An application of choice modeling to measure consumer preferences for GM applications in pork production chain

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Summary

This study evaluates consumer acceptance of different GM applications used in the pork production chain. In general, results indicate that consumers positively value improved in quality, increased animal welfare, a lower impact on the environment, less residues and a price discount. The most positive effect on the choice among all four applications has an improvement in animal welfare. In general consumers prefer conventional pork. However, the negative impact of the GM applications is compensated by improvements in quality, increased animal welfare, a lower impact on the environment, less residues and a price discount.

1. Introduction

The number of ongoing debates in Europe about genetic modification has not decreased over the past years. Different parties like consumers, producers, NGOs, policymakers intensively discuss whether it is ethical, natural and safe to use new technology like genetic modification. Many producers and researches see great potential in the application of genetic modification in food production (Grunert *et al.*, 2001). Although at the same time, European consumers have concerns towards GM products and technology in general (Bredahl, 1999; Cardello, 2003; Cook *et al.*, 2002; Moses, 2002).

The question of consumer attitude to genetic modification has been a main objective of many studies for some years already. A lot of research has been done on understanding consumers' driving factors influencing acceptance of genetic modification (Hossain *et al.*, 2003), on the influence of information on consumer choices, especially information related to the risks and benefits of genetic modification (Lusk *et al.*, 2004) and consumer willingness to pay for different genetically modified organisms (Rigby and Burton, 2005). Despite a colossal amount of literature on consumer attitudes towards genetic modification, still a lot is unknown in understanding of consumers' acceptance of different GM applications, especially in animal production.

2. Problem statement and research goal

There is no study yet that has investigated consumers attitude to the product (1) produced from GM animal (meat in our case) and (2) by using different GM methods/applications.

The current study aims to add new knowledge about consumers' acceptance of GM technology used in food production. Main objective of this study is to estimate consumers' acceptance and trade-off behavior with respect to different applications. In particularly, to investigate (1) how consumers accept and value application of GM technology in the pork production (2) how a consumer make a trade-off between specific GM applications and benefits that GM technology can offer to them.

The paper proceeds as follows. The third section of the paper provides methodology used in this study. Section 3.1 introduces the experimental design used to generate pork choices for consumer evaluation; section 3.2 provides information about respondents and procedure of questionnaire collection; section 3.3 presents an empirical model that is applied to evaluate a choice experiment task. Forth section presents results of the model and the last section outlines conclusions.

3. Methodology

3.1. Experimental Design

Since the objective of this study was to estimate consumers' acceptance and trade-off with respect to different applications of genetic modification in livestock production chain, it is difficult to use methods that rely on the actual market data. To eliminate this problem we used choice-based conjoint analysis. CE is frequently used in environmental and marketing literature to estimate the importance of various attributes for consumer choice by analyzing consumers' stated choices from a number of choice sets that are generated according to some experimental design (Adamowicz *et al.*, 1998; Louviere, 1991). The CE is based on utility model.

To evaluate consumer acceptance of GM technology in pork production chain we used four **GM applications**. We presented consumers with following GM applications: GM animal, GM feed, GM additives & medicines and GM bacteria. Therefore, the pork produced from these applications was considered as GM pork. *GM animal* was defined as pig produced with help of GM technology to change the genes of the pig itself, so future generation of the pigs will be different. *GM feed* was defined as feed that includes crops produced with help of GM technology. *GM additives* (like vitamins, bacteria for digestion) and *medicines* (like vaccines and antibiotics) defined as GM additives & medicine that are produced with the help of GM technology. GM bacteria defined as special bacteria used after slaughtering of the pigs, during processing of the meat, for preservation of meat. Bacteria are produced with the help of GM technology.

Each pork chop was presented as a number of characteristics/attributes, i.e. price, quality, animal welfare, impact on environment and amount of residues in the meat (Table 1).

