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Who are Proponents and Opponents of Genetically Modified Foods in the United States?

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Abstract: A national telephone survey was conducted in the U.S. in April 2002 to assess the consumer acceptance of genetically modified (GM) foods. Attitudes towards GM foods were studied through the use of a multiple correspondence analysis (MCA) method, analyzing the interrelationships among many variables. This method was combined with a cluster analysis to construct a typology of consumers' attitudes. Four distinct behaviors were finally extracted – proponents, non-opponents, moderate opponents and extreme opponents. We estimated that only 35% of the surveyed population was opposed to GM foods. The consumer attitude towards GM foods was found more complex than the usual acceptance / rejection responses; consumers are looking for incentives and GM proponents are likely to choose the non-GM alternative if no benefit is perceived.

Keywords: Genetically modified, correspondence analysis, telephone survey, acceptance.

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Introduction

The United States is the world-leading country in research, development, and sales of genetically modified organisms (GMOs). In 2002, the estimated acreage of GM crops worldwide was 58.7 million of hectares; of those, 66% were from the U.S. [1] In the same year, the adoption rates of GM soybeans and corn were 75% and 32%, respectively, in the U.S. Consequently, besides being a major technological breakthrough, GMO is a tremendous economic stake for the biotechnology industry and the agricultural sector in the U.S.

Currently, all GM crop varieties present on the U.S. market must be "recognized as safe" by the Food and Drug Administration (FDA) and certified as not hazardous to human health (Sheldon, 2002). Under this FDA policy, labeling of GMOs is not required. The fact is that, contrary to the European Union (EU) or Japan where the labeling of GM foods is mandatory, most Americans now eat a significant number of GM foods (especially products with corn or soybeans as ingredients). Nevertheless, the U.S. consumer does not know which products are GM as there is no labeling requirement.

Despite the government's guarantee, GMOs remain a controversial topic for some, for instance, environmental or health-related issues. Some consumers are surely opposed to GMOs and this could affect growers and food producers with respect to their marketing opportunities (Saak and Hennessy, 2002). Thus, for example, in July 1999, Gerber and Heinz, in their efforts to strengthen consumer confidence, declared the intention to cease using GM ingredients in their baby foods. Could food companies be made better off by avoiding GM foods? Are American consumers opposed to GMOs? It is essential to assess the consumer acceptance of GM foods since it will determine the fate of this biotechnology and could dramatically affect the U.S. food industry.

There is an extensive literature evaluating the consumer acceptance of GM foods. The results tend to vary as a function of how questions are phrased (Hallman, 2002a). Generally, it can be shown

that about two-thirds of Americans are positive about biotechnology and support its application in food production (Hallman and Metcalfe, 1994; Hoban, 1998, 1999; Chern and Rickertsen, 2001; Alexander and Schleman, 2003). Some authors, however, show that the trend is towards less consumer acceptance (Susanna H. Priest, 2000; Shanahan et al., 2001).

The objective of this study is to investigate the consumer acceptance of GM foods and obtain an enhanced understanding of the sources of heterogeneity. We propose to show that various attitudes towards GMOs can be found within the American population, and also to present the associated distributional information useful for policy makers and for the biotechnology and food industry in terms of market evaluation.

For the purpose of this study, a telephone survey was conducted in the U.S. in 2002. This comprehensive survey dealt with both stated preferences for GM vs. non GM foods as well as behavioral intentions, since behavioral intention reflects a person's decision to perform the behavior (Fishbein and Ajzen, 1975).

The Survey

The questionnaire, on which the survey was based, focused on attitudes and behavioral intentions towards GM foods. It included various questions dealing with the willingness to consume GM foods in terms of favorable (e.g., if it was more nutritious) or adverse arguments (e.g., if it posed a risk of causing some allergic reactions for some people), the knowledge of the respondents regarding biotechnology in general and GMOs in particular, and the regulation of GM foods. The contingent valuation questions focused on three specific products: namely, vegetable oil, cornflakes and salmon, and asked respondents to make choices between GM and non-GM products under different price scenarios. The first two products were chosen insofar as soybean and corn are the two main GM crops grown in the U.S. and also because those are products consumers are familiar with. The third product was selected because, contrary to the last two products, it is an animal based product.[2] Current research

on public attitudes towards biotechnology have indicated that consumer acceptance of GM products is affected by factors such as the organisms involved, i.e., plant or animal based products (e.g., Chern et al., 2002; Hallman et al., 2002b; Hamstra, 1998; Kinsey and Senauer, 1997; Caswell et al., 1994). Information also was collected on respondents' socio-economic characteristics.

