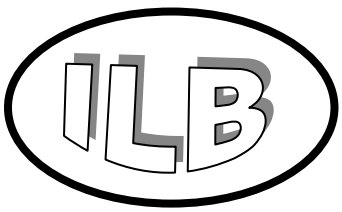
System Dynamics and Innovation in Food Networks 2010

Proceedings of the 4th International European Forum on System Dynamics and Innovation in Food Networks, organized by the International Center for Food Chain and Network Research, University of Bonn, Germany
February 08-12 2010, Innsbruck-Igls, Austria
officially endorsed by

EAAE(European Association of Agricultural Economists)
IAMA (International Food and Agribusiness Management Association)
AIEA2 (Assoc. Intern. di Economia Alimentare e Agro-Industriale)
INFITA (Intern. Network for IT in Agric., Food and the Environment)

edited by

M. Fritz, U. Rickert, G. Schiefer



ISBN 978-3-941766-03-7

European Preferences for Pork Product and Process Attributes: A Generalized Random Utility Model for Ranked Outcome

Francesco Caracciolo, Luigi Cembalo, Gianni Cicia, and Teresa Del Giudice
Department of Agricultural Economics and Policy, University of Naples Federico IIVia Università, 96 – 80055 Portici (Naples) ITALY
francesco.caracciolo@unina.it; cembalo@unina.it; cicia@unina.it; agriqual@unina.it

1 Introduction

The agri-food sector and food consumption models have experienced both worldwide and in Europe a process of change that still appears ongoing. The main effects of this change are clearly visible in a whole series of new developments. The most interesting of these appears to be the role played by food product quality as a basis on which to implement modern marketing policies targeting an increasingly segmented market.
This obviously makes it necessary for food consumption analysts to shed light on what it means, within today's European and world consumption scenarios, to produce quality goods. On this point, in recent years the concept of quality may be said to have undergone rapid evolution. Quality has gone from meaning only intrinsic product attributes, hence synonymous with excellence, to a broader definition full of different meanings.
Currently, it is widely recognised that, in modern consumer markets, food product quality is made up by both a set of intrinsic and extrinsic characteristics (Grunert, 2002) and by the way such characteristics are guaranteed and communicated to end consumers (Caswell and Joseph, 2007). As a result, purchase choices are affected not only by elements such as taste and price, but also by product range in the outlet, communication strategies, by the level of food safety, production process characteristics, nutritional aspects, origin and organic certification, as well as by fair trade certification (Scarpa and Del Giudice, 2002).
This synoptic scenario underlies the base methodological and operative choices made in the study described herein to analyse European consumer preferences regarding pork. Our article evaluates European consumer preferences among different pig production systems using a generalized random-parameter logit model for ranked outcome. The aim is to investigate in what way and with what intensity intrinsic and extrinsic product attributes affect consumer preferences. In terms of extrinsic attributes, we considered those related to the pig livestock system and their relative impact on the environment. As regards intrinsic attributes, attention was focused on the health of the fat produced or on other specific meat characteristics. Differences of preferences across subpopulations, among northern and Mediterranean European countries, were also tested. The study also covered consumer concern for both farm animal welfare and the environmental impact of livestock production.
The current European pig production system is mainly intensive, generating high external costs such as water and air pollution (Basset-Mens and van der Werf, 2005). Animals are bred indoors in flooring stalls, being fed according to market preferences concerning safety and fat quality but with scant attention to environmental and animal welfare aspects.
As suggested by Edwards (2005), European consumers are willing to reward more environmentally friendly pig production systems, such as outdoor breeding herds, in a social context where environmental concern has widely emerged as a key value. Consumers support the naturalness of traditionally livestock systems, allowing animals to experience all their natural

