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Full Length Research Paper

Comparing alternative methods for conjoint analysis: A case of tomatoes in the German market

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Conjoint analysis is a multi-attribute, decompositional and analytical method for estimating the consumer's preference structure from a global evaluation of a set of alternatives on the basis of a series of different attributes and their possible combinations. Conjoint analysis is mature and widely used in the study of consumer goods, recently, this analytical technique is been used in the study of food, and to date, few studies have used the technique in the study of fruits and vegetables. In this paper, the authors used three alternative methods (ordinary least squares, ordered Logit, and doubly-censored Tobit) for estimating preference through conjoint analysis with respect to one of the most highly consumed vegetables in the world: Tomatoes. In particular, the authors studied the tomato market in Germany. They consider four particularly important attributes in vegetable purchase behaviour among German consumers: Level of freshness, country of origin, price, and production method. The results obtained using these three estimation methods provide significant coefficients in all cases, although significant differences do exist in the importance of the different attributes in function of the estimation methods used. Nevertheless, two of the three methods coincide in pointing to the level of freshness as the most important attribute of tomatoes for German consumers.

Key words: Conjoint analysis, vegetables, consumer preferences.

INTRODUCTION

Tomatoes are the most widespread vegetable in the world, and the most economically valuable (FAO, 2008). In particular, tomatoes are the most commonly consumed vegetable in Europe. Consumption of fresh tomatoes ranges from 2.2 kg per person per year in the Netherlands to 17 kg in Spain and to 61 kg in Greece, according to data from Eurostat in 2008.

Germany is the strongest food market in the EU and the country is the world's biggest importer of food products, with almost 40 million MT, of which approximately 2.7 correspond to vegetables. These foodstuffs have become increasingly important in the German diet during the past decade, increasing from 64 kg per capita per year in 1985 (Barceló, 1987) to 85 kg in 2005 (Rioboo, 2006). In fact, fruit and vegetable consumption has followed a clear upward trend in the past 20 years in Germany, and the products are now a very important part of the shopping basket. As De Pablo et al. (2004) point out, German consumers spend 16% of their food budgets on fruit and vegetables, and surprisingly the less wealthy classes spend a higher proportion than the rest.

Tomatoes are by far the most consumed vegetable, with 10.5 kg per household per year, followed by carrots, cucumbers, onions and peppers, with consumption ranging from 5 to 7.5 kg. Moreover, the lion's share of these vegetables are consumed fresh (68%), with 14% frozen, 16% tinned, and 2% dried. Clearly then, "freshness" is an extremely important attribute for understanding the purchase behaviour of the German consumer (Rioboo, 2006).

The present paper aims to determine the most important attributes in the purchase of tomatoes. For this purpose, the authors use the conjoint analysis, a multivariate technique with only a recent tradition in the study of food, particularly vegetables. Its most direct application

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Table 1. Alternative methods for conjoint analysis in food sector.

Estimation	Sector	Authors
OLS	Meat	Steenkamp (1987), Huang and Fu (1995), Walley et al. (1999), Bernabéuet al. (2004)
	Fish	Halbrendt et al. (1991)
	Eggs	Ness and Gerhardy (1994)
	Honey	Murphy et al. (2004)
	Cooking oil	Fotopoulos and Krystallis (2001), García et al. (2002), Van der Lans et al. (2001), Krystallis and Ness (2005)
	Dairy	Souza and Ventura (2001), Murphy et al. (2004)
	Wine	Gil and Sánchez (1997), Sánchez and Gil (1998b), Bernabéu et al. (2001); Barroso et al. (2004), Bernabéu et al. (2007)
	Fruit	Manalo (1990), Fotopoulos and Krystallis (2003), Brugarolas et al. (2003), Campbell et al. (2004), Nelson et al. (2005)
	Vegetables	Sánchez et al. (2000, 2001, 2002); Frank et al. (2001); Jiménez et al. (2010)
Tobit	Meat	Sánchez et al. (2001)
	Dairy	Bernabeu et al. (2004)
	Wine	Sánchez and Gil (1998a, 1998b)
Logit	Fish	Holland and Wessells (1998)
	Wine	Sánchez and Gil (1998b)
	Fruit	Jaeger et al. (2001)

tool to determine the weight or importance of the different levels or categories of a product's attributes in the formation of consumer preferences (Múgica, 1989). The technique is used to analyse consumer preferences among a range of products by assessing the utilities the consumers assign to product attributes. An individual consumer's utility for a product can be disaggregated into partial utilities, or "part-worths", for each of the attribute levels (Hair et al., 1998). Conjoint analysis was first introduced to measure individual preferences – and gained recognition as a statistical technique – in 1964 with the pioneering work of Luce and Tukey, although the technique was first used in market research in the 1970s by Green and Rao (1971).