The data were collected in April 2002 through a national telephone survey of randomly selected households in the U.S. (excluding Hawaii and Alaska). A random digit dialing was used to select the households (generation of random telephone numbers avoiding undercoverage of unlisted numbers). Respondents were limited to food shoppers in the household aged 18 and over. The survey was conducted within a three-week period, with a mix of day times and evenings. Each working telephone number was called several times, at different times of the week, to reach people who were infrequently at home. The survey was conducted by the Center for Survey Research at The Ohio State University. A total of 1,213 telephone numbers were called. Of those, 896 numbers were presumed to be households.[3] A total 256 interviews out of 896 were finally completed, which gives a response rate of 28.6% using the response rate computation method adopted by the American Association for Public Opinion Research (AAPOR), the most conservative calculation.[4] The 256 respondents were spread to 44 different states.

In order to validate the representativeness of the sample, two variables were considered: age and gender. Table 1 compares the age repartition between the sample and the U.S. population for those aged 20 and more in the 2002 U.S. Census. This comparison shows a slight bias as the classes 20-24 and 35-44 years are under-represented whereas 45-54 years are over-represented in the sample. This does not, however, constitutes a serious bias since the attitude towards GM foods of those aged 20-24 years is not found to differ significantly from the rest of the sample.

As for gender, it has to be stressed that participants are skewed towards women since 77.3% of the respondents are women (compared to 51.7% in the U.S. population for people of 18 years and over). Nevertheless, Katsaras et al. (2001) show that women make up a disproportional share of

grocery shoppers (83% of shoppers). Note that our target population is not the U.S. population as a whole, but food shoppers in the household. Therefore our sample can be considered as representative of the food shoppers' attitudes towards GM foods.

Gross Measure of Consumer Acceptance

An extensive literature shows that about two-thirds of American consumers are positive about biotechnology, and about three-quarters have consistently expressed a willingness to buy insect-protected produce developed through biotechnology. For example, Hoban (1999) reports 70% of acceptance for GMOs, Hallman and Metcalfe (1994), 59% in a survey of New Jersey residents, and Chern and Rickertsen (2001), 82% in a student survey. Moreover, in their survey on Americans' acceptance of food biotechnology, Alexander and Schleman (2003) found that 62% of the respondents thought biotechnology would provide benefits for them and their family in the next 5 years. In the present study, 43% of the sample are somewhat or extremely willing to consume foods produced with GM ingredients (Table 2). This result is lower than the ones found in other studies; it might be due to the high percentage of women in the sample as they have been found to be more risk-averse than men. This study also finds that men seem more likely to consume GM foods. The differences between the studies may also be reflective of how the questions were asked. Thus, for example, Hallman (2002) argues that "whether one uses biotechnology, genetic engineering, genetic modification, or genetic manipulation to describe the technology can lead to significantly different approval ratings". Whatever the case is, the percentage of acceptance in our survey is higher when the genetic modification is associated with a benefit: 68% when the GMO application reduces the amount of pesticide applied to crops and 72% when the GM product is more nutritious than its non-GM counterpart.

Even though these results may be taken as a measure of the consumer acceptance of GM foods, they do not indicate clearly who are the opponents vs. proponents of GM foods. In order to obtain

further insights into the consumers' attitude towards GM foods, we apply the multiple correspondence analysis.