activities. Although some aspects of animal health and hygiene may be improved in more extensive systems, outdoor bred pigs are particularly affected by several diseases. Moreover, some authors have demonstrated that conventionally produced meat is more tender than its organic counterpart. That said, consumer perception of meat quality shows a clear differentiation. Our dataset comes from the Q-PorkChains EU FP6 Project and was previously analyzed by Krystallis *et al*. (2009) through a rank conjoint analysis. Their results point out that individuals assign greater importance to "production-related" compared to "product-related" attributes in the pig farming evaluation process. To characterise the various segments of consumers differently, we sought in this study to analyse whether and to what extent the choices made by interviewees were influenced not only by taste parameters but also by socio-demographic and, above all, psychometric characteristics. To achieve these objectives, a generalization of a conditional logit model for ranked outcomes (McFadden, 1974; Allison and Christakis, 1994) was first implemented (FPL). Then we rigorously investigated preference heterogeneity, accounting for correlation among the respondents' choices by using a random parameters model (RPL) (McFadden 1974; Train 2003; Scarpa et al., 2002).

2 Survey and data

A self-administered structured electronic survey was developed to investigate consumer attitudes towards product and process attributes for pork. The questionnaire used for data collection included four sections: a) attitudes towards environmental protection and nature, industrial food production, technological progress, animal welfare and food and environment; b) consumption frequencies of 27 pork products grouped into five categories, as follows: first fresh cut, minimally processed, further processed, pork-based dishes, and pork meat products; c) 15 verbal descriptions of various pig farms based on a conjoint design, with each respondent rating 15 pig production profiles through a Likert-scale; and d) socio-demographic characteristics of the respondents and food-related lifestyle questions to fully outline consumer behaviour in food consumption (Krystallis *et al*., 2009*.)*
Section *c* of the questionnaire was organized around a fractional factorial main effect orthogonal design. Each profile consisted of five different attributes, including those concerning product and process: process attributes such as stocking density and floor type were included as proxies of animal welfare production characteristics; impact on soil, air and water were included to underline environmentally related process attributes; fat contentsand chain type/ product were used to include traditional product attributes in the choice set (Table 1).

Table 1. Description of survey profiles (full orthogonality).

Card	*Farm Size*	*Floor type*	*Env. Impact*	*Fat*	*Quality*
1	about 400	Litter	Some effort	Lower	Similar
2	about 400	Slatted flooring	Max. effort	Standard	Key customer
3	less than	Litter	Max. effort	Standard	Different quality
4	800>	Outdoor Access	Max. effort	Healthy	Similar
5	<400	Slatted flooring	Min. effort	Standard	Similar
6	<400	Slatted flooring	Some effort	Healthy	Similar
7	800>	Slatted flooring	Some effort	Standard	Key customer
8	<400	Outdoor Access	Min. effort	Lower	Key customer
9	<400	Outdoor Access	Some effort	Standard	Different quality
10	about 400	Outdoor Access	Min. effort	Standard	Similar
11	800>	Slatted flooring	Min. effort	Lower	Different quality
12	about 400	Slatted flooring	Min. effort	Healthy	Different quality
13	<400	Slatted flooring	Max. effort	Lower	Similar
14	800>	Litter	Min. effort	Standard	Similar
15	<400	Litter	Min. effort	Healthy	Key customer

The survey was completed during 2008 by a sample of 2,437 nationally representative individuals (TNS European Access panel) from five European countries: Belgium, Denmark, Germany, Greece and Poland. Table 2 summarizes the main characteristics of respondents.

Table 2. Sample statistics (2429 individuals)

Consumer characteristics		Percentage
Living area	Rural	21%
	Urban	79%
Age		41 (Mean)
Gender	Female	51%
	Male	49%
BMI	Obese	56%
	Normal	44%
Country	South Europe	21%
	Central Europe	59%
	North Europe	20%
Pork consumers	Yes	89%
	No	11%
Education	Primary and secondary	44%
	High and University	56%

Individual attitudes towards the environment, and psychological and behavioural attributes (sections a and d of the survey, 79 variables) were factored (PCA) into six major components

without losing important information obtained from the survey[1]. The extracted factors can be defined as

1. *environmentalism* and ecological sensitivity (component 1);
2. *gourmet*, innovations and creativity in cooking (component 2)
3. patriotism and *ethnocentrism* (component 3);
4. animal welfarism (component 4);
5. *awareness of prices* and special offers (component 5);
6. belief in *traditionalism* and purity of cuisine (component 6).