Conjoint analysis has been widely used to examine consumer goods, as a number of reviews stated clearly by: Cattin and Wittink (1982) and Wittink and Cattin (1989) for the US in the period 1971 to 1985, and Wittink et al. (1994) for Europe in the years 1986 to 1991. Although this research technique can be considered mature (Louviere, 1994), surprisingly, researchers have only recently began to use the technique to study food (Van der Pol and Ryan, 1996), with none of the aforementioned studies focusing on this area. In fact, academic research using this technique in the study of food took off only from the 1990s onwards, being more recent in the case of vegetables. Thus, few studies that were carried out to date have analysed consumer preferences with regard to cabbage (Van der Pol and Ryan, 1996), bell peppers (Frank et al., 2001; Jiménez et al., 2010), cucumbers (Jiménez et al., 2010), and tomatoes (Sánchez et al., 2000, 2001; Jiménez et al., 2010).

With regard to the estimation method used, a review of the literature shows that the classic methodology of ordinary least squares is by far the most common (Table 1), with majority of studies adopting this method (e.g., Steenkamp, 1987; Manalo, 1990; Halbrendt et al., 1991; Ness and Gerhardy, 1994; Huang and Fu, 1995; Walley et al., 1999; Murphy et al., 2000; Van der Lans et al., 2001; García et al., 2002; Bernabéu et al., 2004; Campbell et al., 2004; Nelson et al., 2005; Krystallis and Ness, 2005; Bernabéu et al., 2007; Jiménez et al., 2010). Nevertheless, other studies in the literature use alternative estimation methods, which is evidence for some versatility in the methodological application of this statistical technique.

In particular, researchers have used Logit models (Holland and Wessells, 1998; Sánchez and Gil, 1998b; Jaeger et al., 2001) and Tobit models (Sánchez and Gil, 1998a, 1998b; Sánchez et al., 2001; Fotopoulos and Krystallis, 2001; Bernabeu et al., 2004).

Table 2. Hypothetical tomatoes profiles.

Profile	Production method	Price	Freshness	Origin
1	Ecological	Medium	Not very fresh	Netherlands
2	Ecological	High	Fresh	Netherlands
3	Ecological	Low	Fresh	Germany
4	Non-ecological	High	Not very fresh	Germany
5	Ecological	Medium	Very fresh	Germany
6	Ecological	High	Very fresh	Spain
7	Ecological	Low	Not very fresh	Spain
8	Non-ecological	Low	Very fresh	Netherlands
9	Non-ecological	Medium	Fresh	Spain

METHODOLOGY

Research design

The consumer perceives tomatoes as a set of physical, functional or psychological characteristics or attributes, the evaluation that will condition the final purchase decision. Thus, when evaluating this vegetable, the consumer implicitly associates subjective values – called part-worths – to the perceived attributes. These part-worths express the consumer's system of values, in other words, the classification by order of overall preference of the different concepts of the product, each product being represented by a specific combination of attributes.

The main objective of the current research is to analyse the preferences of the German consumer when purchasing tomatoes using three alternative methodologies to estimate the conjoint analysis. With this, the authors aim to determine, first, which tomato attribute or attributes are the most important in the consumer's purchase decision, and second, if these preferences coincide over the three estimation techniques.

In the first stage of the conjoint analysis, the authors chose the attributes and their different levels. In the current work, the attributes chosen to analyse the German consumer's preferences are as follows: 'Origin of product', 'production method', 'freshness' and 'price'.

These attributes were chosen for a number of reasons. The literature considers origin as one of the most important extrinsic attributes in the evaluation stage of the purchase process and a fundamental aspect in the differentiation of the product (Verlegh and Steenkamp, 1999; Laroche et al., 2003, 2005).

German consumers are increasingly demanding ecological products. In fact, as Montaner and Uzcanga (2007) point out that 90% of German households consume some ecological food, although this figure drops to just above 50% for vegetables. As a consequence, the 'production method' is also considered.

'Freshness' is the most important attribute for the German consumer (Spanish Trade Office in Dusseldorf, 2003), hence the need to include it in this analysis. Indeed, Steenkamp (1997) indicates that freshness is critical in the evaluation of food products before other attributes such as quality, price and reputation of brand/origin.

