 when the reference is sold as a whole leg or packaged, respectively, and zero otherwise; Ter = 1 when the geographical origin of the reference is Teruel and zero otherwise; QcTer = 1 when the reference carries the PDO 'Jamón de Teruel' and 0 otherwise; Qc = 1 when the reference carries an EU Quality Certification and 0 otherwise; Res = 1 when the reference uses the descriptors '*Bodega'* or '*Reserva'*; Ib = 1 when the reference is of Iberian ham and 0 otherwise; and Price_Ib, Dist_Ib, Prod_Ib, Leg_Ib, Pac_Ib represent interactions (product) of the characteristics (dummies) above defined with the Iberian breed (dummy), in order to capture a

differential impact according to breed. These are included, as both types of ham, Iberian and White, can be considered different varieties altogether, in particular, when such large gap of prices exist. Besides, monthly dummies are included in order to account for a possible seasonal effect in ham purchases. For each dummy variable, (at least) one level is left out, to avoid the multi-collinearity trap.

GAUSS software is first used in the screening, organisation and description of data, and LIMDEP 8.0 is then applied to estimate by maximum likelihood an array of count models: Poisson, Negative Binomial, ZIP(τ), and ZIB(τ).

Results on the model selection are shown in Table 2. The pseudo-deviance-R^2 for the Poisson model [12] is 0.349. Over-dispersion is confirmed by three different tests: Cameron and Trivedi's test [18]; a log-likelihood ratio (LR) test, that compares the value of the log-likelihood function in the NB and Poisson models, which differ only in the over-dispersion parameter α; and the significance of the dispersion parameter α at 1% level of significance. Accordingly, at this stage the Negative Binomial model is preferred over the Poisson model.

Table 2. Model selection tests [a]

Models	*Poisson*	*NB*	*ZIP(τ)*	*ZIB(τ)*[2]
Log-likelihood function	-16407514	-23027	-217040	-21436
Log-likelihood ratio test	32768974[b] (0.000)		39120[c] (0.000)	1769[d] (0.000)
τ	-	-	0.150 ***	-0.008 **
Over-dispersion parameter α	-	10.881 ***	-	0.747 ***
Vuong's statistic	-	-	92.554[e] (0.000)	43.163[f] (0.000)
Pseudo-R^2 (Pearson)	0.349	-	-	-

[a] ** and *** indicate significance at 5% and 1%, respectively.
[b] Log-likelihood ratio to detect the presence of over-dispersion and to test the overall significance of Poisson in comparison to negative binomial (p-value in parentheses).
[c] Log-likelihood ratio to test the overall significance of ZIP(τ) in comparison to ZIB(τ) (p-value in parentheses).
[d] Log-likelihood ratio to test the overall significance of ZIB(τ) in comparison with a restricted model that only includes the constant (p-value in parenthesis).
[e] Vuong's statistic to test the overall significance of ZIP(τ) in comparison to Poisson model (p-value in parentheses).
[f] Vuong's statistic to test the overall significance of ZIB(τ) in comparison to NB model (p-value in parentheses).

Next, we apply Vuong's test [19] to compare between Poisson and ZIP(τ) models, as well as NB and ZIB(τ). This test is designed for non-nested models and is based on a t-statistic distributed asymptotically as a normal distribution: large positive values (bigger than 1.96) favour the zero inflated model, whereas large negative values (lower than -1.96) favour the non-inflated versions [17]. Results show that the ZIP(τ) is preferred over the Poisson model (Vuong's test = 92.554) and ZIB(τ) is preferred over the Negative Binomial model (Vuong's test = 43.163). The significance of the zero inflated parameter (τ) confirms a better adequacy of the zero-inflated models (at 1% and 5% for the inflated models ZIP(τ) and ZIB(τ), respectively).

Finally, a log-likelihood ratio to compare the ZIP(τ) (restricted) versus the ZIB(τ) (non-restricted) model, is then applied. The LR tests the null of $\alpha = 0$ and follows a Chi-squared distribution with one degree of freedom. The null hypothesis is rejected and the overdispersion parameter in the ZIB(τ) is found to be statistically significant. Accordingly, the ZIB(τ) model is found to suit better the characteristics of the data than the ZIP(τ), and is selected for the interpretation of parameters' estimates. Moreover, ZIB(τ) model predicts more accurately the percentage of zeros in the dependent variable (98%) versus a significant over-prediction by the ZIP(τ) model (124%).

Estimation results of the Zero Inflated Negative Binomial Model ZIB(τ), including the estimated coefficients and standard errors, are shown in Table 3, whereas the conditional mean of quantity purchased and the implicit prices for each characteristic are presented in Table 4. The implicit economic value is calculated as the ratio of each characteristic's parameter over the absolute value of the price coefficient [3]. For Iberian breed, the price coefficient becomes $\beta_{Price} + \beta_{Price\_Ib}$. In the interpretation of coefficients we follow [12].

The impact of price is significant and negative, as expected in a normal demand. Interestingly, the demand for Iberian ham is slightly less elastic than for ham in general: and increase of 1€/kg (0.001€/g) leads to a fall of 14.35% of the ham whilst the demand for Iberian ham would decrease by 4.38% ((-143.56+99.709)*100/1000); scaling the coefficients by the respective mean prices (see Table 1) reveals a price-elasticity of -2.78 and -1.65, of general ham and Iberian respectively.