Factor scores were subsequently computed for each respondent and included as explanatory variables in the empirical models. As eight individuals were excluded due to missing values in key variables, a total of 2,429 observations were used.

3 Methods

3.1 Fixed-Parameter Rank-Ordered Logistic Model (FPL)

In order to obtain point estimates of the effect of individual characteristics in explaining differentiation within profiles, a generalization of the conditional logit model for ranked outcomes is applied. The objective is to attach to each profile a probabilistic fully informative "event" that yields a significance test performed on coefficient estimates If a number J of a consumption alternative is available to a consumer (in our case 15), each observed choice j will represent the outcome of an income-constrained utility maximization exercise, which implies that each observed purchase will be such that U(j*) = U(j) for each Ialternative j in the choice set J. This theoretical framework is conducive to the classic well-known random utility maximization analysis McFadden (1974) in his seminal paper, has shown that under the assumption that an unobservable utility component ε_{ij} or error term is assumed to have a type one extreme
value distribution, observed discrete choices may be modelled using the conditional logit model consistently with the assumption of utility maximization. Let the outcome of the choice experiment, the individual rate of each profile, be $Y_{ij}=m.$ It indicates that alternative *j* was rated *m* by the *i-th* individual interviewed, with *j*ÎJ alternatives and *m* an integer value that goes from M (best rate) to 1 (worst rate). U_{ij} is the utility associated by the *i-th* individual to the alternative *j*. We assume that $U_{ij} \geq U_{ik}$ when $Y_{ij} > Y_{ik.}$, and $U_{ij}=U_{ik}$ when $Y_{ij}= Y_{ik}$ with the alternative *kÎJ* and *k≠j*. In this way we appeal to the transitivity of preferences, recoding

1. Percentage of variance extracted equal to 77%.

ratings to ordinal ranks (Holmes *et al.*, 1998). The utility U_{ij} is the sum of an observable component μ_{ir} and a stochastic component ε_{ij}:

(1) $U_{ij}=\mu_{ij}+\varepsilon_{ij}$. Commonly (Cicia *et al.*, 2002) the observable component μ_{ij} is decomposed into a linear function of explicative variables:

(2) $\mu_{ij}=\beta x_j + \gamma_j z_{ij}$

where the x_j vector contains variables that vary only over the *j* alternatives (i.e different levels of product and process attributes) and

(3) $z_{ij} = q_i \acute{} \, x_j$.

The z_{ij} vector contains variables that represent the interactions between the social and psychological and behavioural characteristics of each individual *i* (q_i) with the characteristics of each alternative (x_j).

To maximize his/her utility the consumer is assumed to choose the alternative with the most desired set of attributes. The probability that the individual values alternative *j* more highly, Y_{ij} = M, across the set of other possible alternatives J is defined by the probability that theutility of alternative *j* is greater or equal to the utility accruing on each and every other alternative within the choice set:

(4) $Pr(U_{ij})= Pr\{U_{ij}>max(U_{ik},...,U_{iJ})\}$

According to Mcfadden (1974) if ε_{ij} are *iid* Gumbel distributed, then the probability of choosing alternative *j* is logit:

(5) $Pr(U_{ij})= \dfrac{\exp(\mu_{ij})}{\sum_{j=1}^{J}\exp(\mu_{ij})}$.

In a complete ranking we observe J-1 sequential choices and so we are interested in the joint probability of a sequence of ordering:

(6) $Pr(U_{ij}\geq U_{ij}\geq ... U_{iJ})= \prod_{j=1}^{J}\dfrac{\exp(\mu_{ij})}{\sum_{k=1}^{J}\delta_{ijk}\exp(\mu_{ik})}$. with d_{ijk}= 1 if $Y_{ij}>Y_{ik}$, and 0 otherwise.