Table 1. Pork attributes and attributes levels in the choice experiment

Pork attributes	Attribute levels
Price	0% reduction
	10% reduction
	33% reduction
Quality	Current quality
	Substantially improved
Animal welfare	Current level
	Substantially improved
Impact on environment	Current level
	Substantially improved
Presence of residues	Current level
	Substantially reduced

Among the choices, the **price** varies from "no price reduction" to "price reduction of 10%" and to "price reduction of 33%". Conventional pork has always "no price reduction." **Quality** of pork is presented as "current quality" and "improved quality". "Current" quality means that the pork chop has the same quality than pork chop you can buy in the supermarket. "Improved" quality means that the quality of the pork chop is substantially improved by one of the methods of genetic modification, for example the meat has become leaner or has a longer shelf life. Level of **animal welfare** is also distinguished as "current" with no improvements and "improved". "Improved" animal welfare means that by one of the methods of genetic modification animal welfare is substantially improved, for example animals feel less stressed and grow healthier. **Impact on environment** is presented as "current" impact on environment and "improved". "Improved" impact on environment means that by one of the methods of genetic modification the production of genetically modified pork may have a substantially improved impact on environment, for example, animals produce less phosphorus in manure that reduces the pollution problem. The last characteristic of the pork chop is the presence of the **residues in meat**, so we distinguish "current level of residues in meat" (e.g. antibiotics) and substantially reduced level of residues. The same attributes and levels were applied to every GM application besides GM bacteria. By using GM bacteria it is not possible to improve animal welfare and environment. Therefore, these attributes were excluded from the choice design for GM bacteria application.

To generate choices we used orthogonal main-effects design in SPSS; as a result we obtained 16 choice options. Using cyclic procedure we created choice sets where two of the choice options where the GM pork and one was conventional pork. After this procedure we had 16 choice sets. Each choice set consists of three options A, B and C (see Table 2).

Table 2. Examples of choice set

A: GM animal	B: GM animal	C: Conventional
Price **reduction of 33%**	No price reduction	No price reduction
Current quality	**Improved** quality	Current quality
Current animal welfare	**Improved** animal welfare	Current animal welfare
Current impact on env.	**Improved** impact on env.	Current impact on env.
Current residues	**Reduced** residues	Current residues
Which pork chop do you prefer? (Tick one box)		
☐	☐	☐

Each respondent had to view sets for all four GM applications; that was in accordance with our research goal. Therefore each respondent had to evaluate 64 choice sets, what in practice is impossible. For that reason we used blocking procedure to obtain four blocks. Thus each respondent was presented with four GM applications blocked in four choice sets. Four types of questionnaire were created.

To avoid the problem that in any type of the questionnaires respondent will get the same block with identical order of GM applications we used the Greco-Latin square to mix the order of the GM applications and blocked used in the questionnaires.

3.2. Respondents

In the autumn of 2004, 2600 surveys were mailed to the consumers in the Netherlands. Addresses were obtained randomly using electronic telephone book. After 10 days a reminder was sent. After adjusting for undeliverable surveys and excluding individuals who did not completely fill in the questionnaire, the response rate was 11%. In total 253 usable questionnaires were obtained.

The sample (135 females and 116 males) was representative of the Dutch population only regarding gender. The sample was not representative with respect to age, household size, number of children in household and education level, with more highly educated respondents and households of two persons and without children over-represented.

Table 3. Socio-demographic characteristics of the sample

	Sample (n=253)		Population	P-value
	Number	%	%	
Gender [c]				
Female	135	53.8	50.5	0.298
Male	116	46.2	49.5	
Age (years) [c]				
<24	5	2.0	8.0	0.000
25-39	60	24.0	28.9	
40-49	51	20.4	20.8	
50-59	63	25.2	18.5	
>60	71	28.4	23.8	
Household size (persons) [b]				
1	45	18	34.4	0.000
2	119	47.6	32.7	
3-5	84	33.6	32.9	
>5	2	0.8	--	
Children in household [b]				
Yes	87	35.5	50.5	0.000
No	158	64.5	49.5	
Education [a]				
Primary education	15	6.0	12.5	0.000
Junior general secondary education	15	6.0	10.0	
Senior general secondary education	24	9.7	6.5	
Pre-vocational education	10	4.0	14.8	
Senior vocational education	55	22.2	32.7	
Vocational colleges	96	38.7	16.2	
University education	33	13.3	7.3	
Income (euro)				
<1000	16	6.8	--	--
1000-2000	74	31.2	--	
2000-3000	86	36.3	--	
3000-4000	37	15.6	--	
>4000	24	10.1	--	