Multiple Correspondence Analysis

Consumers have clearly different behaviors and attitudes towards the GM technology. These attitudes can be grouped within distinct profiles. Thus, from the questions assessing the attitudes of the respondents, two individuals can be assumed having the same attitude if they answered the same way to the questions, or in statistical terms, if they chose the same categorical modalities. Moreover, two individuals can be thought belonging to the same profile if their answers only diverged slightly. Lastly, each profile can be described through the people belonging to it. If all the people are women aged over sixty years, it can be thought as being one of the dominant features of this profile. Therefore we can explore and identify the structure of association amongst the set of categorical variables related to the consumer attitude.

The five questions used as active variables for this analysis are the following; they were aimed at assessing the attitudes of the respondents towards GM foods:

(1) How risky would you say GM foods are in terms of risk to human health?

(2) How willing are you to consume foods produced with GM ingredients?

(3) How willing would you be to consume GM foods if it reduced the amount of pesticide applied to crops?

(4) How willing would you be to purchase GM foods if it was more nutritious than similar food that isn't genetically modified?

(5) How willing would you be to purchase GM foods if it posed a risk of causing allergic reactions for some people?

For each of these questions, respondents were proposed the 6 following categorical modalities:

1- Extremely unwilling / risky.
2- Somewhat unwilling / risky.
3- Neither willing nor unwilling / risky nor safe.
4- Somewhat willing / safe.
5- Extremely willing / safe.
6- Don't know (not spontaneously proposed to the interviewees)

Considering the complexity to analyze these five variables conjointly, a technique of data analysis is required, an exploratory technique intended to reveal features in the data.[5] Multiple correspondence analysis (MCA) is one such method to analyze the associations amongst categorical variables, with the purpose of visualizing the most salient relationships and patterns in the data.

MCA is a multivariate extension of correspondence analysis (Benzécri, 1992). It permits an analysis of the interrelationships between three or more variables. It is a technique for displaying the rows and columns of a data matrix as points in dual low-dimensional vector spaces (Greenacre, 1984). Data are typically tabulated as shown in Figure 1. In this figure, the table on the left is equivalent to a matrix **Z** with n rows, corresponding to the number of individuals, and p columns, where p is the number of questions, k, multiply by the number of categorical modalities (in our case, p equals to 30). This is homologous to the matrix R, the condensed matrix of Z, containing n rows and k columns. Each respondent is characterized by the modalities chosen in the survey. For example, in the question, "How risky would you say GM foods are in terms of risk to human health?", a respondent is characterized by the categorical modality he chose, such as "somewhat risky" or "extremely safe". Respondents can therefore be represented in a multidimensional space. Since we cannot observe points in a space with more than three dimensions, it becomes necessary to reduce the dimensionality of the points. The points are projected on a lower-dimensional subspace which is chosen to capture as much of the dispersion of the profiles as possible. A new orthogonal set of axes (the factor axes or factors) is found, so as to maximize the inertia of the projected points onto the new axes; this procedure is shared with the principal component analysis. [6] These axes define a two by two factor plane. Each factor represents a salient feature related to the consumer acceptance of GM foods. By studying the modalities

significantly associated with the main factor axes, one can explain the main oppositions within the population and thus discriminate the people. The main variables eliciting the consumer acceptance of GM foods can then be extracted from the analysis.

MCA is used to construct principal components, which best summarize the individuals' characteristics within the population represented by the sample. To search for a typology of the attitudes related to the consumer acceptance of GM foods, an ascending hierarchical classification method can be carried out on the individuals described by the factors (Ward's minimum variance method). Using this method, individuals are grouped into clusters according to their proximity, i.e., their similar characteristics. A class is then defined as a group of individuals with common characteristics or, more specifically in this study, with a similar acceptance of GM foods.

The Agglomerate Hierarchical Clustering algorithm constructs the hierarchical tree starting with the individuals. Ward's method seeks at each step to form a new cluster which minimizes the internal variance (inertia within) of the new merged class (Ward, 1963). Inertia is computed from the coordinates of the elements to be classified on the factor axes (Lebart et al., 1977). The construction is continued up to the root of the tree where the cluster containing all the individuals in the sample is created. We can then choose a classification that best summarizes the information.