Finally, the 'price' attribute is included practically in all the studies because it represents a distinct component of value for many products or services being examined, despite the fact that it can have a high degree of inter-attribute correlation with other factors, and that it can interact with other factors (particularly more intangible ones like the brand name), researchers should not exclude it from their analyses.

Having selected the attributes, the levels assigned to each attribute are as follows:

1. 'Product origin': The Netherlands, Germany, and Spain
2. 'Production method': Ecological and non-ecological
3. F'reshness': Very fresh, fresh, and not very fresh
4. 'Price': High, medium, and low[1].

The number of profiles resulting from the combination of all the levels of the four attributes is 54 (3×2×3×3), which has too many stimuli for respondents to be able to make a coherent evaluation. To reduce the number of stimuli from the different methods available, the authors used an orthogonal fractional factorial design. The orthogonal experimental design allows the researcher to determine the minimum number of combinations needed to be able to accurately estimate the respondent's preference function, considerably reducing the initial number of stimuli. Thus, the authors used the Orthoplan command in SPSS 14.0, and obtained nine combinations (Table 2). The respondents were asked to rate each combination from 1 to 10.

The three estimation methods chosen (OLS, Logit and Tobit) have some important differences, but in all three cases, the authors started from an additive model[2], since it is considered that the overall judgement of the product is obtained by summing the individual evaluations of each attribute (Steenkamp, 1987). Moreover, the additive preference model is one of the most commonly used models in the marketing literature, and the one that best tends to explain individuals' preferences (Hair et al., 1998).
Given the attributes selected, the conjoint model is expressed as follows:

$$preference = \beta_0 + \sum_{i=1}^{n} \beta_{1i} D_{1i} + \sum_{j=1}^{m} \beta_{2j} D_{2j} + \sum_{k=1}^{p} \beta_{3k} D_{3k} + \sum_{l=1}^{q} \beta_{4l} D_{4l} \quad (1)$$

where β_{1i}, β_{2j}, β_{3k} and β_{4l} are the coefficients (part-worths) associated with levels i (i=1,2,…,n), j (j=1,2,…,m), k (1,2,…,p), and l (l=1,2,…,q) of the attributes price (1), freshness (2), origin (3), and production method (4), respectively, and D_{1i}, D_{2j}, D_{3k} and D_{4l} are the dummy variables of each attribute. Equation (1) represents the former representation of preferences developed by Steenkamp

[1] At the time of the data collection the researchers set the price levels as follows: high (3€/kg), medium (2€/kg), and low (1€/kg). They chose these prices after consulting the Internet portal www.infoagro.com, which offers data on the destination retail prices of vegetables in markets in Hamburg, Munich and Frankfurt.

[2] The additive model assumes that each attribute level participates independently, and that the individual's total utility is the sum of the utilities of the different levels.

(1987) and assumes that all attributes are represented as dummy variables[3].

The authors now briefly explain the main differences between the three estimation methods chosen.

Estimation by Ordinary Least Squares (OLS)

The model to be estimated using the classic least-squares methodology given the attributes and levels as discussed is as follows:

$$preference = \beta_0 + \beta_1 PR_t + \beta_2 FR_{1t} + \beta_3 FR_{2t} + \beta_4 OR_{1t} + \beta_5 OR_{2t} + \beta_6 PM_t + e_t \quad (2)$$

Where:
Preference: The values assigned, which ranged from 1 (minimum preference) to 10 (maximum preference); PR_t = price; FR_{1t}= dummy variable that equals 1 if freshness of tomato is very high, 0 otherwise; FR_{2t} = dummy variable that equals 1 if freshness is high, 0 otherwise; OR_{1t} = dummy variable that equals 1 if origin of tomato is Germany, 0 otherwise; OR_{2t} = dummy variable that equals 1 if origin is Spain, 0 otherwise; PM_t = dummy variable that equals 1 if tomato is ecological, 0 otherwise

Estimation by ordered probability models: Logit models

This type of model assumes that the values of any variable can be classified in a set of ordered categories. In the current case and bearing in mind the frequency distribution of the values measured in the variable "preference", the authors followed the method of Sánchez and Gil (1998b) and classified them in three categories: (1) score less than or equal to 3; (2) score between 4 and 7; and (3) score greater than or equal to 8.