[a] Statistics Netherlands, for 2002 year
[b] Statistics Netherlands, for 2004 year
[c] Statistics Netherlands, for 2005 year

3.3. Empirical model

The analysis of the choice data is based on the random utility model (Ben-Akiva and Lerman, 1985; Louviere, 1991). This model assumes that consumer choices can be modelled as a process in which different levels of the *m* product attributes are evaluated in terms of the utility that they present to the consumers. The random utility model assumes that consumer i maximises his/her utility when choosing between j alternatives of pork chops as shown in Equation (1):

$$U_{ij} = V_j + \varepsilon_{ij} = \sum_m \sum_l \beta_{lm} x_{jlm} + \varepsilon_{ij} \tag{1}$$

where U_{ij} is the overall utility of choice option j for consumer i, V_{ij} is the systematic proportion of the utility function determined by the pork attribute levels for alternative j, and ε is the stochastic element. The utility V_{ij} of the jth alternative for the ith consumer consists of the sum of the values of different attributes m, x_{mij} is the weight of the attribute m in the valuation of alternative j. Given that the consumer is faced with three choices (options A, B and C) in each choice set A, the probability that a consumer will choose alternative j over some other option r if and only if:

$$U_{ir} > U_{ij} \text{ for all } j \neq r \in A \tag{2}$$

and the probability that consumer i chooses j from set A is given by:

$$P_{ir} = P[\{V_r + \varepsilon_{ir}\} > \{V_j + \varepsilon_{ij}\}], \text{ for all } j \neq r \tag{3}$$

Equation (3) means that consumers will make the choice between three choice options, from which they derive the most utility. Thus the probability that a consumer will choose the option j equals the probability that the difference between the random component of the utility function is smaller than the systematic component of the utility function across the two alternative choice options under consideration (Equation 4).

$$P_{ir} = P[\{V_r - V_j\} > \{\varepsilon_{ij} - \varepsilon_{ir}\}] \tag{4}$$

If random errors in Equation (1) are independently and identically distributed across the J alternatives and N individuals with extreme value distribution and scale parameter equal to 1, then the probability of consumer i choosing alternative j becomes:

$$P_{ir} = \frac{e^{V_r}}{\sum_{j=1}^{J} e^{V_j}}, j \neq r \tag{5}$$

Assuming V_{ij} is linear in parameters, and then the functional form of the utility function is expressed as:

$$V_j = \beta_{11} x_{j11} + \beta_{21} x_{j21} + \ldots + \beta_{LM} x_{jLM} \tag{6}$$

where x_{ijm} is the mth attribute value for alternative option j for ith consumer, and β_m represents the coefficients to be estimated. Equations (5) and (6) describe a multinomial logit model.

4. Results

4.1 Main effects results

The analysis is based on 4047 choice sets (i.e., GM animal: 1012; GM feed: 1011; GM additives and medicines: 1012; GM bacteria: 1012). For the analysis we have merged the data for different GM applications.

Table 3 presents the estimated main effects for the kind of GM application and for the benefits. Notice that the estimated utilities are expressed relative to a reference level. The utilities of the "improved" levels of the benefits are taken relative to the utility of the levels that represent no improvement, which were set at zero. The utilities for the different GM applications are taken relative to the utility of conventional pork, which was set at zero.