Empirically, equation 6 can be estimated using maximum likelihood estimation, providing estimates of the parameters of vectors z_{ij} and x_{ij} (Allison and Christakis, 1994):

(7) $\text{Log L} = \sum_{i=1}^{n}\sum_{j=1}^{J_i}\mu_{ij} - \sum_{i=1}^{n}\sum_{j=1}^{J_i}\log\left[\sum_{k=1}^{J_i}\delta_{ijk}\exp(\mu_{ik})\right]$

Tab 3: Fixed-Parameter Rank-Ordered Logistic Model (FPL)

	Farm Size		Floor type		Env. Impact		Fat		Quality	
	About 400	800>	Litter	Outdoor Access	Some effort	Max Effort	Lower	Healthy	Different	Key customer
Average Effect	3.1	-10.9	76.6	74.8	64.6	110.5	9.3	13.1	4	-11.4
(pvalue)	*0.24*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.14*	*0*
					Conditional Effect					
Etnocentrism		3.2	-6.8	-8.8	-4	-3.6			-2.9	
Price Awareness	2.2		4.1						-2.2	
Environmentalism	-2.9	-2.5	-5.7	-4.7	5.4	11.8			6.3	
Traditionalism			-10.7	-11.9	-3.0	-7.4			-3.0	2.2
Gourmet					2.9	3.6				
Animal welfarism	-2.5		16.2	24.9	3.6	11.4		2.1	5.1	
Rural										
Age	-0.2		-0.3			-0.5			-0.4	
Gender	-6.2			12.5	-5.4	-8.1		4.6		-4.2
Obesity										
South Europe	-17.1	26.5	-74.8		-20.4	-12.5	5.8	37.5	-15.6	-9.1
North Europe	-7.8	5.1	45.7	103.1	-14.9	-18.1	-10.7		12.7	

P>|z| = 0.1

Odds of: ranked ahead vs ranked behind (EU) n=2429

Maximum likelihood estimates for fixed-parameter rank-ordered logit models (FPL) are reported in Tab. 3. The estimate can be easily interpreted in terms of the exponentiated coefficients, which provide an odds ratio interpretation: the odds of ranking a particular alternative ahead of the base category for a unit change in an explanatory variable, holding other variables constant.

Analysis of table 3 shows that the main consumer characteristic able to segment preferences as regards the attributes in question is the sample's geographic distribution. In particular, southern European consumers display little interest in aspects concerning animal welfare and environmental impact. They prefer standardised meat with a strong propensity towards the health aspects of the product.By contrast, the northern European consumer displays marked sensitivity to animal welfare, a moderate interest in reducing environmental impact and little interest in the health aspects associated to demand for a more differentiated product.

As regards psychographic variables, consistent with our expectations, environmental consumers show a marked preference for low-impact and more extensive processes, a moderate interest in animal welfare and scant interest in intrinsic attributes. Also the group of consumers attentive to the hedonic function of food (Gourmet) display behaviour consistent with expectations, showing a clear preference for personalised food and little

interest in the other attributes considered. Price-aware consumers showed only a slight preference for animal welfare, almost completely overlooking other intrinsic attributes, with a slight propensity for meat with standard characteristics.

Of the socio-economic variables, it is worth noting that the presence of obesity (individuals with a Body Mass Index >25) does not affect consumer preferences, even concerning important attributes such as fat content and quality.

3.2. Random Parameter Rank-Ordered Logistic Model (RPL)

Since information on interactions between individual characteristics is provided by the previous estimation, the following step is to investigate the previously verified heterogeneity in consumer preferences, extending the information for the purpose of consumer analysis. Although fixed parameters allow us to capture part of the heterogeneity of consumer preferences through the estimation of g_j parameters (eq. 2), conceptually "taste-parameters" in their form of "utility weights" could not be fixed across the population (Train, 2003; Cicia *et al.*, 2002).