The underlying model can be expressed as follows[4]:

$$Y_t = \beta_0 + \beta_1 PR_t + \beta_2 FR_{1t} + \beta_3 FR_{2t} + \beta_4 OR_{1t} + \beta_5 OR_{2t} + \beta_6 PM_t + e_t \quad (3)$$

where the explanatory variables are the same as seen in Equation (3), e_t is a sequence of random disturbances, and Y_t is the underlying preference assigned to tomatoes (the vegetables are analysed here). The variable Y_t is not observable, but it is possible to know the category to which it belongs, depending on the preference assigned to the vegetable. In this case, the variable Y_t is assigned the values 0, 1 and 2 for the categories 1, 2 and 3, respectively.

Estimation by censored Tobit models

The third estimation method considered here is the doubly-censored Tobit. This method starts from the classic linear regression:

$$preference^* = \beta_0 + \beta_1 PR_t + \beta_2 FR_{1t} + \beta_3 FR_{2t} + \beta_4 OR_{1t} + \beta_5 OR_{2t} + \beta_6 PM_t + e_t \quad [4]$$

where the variable *Preference** is not directly observable and the exogenous variables are the same as those in Equation (2). The variable *Preference* is observable and it is censored with respect to the original variable as follows:

$$Preference = \begin{cases} 1 & \text{if preference}^* \leq 1 \\ preference^* = \beta_0 + \beta_1 PR_t + \beta_2 FR_{1t} + \beta_3 FR_{2t} + \beta_4 OR_{1t} + \beta_5 OR_{2t} + \beta_6 PM_t + e_t & \text{if } 1 < \text{preference}^* < 10 \\ 10 & \text{if preference}^* \geq 10 \end{cases}$$

As Sánchez and Gil (1998b) pointed out, the Tobit model might initially seem to be a linear regression model, and hence capable of being estimated by ordinary least squares, but the estimators assert that doing it would be biased and inconsistent (Maddala, 1983), so a better approach is, in fact, to use a maximum likelihood.

Using the partial utilities (part-worths), it is possible to determine the relative importance of each attribute in the evaluation process. In the case of OLS, estimation of the relative importance of attribute (i) is directly extracted from the econometric software, while in the Logit and Tobit, it is given by the following expression (Halbrendt et al., 1991):

$$\text{Relative importance (i)} = \frac{Range\ (i)}{\sum Range\ (i)} \times 100 \quad (5)$$

RESULTS

Table 3 shows the results of the estimations using the three methods.

The parameters of the attributes are significant irrespective of the estimation method. With regard to the signs of the coefficients, which are similar in the three cases, the coefficient for price is negative, which indicates that the consumer's preference declines as the price increases, while the positive values associated with the origins indicate that the consumers prefer German and Spanish tomatoes to Dutch ones. The positive values of the levels fresh and very fresh indicate that the consumers prefer these to less-fresh tomatoes. It is also interesting to note that the consumers prefer ecological tomatoes to non-ecological ones.

The researchers used the previous parameters to determine the utilities of each level in the four attributes of tomatoes (Table 4).

The results show some differences in the utilities obtained between the three estimation methods used, although in the three cases, the combination of low price, ecological production method, German origin and medium freshness is preferred. German consumers' preference for their own country's products may be revealing a certain level of ethnocentrism in favour of national production and to the detriment of foreign producers.

With regard to the freshness attribute, the three methodologies do not fully coincide. Thus, the level fresh

[3] Although this paper considers price as a continuous variable rather than a dummy one, it maintains Equation (1) as originally designed by Steenkamp (1987).

[4] The ordered probability model was introduced by Mckelvey and Zavoina (1975), who in turn developed an algorithm to estimate it. The resulting output is very similar to that of the typical linear regression.

Table 3. Parameters estimated from conjoint preference model.

Variable	β* OLS	t	β* Logit	t	β Tobit	t
Constant	1.184	5.084	1.470	22.561	0.927	3.800
PR	-0.345	-4.363	-0.651	-81.240	-0.370	-4.188
FR1	3.577	22.614	0.316	8.924	3.951	22.838
FR2	2.385	15.076	0.353	13.422	2.522	14.756
OR1	2.600	16.441	0.170	6.895	3.020	17.405
OR2	1.639	10.348	0.141	4.582	1.730	10.145
PM	1.439	10.506	0.327	11.080	1.673	11.008
R^2	0.401					
Adj. R^2	0.399					
ANOVA	156.014					
Log-likelihood			14404.32		-3140.01	
Chi-square			1130.75			
Sample size			1,404			

$p < 0.001$.