Table 3. Main effects model

Variable	Utility estimate	Standard error	Chi-Square	P-value
1% Discount	0.01309	0.00178	53.98568	0.0001
Improved quality	0.34991	0.04698	55.4709	0.0001
Improved animal welfare	0.86441	0.05760	225.2188	0.0001
Improved environment	0.15293	0.05320	8.2626	0.0002
Reduced residues	0.41309	0.04730	76.2780	0.0001
GM animal	-2.06525	0.08833	546.7369	0.0001
GM feed	-1.86500	0.08542	476.7291	0.0001
GM additives & medicines	-2.06521	0.08798	550.9898	0.0001
GM bacteria	-1.47825	0.07091	434.5328	0.0001
Model Statistics				
Likelihood Ratio	1123.9043			
Score	1033.7883			
Wald	922.7719			
DF	9			
p-value	<.0001			

All coefficients are significant at 1% level

The chi-squared estimated values for likelihood ratio, score and Wald statistics indicate that the model fits the data well. Across GM applications, there is a significant relation between the benefits and consumers' choices ($p < 0.01$).

All estimated utilities have the expected a priori sign and are highly statistically significant. In general, results indicate that consumers attach positive utility to improvements in quality, animal welfare, environment and residues. Improvements in animal welfare have the strongest effect on consumer choice and improvements in the environment the weakest. According to our expectations, consumers attach positive utility to price discounts[1].

In addition, results show that consumers derive more utility from conventional pork than from GM pork, everything else being equal. All utilities attached to the GM applications are with negative sign. Among four GM application, GM bacteria still has the least negative utility (-1.47825), followed by the utility of GM feed (-1.86500). GM additives & medicines (-2.06521) and GM animal (-2.06525) have the least utility. These are the utilities that consumers attach to the GM applications without benefits relative to conventional pork. However, the consumers' preference for GM pork would be changed if GM pork is sold with a price discount increases and the improvement on all four benefits over conventional.

4.2 Effects of benefits within specific GM application

Based on the results of previous research, we assumed that respondents could imagine different kind of improvements in quality, animal welfare, environments and residues when we talk about different applications. Therefore, in addition to the previous model we have tested another model that included GM applications specific effects of each of the five benefits across GM applications. Estimates for the effects of each benefit within each GM application and their significance are presented in Table 4. The overall fit of the model was satisfactory, with Likelihood Ratio's, score and Wald's p-values of 0.00001.

The parameters in this model are fairly similar to the main effects model. All effects coefficients have positive sign and significant with the exception of the effects of environment within GM feed, environment within GM additives & medicines and environment within GM bacteria. Thus, the insignificant coefficients on these effects variables implies that reducing impact on environment by using these applications does not increase utility for the consumers still the significant coefficient for environment within GM animal suggests it does have an impact using GM animal application.

The effects of price within each GM application are significant. Although, coefficients are positive they do not add much utility for the consumers. The differences in the utility of price discounts for different GM applications are not significant. It means that the price reduction is valued equally and positively by the consumers, no matter what kind of GM application is applied.

The effects of quality benefit within each GM application are different depending on GM application: with GM bacteria consumers perceive the highest utility of quality improvements,

[1] In the table the utility of a price discount of 1 % is presented. From this the utilities of different price discounts can be calculated by multiplying the coefficient for 1% by number of desirable price discount. For example, the price coefficient for 10% will be 0.01309*10%=0.1309

the lowest utility is from quality within GM feed application. Pairwise comparisons revealed that the effect of quality under application GM feed versus effect of quality under application GM bacteria and effect of quality under application additives & medicines versus effect of quality under application GM bacteria are significantly different from each other. Utility that consumers attach to improved quality under GM feed is almost three times and one and half times smaller than under GM bacteria and GM additives & medicines, respectively.

The highest utility among other possible benefits consumers attach to an improvement in animal welfare. Pairwise comparisons of animal welfare within GM animal, GM feed and GM additives & medicines application show that the improvements in animal welfare by GM feed and GM additives & medicines has higher utility and, hence, probability of choosing these methods compared to GM animal. For example, for GM animal and GM feed, GM animal and GM additives & medicines the difference in utility are -0.18755 and -0.26301, respectively.