Furthermore, the ***FPL*** specification in eq. 5 imposes the usual independence of irrelevant alternatives, IIA, assumption as the multinomial/conditional logit model. Although the IIA assumption is computationally favourable, it is not negligible in the presence of sequential choices such as those made in the ***FPL*** model. For the above reasons, a random parameters version (Revelt and Train, 1998) of the ***FPL*** was applied to study preference heterogeneity in an unconditional framework, assessing correlation among the respondent's choices.
The ***RPL*** assumes that a subset of eq.2 parameters is distributed in the sample according to a distribution (a normal distribution in our case), defined by the parameters of location (μ) and scale (σ) that become the objective of the estimation.

(8) $U_{ir} = \mu_{ir} + \varepsilon_{ij}$.

$= b_i x_j + g_{ij} z_{ij} + \varepsilon_{ij}$

$= \beta x_j + \gamma j z_{ij} + v_i x_j + w_{ij} z_{ij} + \varepsilon_{ij}$

where $b_i = b + v_i$, $v_i \sim N(0, \sum_b)$ and $g_{ij} = g_j + w_{ij}$, $w_{ij} \sim N(0, \sum_{gj})$, and the errors ε_{ir} are type-II extreme-value distributed. The combined error term ($v_i x_j + w_{ij} z_{ij} + \varepsilon_{ij}$) is now correlated across alternatives, relaxing in this way the IIA assumption. Because our estimation objective is the unconditional heterogeneity, only x_j variables are finally included in the ***RPL*** empirical specification.
Routines based on maximum simulated likelihoods methods (Train, 2003) are available, obtaining consistent estimates of these parameters. The estimation presented here is

derived using 150 Halton draws (Train, 1999) for the simulation. Simulated likelihood estimates for random parameter rank-ordered logit models are reported in Tab 4.

Tab 4: Random Parameter Rank-Ordered Logistic Model (RPL)

	Farm Size		Floor type		Env. Impact		Fat		Quality	
	About 400	800>	Litter	Outdoor Access	Some effort	Max Effort	Lower	Healthy	Different	Key customer
Coefficient μ	-0.07	-0.05	0.49	1.05	0.46	0.85	0.11	0.26	0.01	-0.21
(pvalue)	0	0	0	0	0	0	0	0	0.44	0
Coefficient σ	0.13	0.19	1.16	1.05	0.04	0.73	0.08	0.01	0.22	0.04
(pvalue)	0	0	0	0	0.84	0	0.03	0.95	0	0.36

As may be noted from table 4 and figure 1, floor type and max environmental effort were attributes with taste heterogeneity among European consumers, while preferences for the other characteristics do not appear variable in the population in question.
Consistent with the discussion in the section of the FPL results, the geographic location of consumers is important in explaining heterogeneity of the taste parameters: as may be noted in figure 2, heterogeneity of the floor type parameter is well explained by the geographic

gradient South, Centre, North Europe, with growing attention to animal welfare. It is worth noting (figure 3) that the "*animal welfarism*" component is unable to explain the

heterogeneity found in the preferences concerning animal welfare attributes, highlighting the absence of a link between a particular sensitivity and the choices made.

This problem emerges even more clearly for the process attribute "environmental effort". Figure 4 shows that the component "*environmentalism"* only partly explains the taste heterogeneity with respect to environmental impact.
As deduced from the odds estimated for the attribute "environmental impact" for the various covariates (table 3), this characteristic shows a taste heterogeneity which is transversal to the population.