Table 4. Utilities of attribute levels.

Attributes	OLS	Logit	Tobit
Price			
Low (1€/kg)	-0.347	-0.651	-0.370
Medium (2€/kg)	-0.694	-1.303	-0.741
High (3€/kg)	-1.042	-1.954	-1.111
Freshness			
Very fresh	1.591	0.316	3.951
Fresh	0.399	0.353	2.522
Not very fresh	-1.990	-0.669	-6.473
Origin			
Germany	1.194	0.170	3.020
Spain	0.222	0.141	1.730
Netherlands	-1.415	-0.311	-4.750
Production method			
Ecological	0.722	0.327	1.673
Non-ecological	-0.722	-0.327	-1.673

obtains the highest score in the Logit model, while very fresh is the most important level for the consumers in the other two methods.

Finally, Table 5 shows the relative importance of each attribute in the evaluation process.

The three estimation methods diverge significantly in the importance of the different attributes, with not only the weights of the attributes, but also their hierarchical order changing. Thus in the OLS and Tobit models, the order assigned to the four attributes coincides with freshness being the most important and price the least important. The Tobit model does, however, assign more importance to freshness and considerably less to price. In the Logit model, the results are very different, since price is the most important attribute and freshness the second most important. Origin, the second most important attribute in the two other models, is the least important in this model.

CONCLUSIONS AND MANAGERIAL IMPLICATIONS

When analysing consumer behaviour in the evaluation stage prior to purchase, conjoint analysis is an extremely useful tool for determining the consumer's preference

Table 5. Relative importance of attributes (%).

Attributes	OLS	Logit	Tobit
Price	13.23	37.66	3.33
Freshness	38.74	29.54	46.78
Origin	30.70	13.90	34.87
Production method	17.33	18.90	15.02

structure and ranking the different attributes in order of their relative importance.

The literature offers a number of alternative methods for estimating conjoint analyses, but the classic least-squares methodology is one of the most commonly used, both in general and in the food sector. Other estimation methods like Logit or Tobit models are much less frequent.

However, when various alternative methodologies are compared, the results do not always coincide. This is what happens in the current work, which examines the German consumer's preferences with respect to tomatoes using three alternative methods to estimate the conjoint analysis: OLS, Logit and Tobit. It might be expected that these methods would result in a similar ranking of the attributes in order of relative importance, but the Logit model produces a very different order from that of the other two methods. Thus, the results obtained from the OLS and Tobit estimations stress the importance of freshness as the key attribute in the German consumer's evaluation of tomatoes, whereas, the estimation through an ordered Logit structure points to price as the most important attribute for the consumer. These results are logical, given the philosophy of each estimation method. Thus when the most and least important attributes are ignored (that is, in the doubly-censored Tobit model), freshness is the most important attribute for the group of consumers as a whole. In contrast, the ranking of attributes through a Logit structure reveals the existence of a significant number of highly price sensitive consumers and another group for which the price is practically irrelevant, which provokes the appearance of this attribute within the extreme values of the preference scores.

From the perspective of marketing management, the results of the current analysis provide a number of interesting conclusions. Thus managers should be aware that although conjoint analysis can help them to determine how best to present the product to the consumer, the final design of their marketing strategies will depend on how the relative utilities of the attributes used in the conjoint analysis are modelled. In light of the different results obtained in the current estimation and in the final choice of attributes to design their marketing strategies, firms should evaluate the utilities through different methodological approaches so as to take into account the potential for different results. Thus for example, in the current case, it seems advisable for the marketing strategy of firms commercialising tomatoes in the German market to largely focus on stressing the product's freshness. In other words, the firm should also consider the consumers' use of price as an important element in the evaluation of the product, and for example the use promotional strategies based on the retail price. The marketing strategy will then take into account the consumers' mean preference and also the more extreme preferences of certain groups of individuals. This is particularly important for companies adopting 'micro-marketing' segmentation strategies.

Limitations and future research

This work has a number of limitations in which future work could aim to overcome. Its results need to be compared with those of similar analysis involving other vegetables or food products in general with the aim of determining if the different estimation methods could condition the final results. It would also be useful to consider other destination markets such as France, the Netherlands or the UK in order to help managers design global marketing strategies or strategies adapted to the profile of each particular market. Future work should also consider other conjoint analysis methodologies that were not considered in the current work, such as Probit models. This could help decision-makers to choose the most appropriate methodology depending on the type of good considered (food or non-food, fast-moving consumer goods or consumer durables).

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