Empirical Results

The principal objective of our analysis is to differentiate the respondents according to their attitude towards GM foods with respect to a range of different arguments. As we have already mentioned, our analysis concentrates solely on shoppers in the household, as we consider that their attitudes are the closest to the reality, thereby decreasing the hypothetical bias of the study.

Note that, as in any factorial method, it is possible to include what are known as the "illustrative" variables. These are not used in the construction of factor planes, but can help in the interpretations of the factors or later in the description of the classes. In our case, we included: the socio-demographic

variables, the questions dealing with the knowledge about GM foods and biotechnology, some questions about the regulation of GM foods (especially labeling), and also the questions asking for choices between GM and non-GM foods (specifically vegetable oil, cornflakes and salmon) under different price scenarios.[7]

Factor Planes

Typically, in MCA, analyses of factor planes are guided by the centroid principle: category coordinates are the center of gravity (or centroid) of respondent coordinates occurring in that category. Stated differently, respondents are relatively close to categories they are in and relatively far from categories they are not in.

The variable category points are plotted in Figure 2, a typical graph produced in MCA (see for example, Greenacre and Blasius, 1994) – all modalities from the five questions chosen as active variables are represented in the graph. The illustrative variables could also have been represented on this factor plane, but it would have been detrimental to the clarity of the graph. This first plane represents 24.7% of the total inertia, in other words, one quarter of the total information. It can therefore be considered as a good summary of the information.

In correspondence analysis, so called weighted Euclidean distance is used to measure the distances between points. In practice, the weighting scheme is such that categorical modalities occurring less frequently contribute more to the creation of the factor axes (we are interested in characterizing the sample, not in finding the common features within the sample), while those occurring more contribute less. Hence, modalities of higher weight tend to be close to the center of gravity (the origin of the axes represent the center of gravity) while modalities of lower weight are plotted further from it. Specifically, we divide each of the squared differences in the distance calculation by the corresponding element of the average profile; this distance is known as the chi-squared distance, (Greenacre and Blasius, 1994). The singular value decomposition, a generalization of

the eigenvalue decomposition, is used for this purpose (Eckart and Young, 1936; Greenacre and Blasius, 1994). Note that a negative coordinate indicates a negative correlation between the modality and the factor axis.

Different regions of consumer acceptance are revealed in Figure 2. We can see that in the upper right quadrant are the variable categories associated with the most extreme level of acceptance: extremely safe, extremely willing to consume GM foods, etc. Thus, respondents in this area of the map are associated with these categories. We can further identify a region of extreme rejection in the upper left quadrant. Moving down in the figure, in the lower center of the map, we identify two clusters of moderate variable categories: modalities in favor of GM foods (e.g., "somewhat willing to consume foods produced with GM ingredients") in the right part and of rejection in the left part (e.g., "somewhat unwilling even if it was more nutritious than similar food that is not GM"). Hence, the MCA has clearly identified four distinct regions relating to consumer acceptance of GM foods.

Figure 2 exhibits what is called the "horseshoe" or Guttman effect (Guttman, 1950); the lines linking the modalities of the active variables exhibit a “U”-shape (the line for question 5 is not drawn here, it is discussed later). It has a quadratic structure, in the sense that respondents are on or close to a second degree polynomial in two-dimensions. That is, the second dimension is a quadratic function of the first dimension. Because respondents are on a horseshoe, and category points are close to the respondents occurring in them, the category points will tend to be on a horseshoe, as well. It has to be stressed that the origin of the axes corresponds to the center of gravity of the cloud of points. Lastly, the coordinates are drawn based on the squared distance to the origin and to the quality of representation in the new subspace.

The horseshoe effect shows a strong underlying order structure in our data. In effect, the horseshoe in MCA is equivalent to the general factor in the principal component analysis. In this example, the underlying variable is acceptance of GM foods. Notice also that the analysis has revealed distinctly non-linear patterns of consumer acceptance. This illustrates an advantage of non-linear

multivariate analysis. By treating all variables as categorical, we may discover patterns in the data that would be hidden by a conventional linear multivariate analysis.