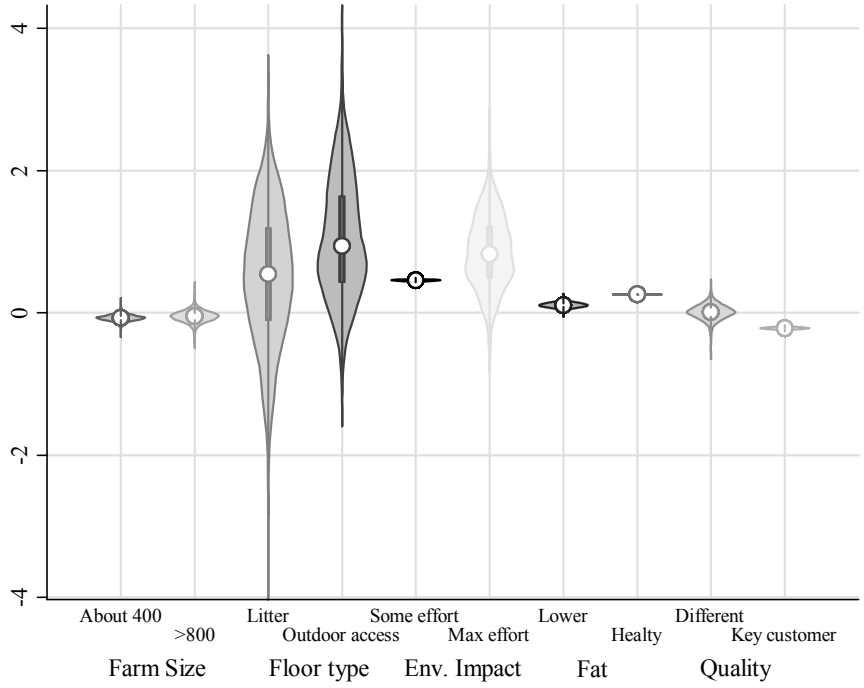


Figure 1. Violin plots of estimated coefficients (RPL)

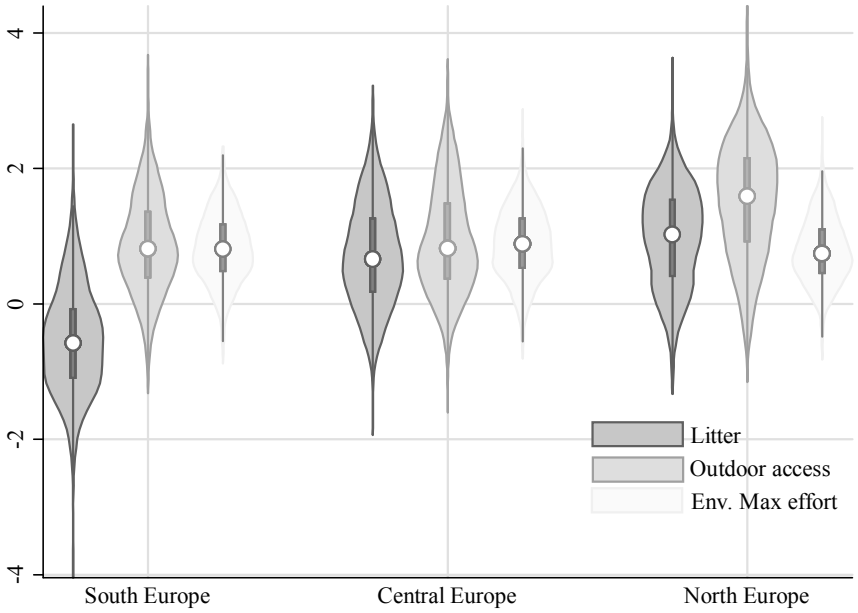


Figure 2. Violin plots of selected coefficients over countries (RPL)