Contrary to the other significant effects of benefits with specific GM application, the effects related to the improvement in the environment are not significant with exception of GM animal within environment which, however, does not receive high utility. Moreover, neither of the effects of environment within different GM applications was significant.

With regard to the reduced residues benefit, consumers attach the highest utility to the effects of residues within GM bacteria and the lowest utilities to the effects of residues within GM feed and GM additives & medicines. The last two are also not significantly different from each other. Pairwise comparison show that the effect of reduced residues within GM feed and GM additives & medicines is twice lower than within GM animal and three times lower than within GM bacteria.

With respect to the estimates of GM applications, coefficient of application GM animal is significantly different from the GM feed and GM feed is significantly different from the GM additives & medicines.

Table 4. Effects of benefits within GM applications

Variable	Utility estimate	Standard error	Chi-Square	P-value
Main effects of GM applications				
GM animal [a]	-1.99776	0.14370	193.2862	0.0001*** [1)]
GM feed pork [ab]	-1.66556	0.12920	166.1810	0.0001***
GM additives & medicines [b]	-2.03888	0.14634	194.1081	0.0001***
GM bacteria	-1.84016	0.11907	238.8470	0.0001***
GM applications specific effects of benefits				
GM animal x price	0.00966	0.00363	7.0945	0.0077***
GM feed x price	0.01244	0.00330	14.2301	0.0002***
GM additives & medicines x price	0.01599	0.00358	19.9702	0.0001***
GM bacteria x price	0.01396	0.00364	14.7276	0.0001***
GM animal x quality	0.37691	0.09701	15.0943	0.0001***
GM feed x quality [a]	0.18600	0.08728	4.5418	0.0331**
GM additives & medicines x quality [b]	0.30185	0.09698	9.6882	0.0019***
GM bacteria x quality [ab]	0.56356	0.09957	32.0366	0.0001***
GM animal x animal w. [cd]	0.70523	0.10095	48.8009	0.0001***
GM feed x animal w. [c]	0.89278	0.09437	89.5047	0.0001***
GM additives & medicines x animal w. [d]	0.96824	0.10587	83.6491	0.0001***
GM animal x environment	0.17869	0.09594	3.4690	0.0625*
GM feed x environment	0.13350	0.08712	2.3484	0.1254
GM additives & medicines x environment	0.13425	0.09627	1.9446	0.1632
GM animal x residues [fgh]	0.50950	0.09848	26.7685	0.0001***
GM feed x residues [fi]	0.22176	0.08738	6.4414	0.0111**
GM additives & medicines x residues [gj]	0.23143	0.09649	5.7527	0.0165**
GM bacteria x residues [hij]	0.75542	0.10230	54.5250	0.0001***
Model Statistics				
Likelihood Ratio	1158.6998			
Score	1055.9202			
Wald	933.8899			
DF	22			
p-value	<.0001			

[1)] * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level
[2)] categories that share the same superscript character are statistically different from each other

5. Conclusions

This study has presented the results of choice modeling approach used to evaluate consumer preferences with respect to the different GM applications. By examining consumers' preferences, choices with respect to the GM pork, the study adds to knowledge to the existing body of knowledge about potential market and new opportunities for pork production chain.

Results of the analysis indicate that GM applications get less utility compared to the conventional pork. Among all possible benefits consumers value the highest the improvements in animal welfare, improvement in environments receives the lowest utility. In line with the previous studies, results show that consumers have an interest in GM products (produced by using different GM applications) as long as they bring them different benefits and they are substantially cheaper.

This study is important for scientists, industry and policy makers. For scientists, this study provides additional information on how consumers evaluate different benefits. How consumers make a trade-off between different attributes. For industry, it gives the information about the product attributes and GM applications that consumer's value most. For policy makers, this study provides additional view on how consumers evaluate genetic modification in meat production.

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