Figure 3 shows the plot for question 5 as embodied in Figure 2. The modality "extremely unwilling to consume GM foods if it posed a risk of causing allergic reactions for some people" is close to the center of gravity whereas the other "extreme" modalities (e.g. extremely risky in terms of risk to human health) are located on the left or right extremities of the graphic. The interpretation is that the rejection of GM foods if it posed risks of causing allergic reactions is widespread among the population (closer to the center of gravity), even those in favor of GM foods tend to be unwilling to consume transgenic foods in that case.[8]

The graphic representation of factors 1 and 2 are further explained by factors axes created by the MCA.

Factor Axes

As factor axes can be considered as summary variables, their interpretation reveals the salient patterns related to the notion of acceptance. The first three axes together account for one third of the total inertia. This proportion is not so high and suggests that more dimensions are needed in order to explain the complexity of the consumer acceptance of GM foods. The analysis is limited to these three axes since they appear to be the most relevant. In MCA, the fact that each variable presents different modalities means, when many variables are considered, the percentage of inertia of each factor would be small. The three main factors are detailed below.

It is important to determine whether or not a modality is significantly associated to a factor (variables) or a class (individuals). That is, whether there is a discrepancy of appearance between the modalities in the factor/ class. The test-value (TV) method is used. The difference is deemed significant, with a level of confidence equal to 95%, if the absolute value of the estimator is equal or

greater than 1.96.[9] As indicated by the absolute value, TV can be positive or negative. The interpretation of the sign varies whether we consider a factor [9] or a class [10] (to be discussed later):

(1) When modalities are used to characterize a factor, the sign coincides with the coordinate of the modality in the factor. Thus, if a modality has a negative coordinate, then TV is negative.

(2) When modalities are used to characterize a class, the positive sign means that the modality is over-represented in the class whereas the negative sign highlights an under-representation.

First Factor: 13.5%

The first factor axis accounts for 13.5% of the inertia, in other words, 13.5% of the intrinsic variance of the cloud of points. It emphasizes the consumer acceptance of GM foods through the attitude of respondents. There is an ordering along the axis: individuals with an "extreme" rejection of GM foods are plotted on the left side, then moderate opinions and, at last, "extreme" acceptance of GM foods on the right side.

Comparing the two extremities of the axis, one side contains all the extreme modalities in favor of GM foods ("extremely") and, on the other side, all the extreme modalities in disfavor of GM foods. It means that when one supports GM foods, one tends to accept all the positions; the contrary is also true. By studying the modalities from both active and illustrative variables significantly associated to the first factor, it is possible to characterize the attitudes of rejection and acceptance of GM foods.

From the analysis of the illustrative variables such as demographic variables (not plotted as the number of points would have been too large, impeding the readability of the graph), it emerges that GM-opponents tend to choose non-GM foods, even when the price associated to the GM counterpart is significantly lower. They are not too price-sensitive as they consider price is "extremely unimportant" when deciding whether or not to buy GM foods (TV= -6.40). As a consequence, it is not surprising that they prefer mandatory to voluntary labeling (TV=-2.35) even if prices are higher by 5% (TV= -4.11).

This profile of opponents is also associated with a poor opinion about the U.S. government performance in food safety (TV= -3.19). Lastly, vegetarians (TV= -2.80), zero-consumption

expenditures for food away from home (TV= -2.65) and Afro-Americans (TV= -2.07) are over-represented in this profile.

Proponents, on the other hand, are more likely to consider both non-GM and GM products as equally good. This absence of differentiation has to be linked to apparent higher levels of education (Master degree, TV= 2.82) and knowledge (they tend to answer correctly the two questions included in the survey; TV> 2 for both), suggesting that the more people know about biotechnology, the more they are in favor of the technology. Given that the products are perceived as being the same (when they face two products, GM and non-GM, with the same price, they tend to consider both as equally good), whenever price is a decision factor, they tend to choose the cheapest good. Furthermore, they have a high opinion of the U.S. government with regard to its performance in food safety ("excellent performance", TV= 2.06).