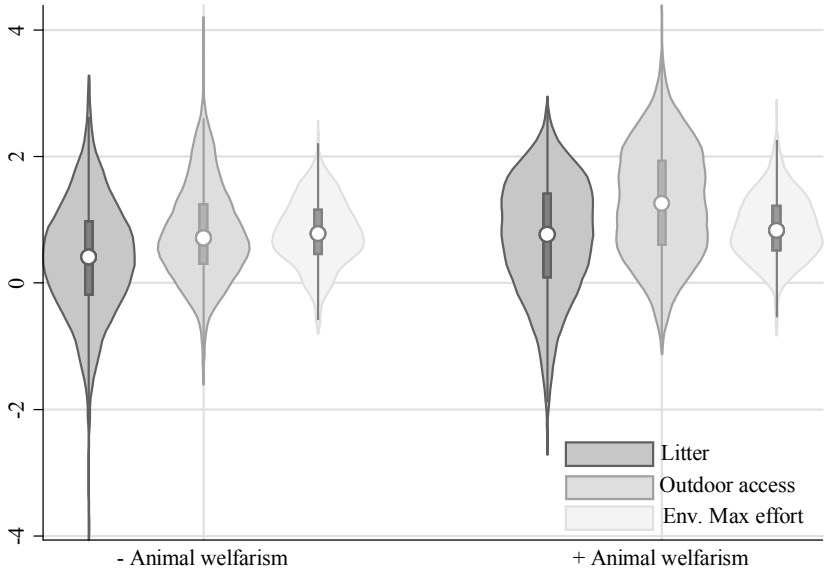


Figure 3. Violin plots of selected coefficients over “animal welfarism” (RPL)

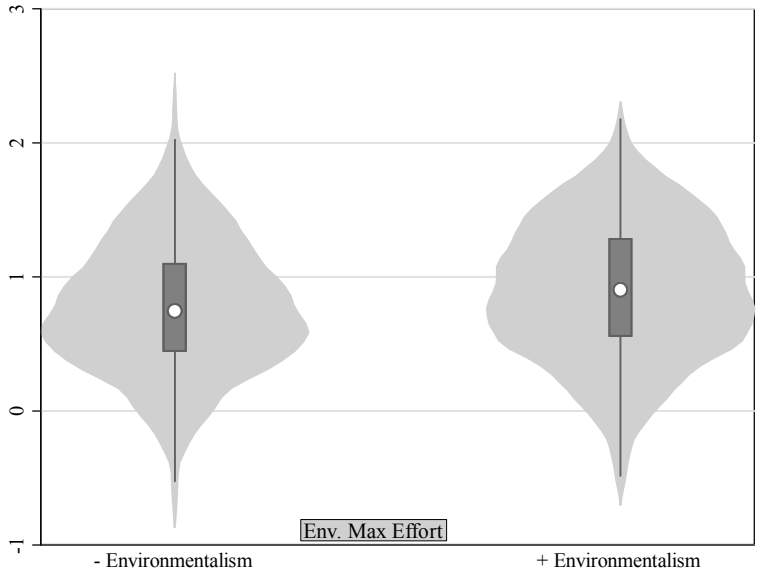


Figure 4. Violin plots of selected coefficients over "environmentalism" (RPL)

4 Results and discussion

In general, in terms of importance, the attributes that most appear to influence the preferences of European consumers with regard to pork comprise livestock production characteristics. The type of paving used in livestock areas and the use of practices that reduce the environmental impact of pig-farming represent the most strategic elements. Such characteristics are closely correlated with animal welfare issues and more sustainable production. In the survey, they acquire much more importance, at least for much of Europe's population, than that of the intrinsic product characteristics such as fat content or quality differentiation. The results are however, differentiated between northern, central and southern Europe. In particular, dividing the sample into North and South, what emerges is that northern European consumers appear to show a higher propensity towards sustainable pig farms, while Mediterranean consumers show greater attention to meat fat quality.

Implementation of a model belonging to the broad family of Random Utility Models allowed us to obtain further indications, useful for completing the picture already well defined by previous conjoint analysis (Krystallis et al., 2009). Indeed, being able to estimate the effect of the different explanatory variables upon consumer preferences for the various attributes considered allowed us to carry out market segmentation based both on geographic, socio-economic and psychographic characteristics, and directly on the taste heterogeneity of the population.