A cured ham carrying a quality certification has a negative impact over the quantity purchased and would need to be priced approximately 4.3 €/kg cheaper than a ham without quality label to achieve the same quantity of cured ham purchased. However, we need to be cautious with this result because the quality certifications include different squemes (PDO, PGI or TSG) that correspond with different origins such as Trevelez or Teruel. For this reason, we also analyse the effect when this quality certification is attached to the regional origin Teruel. Interestingly, the PDO Teruel has a significant and positive impact on purchases of ham which increase almost twice when it is PDO Teruel in comparison to a ham without this PDO. It is also remarkable that the PDO adds information to the origin, as it reinforces the positive impact of Teruel origin.

[2] Although NB and ZIB(τ) models presented convergence problems in estimation, the increase of the maximum number of iterations (up to 45) was enough to solve this problem.

The implicit price for the origin Teruel and its PDO are 4.851 and 4.804 €/kg, respectively.

Although the presence of any type of brand affects positively purchases, consumers' purchases reveal a preference towards distributors' brand over producers' brands. The impact on quantity is 2.47 times larger when the product carries the distributor's brand than when it does not, while the impact of a producer's brand is 1.25 larger. Consequently, the implicit value for the former is 6.28 €/kg against 1.54€/kg. The positive impact of both categories of brands are reinforced when attached to Iberian ham, with implicit prices that move up to 36.59€/kg and 24.39€/kg, respectively. The distributor's name provides notoriety that some small producers' brands lack, and this notoriety may influence positively consumers' perception of the quality of the product. On the other hand, the consumers included in the database are customers with the distributor's loyalty card, and we might hypothesize that loyalty to the store might favour loyalty to the stores' own brand.

Consumers prefer purchasing cured ham in whole leg format over package, with purchases 1.30 times larger when the product is sold in leg, and 0.72 times larger when packaged. Accordingly, the implicit price for the former is positive and for the latter, negative (non-desired characteristic). Some of the features that may favour the preference for legs are: the advice of the butcher's, the higher preservation of the cured ham's organoleptic features in relation to packages preserved under refrigeration and vacuum or modified atmosphere, which can alter significantly the sensory quality of the product [9], or the tradition to purchase a whole leg to give as a present in some festivities such as Christmas, or to consume in special events, or simply to be able to have the product available at home in good conditions and for a long time. Although the leg is still preferred in the case of Iberian ham, packages become more relevant in comparison to white ham, probably because it enhances to some consumers to try this speciality without a large outlay of money.

Table 3. Estimation results of the ZIB(τ) model

Variable	Coeff.	Std. Err
Constant	10.491***	0.137
Price	-143.563***	5.952
Dist	0.903***	0.089
Prod	0.222***	0.077
Leg	0.262***	0.078
Pac	-0.333***	0.055
Ter	0.696***	0.128
QcTer	0.690**	0.226
Qc	-0.617***	0.185
Res	-0.142**	0.057
Ib	-3.189***	0.444
Price_Ib	99.709***	8.761
Dist_Ib	0.702**	0.350
Prod_Ib	0.848**	0.305
Leg_Ib	1.853***	0.262
Pac_Ib	0.496**	0.210
Ab	-0.378***	0.090
My	-0.209**	0.090
Jn	-0.448***	0.090
Jl	-0.174	0.092
Ag	-0.210**	0.087
Sep	-0.305**	0.098
Oct	-0.237**	0.085
Nov	-0.277**	0.099
Dic	-0.209**	0.091
En	-0.087	0.084
Feb	-0.242**	0.092
τ	-0.008**	0.004
N.obs.	3869	

** and *** indicate significance at 5% and 1%, respectively.

Table 4. Conditional mean of quantity purchased and implicit price of each characteristic

Characteristic	$\exp(\beta_j)$	Implicit value (€/kg)
White ham:		
Distributor's brand	2.466	6.287
Producer's brand	1.248	1.544
Format: Leg	1.299	1.823
Format: Packages	0.717	-2.321
Origin Teruel	2.006	4.851
PDO 'Jamón de Teruel'	1.993	4.804
Quality Certification	0.539	-4.300
Ripening indication	0.867	-0.992
Iberian ham:		
Distributor's brand	4.977	36.594
Producer's brand	2.914	24.391
Format: Leg	8.286	48.219
Format: Packages	1.177	3.715
Monthly dummies:		
April	0.685	
May	0.812	
June	0.639	
July	0.840	
August	0.811	
September	0.737	
October	0.789	
November	0.758	
December	0.811	
January	0.917	
February	0.785	

Carrying out a ripening phase after drying, is considered by food technologists to improve the sensory quality of ham [8]. However, this is not a clear quality sign for consumers as we get a negative sign and negative implicit value. The lack of normalization under the existing legislation over the use of the descriptors '*Bodega*' and '*Reserva*' may be misleading for the consumer. Moreover, it is demonstrated that consumers do not find significant differences in acceptability when the ripening period is extended up to 18 months, and even after this time, it is likely to suffer from over-ripening which leads to consumer's acceptability to decrease [8].

Finally, the significance of the monthly dummies indicate that purchases in most of the months are significantly lower than in the last period available in the database, march 2004, and left out of the estimation. The estimation results also indicate seasonality, with peaks of purchases in the summer vacation period (July and August) and Christmas (December and January) (the exponential of the monthly dummy coefficient are the largest, between 0.81 and 0.92).

VI. CONCLUSIONS

The paper illustrates the selection process in count models and the interpretation of a Zero Inflated Binomial Model, applied to investigate implicit prices for an array of characteristics that describe cured ham, using revealed preferences by means of actual purchase records. The EU Quality Certifications *per se* have not been successful in signalling superior quality to consumers. In fact, the results reveal that the implicit value for this characteristic is negative. However, when the certification is attached to a local speciality, it becomes relevant for consumers purchase decisions. This is the case of PDO 'Jamón de Teruel', where the PDO reinforces the implicit value of the local origin.

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