Our results show that variations in preferences between different groups of consumers are due more to geographic and psychographic variables than to traditional socio-economic characteristics. Of interest was the behaviour of a segment which due to consumption habits, lifestyles and biometric characteristics was identified as "prone to obesity". Compared to the rest of the sample, this group does not seem to show greater attention to important nutritional aspects such as fat quality in the meat. Further mention should be made of

“environmental” consumers for whom attributes concerning lower environmental impact do not appear to differ in importance from that reported for other segments.
The attributes with greater taste heterogeneity among the populations in question were floor type and max environmental effort. This heterogeneity represents a fundamental element both in the phase of reference market segmentation and in that of implementing product-oriented marketing policies.
The importance attributed by consumers to floor type and, at the same time, its great heterogeneity represent a combination of elements which might lead to enhancement policies of a product which, in the case of pork, has long reached its mature phase. To better appreciate the role played by such process elements in consumer preferences we

investigated the possible correlation between the importance attributed to floor type and the level of interest shown by the interviewees concerning the condition of the livestock farm and animal welfare. This disaggregation, using the "*animal welfarism*" component does not seem to have a discriminating effect on the importance attributed to the process elements described. Variability in the taste parameter relative to animal welfare conditions is, instead, explained by the geographical gradient: South, Centre, Northern Europe. Variability of the characteristic "*environmental effort*", however, cannot be easily explained with psychographic or with geographic variables, highlighting "transversality" in the variability of taste.

In conclusion, our analysis highlights the fundamental strategic role played by the process attributes considered. Such an influence in choices, however, does not seem connected to psychographic or particular lifestyle variables. This might suggest that a floor type more conducive to animal welfare and considerable effort made by the farm to limit environmental impact both represent for consumers indirect indicators of food health and safety. In addition, for a mature product, as is pork in current European consumption models, to focus on intrinsic attributes such as fat quantity and quality would not appear efficient. This is confirmed by the result obtained for the "obese" segment, for whom fat quality is unimportant in their choice to purchase pork.

5 References

Allison, P. D., and N. A. Christakis., 1994. Logit Models for Sets of Ranked Items. *Sociological Methodology* 24, 1994: 199-228.

Basset-Mens, C., and H. M. G. van der Werf., 2005. Scenario-based environmental assessment of farming systems: the case of pig production in France. *Agriculture, Ecosystems & Environment* 105, no. 1-2: 127-144.

Caswell J. A., Joseph S. (2007): Consumer Demand for Quality: Major Determinant for Agricultural and Food Trade in the Future?, Working Paper No. 4, University of

Massachusetts Amherst, Department of Resource Economics, http://www.umass.edu/resec/workingpapers

Cicia, G., T. Del Giudice and R. Scarpa, 2002. Consumers' perception of quality in organic food. *British Food Journal* 104(3/5): 200-213.

Grunert, K.G. (2002): Current Issues in the Understanding of Consumer Food Choice,

Trends in Food Science & Technology, Vol. 13.

Holmes, T., K.A.C. Zinkhan, and E. Mercer, 1998. The Effect of Response Time on Conjoint Anal- ysis Estimates of Rain Forest Protection Values. *Journal of Forest Economics*. 4(January 1998):7-28.

Krystallis, A., de Barcellos, M. D., Kügler J. O., Verbeke W., and K.G. Grunert., 2009. Attitudes of European citizens towards pig production systems. *Livestock Science* 126(1-3): 46-56.

Revelt, D., and K. Train., 1998. Mixed logit with repeated choices: households' choice of appliance efficiency level. *Review of Economics and Statistics*, Vol.80, pp. 1-11.

Scarpa R., Del Giudice T., Market Segmentation via Mixed Logit: Extra-Virgin Olive Oil in Urban Italy, Journal of Agricultural & Food Industrial Organization, vol. 2, No. 1, Article 7, http://www.bepress.com/jafio/vol2/iss1/art72004.

Train, K., 2003. *Discrete choice methods with simulation*, Cambridge Univ Press.

Wessells, C. R., R. J. Johnston, and H. Donath., 1999. Assessing Consumer Preferences for Ecolabeled Seafood: The Influence of Species, Certifier, and Household Attributes. *American Journal of Agricultural Economics* 81, no. 5(1999): 1084-1089.