Second Factor: 11.2%

The second factor represents 11.2% of the information. It contrasts extreme ("extremely") to moderate modalities ("somewhat") as shown in Figure 2. Whereas moderate attitudes are difficult to characterize since they represent the main tendency in the sample, it is possible to find some significant associations with the "extreme" behaviors. Hence, extreme modalities are likely to be linked with a higher level of acquaintance (such as very well informed, TV= 2.95). They also have a more extreme attitude regarding the U.S. government performance in food safety (poor and very poor, respectively, TV= 2.10 and 3.62).

Results also show that salmon is the only product in the survey significantly associated with extreme attitudes. The "extreme" respondents do not differ from others with respect to vegetable oil and cornflakes in term of the choice between GM and non-GM. Therefore it means that the perception of salmon is significantly different from the perception of the two plant products. Furthermore, the modalities related to salmon corresponds to the disfavor of non-GM salmon, i.e. respondents do not choose the modality "I would choose the non-GM salmon" as often as the rest of the sample. Given that

the extreme modalities are much more seldom than the moderate ones, we can conclude that, overall, respondents are less likely to choose GM salmon or GM-fed than any of the other GM plant products included in the study.[9] Consequently, people are far less supportive of the GM technology when used with an animal. Figure 4 shows that the acceptance rates for GM-fed and GM-salmon are lower than those found with products of plant origin – vegetable oil and cornflakes. This result is in accordance with research on public attitudes towards biotechnology indicating that consumer acceptance of GM products is affected by factors such as the organisms involved, i.e., plant or animal based products (e.g., Hallman et al., 2002b; Hamstra, 1998; Kinsey and Senauer, 1997; Caswell et al., 1994). Lastly, "moderate" respondents are more supportive of the mandatory labeling policy of GM foods and are more price sensitive than "extreme" respondents are.

Third Factor: 8.7%

The third factor, representing 8.7% of the total inertia, highlights the differences between moderate opponents and moderate proponents to GMOs. In general, respondents moderately opposed to GM foods consider themselves to be "very well informed" about GMOs (TV= -3.21) and think that price is "extremely unimportant" when deciding whether or not to buy GM foods. Furthermore, whereas moderate proponents grade highly the U.S. government in food safety (good, TV= 2.55), moderate opponents mostly mention a "fair" performance (TV=-2.29).

A Typology of Consumer Acceptance for GM Foods

The MCA is used to construct principal components, which best summarize the individuals' characteristics within the sample. To search for a typology of the attitudes related to the consumer acceptance of GM foods, an ascending hierarchical classification method is carried out on the individuals described by the factors discussed previously (Ward's minimum variance method – Ward, 1963). Then, the individuals are grouped into clusters according to their proximity, i.e., their similar characteristics.

The hierarchical classification method leads to the construction of four clusters expressing 36.8% of the total inertia. We use, for this classification, all the factors created by the MCA, not only the three main factors analyzed earlier. Table 3 shows the sample distribution among the four classes. Respondents are assigned a class depending on the answers they chose in the survey.

Class 1: Non-opponents (61% of the sample)

The first class, extracted from the hierarchical classification, is composed by non-opponents of GM foods. These respondents can be characterized by a moderate propensity to consume GM foods. They are indeed "somewhat willing" to consume GM foods (51% of this group, TV= 9.00), somewhat willing if the amount of pesticide applied to crops is reduced (83% of this group, TV=11.96)[10].

Their support for GM foods is mainly due to the benefits associated: less pesticide used (TV=11.96), more nutritious (TV= 8.52). Besides, the only extreme modality significantly associated to this profile is: "extremely willing to purchase GM food if it was more nutritious" (22.4% of the respondents of this class chose this modality vs. 18% in the sample, TV= 2.20). Given that 32% of them (TV=3.40) consider that reducing saturated fat in foods is the most important potential benefit of GM foods, it means they are mainly interested in health benefits. This is in line with consumer behavior theory: consumers perceive a product as a bundle of benefits. When neither GM nor non-GM products are associated with a specific benefit, respondents tend to answer that "both products are equally good" (TV= 2.20 for cornflakes and oil). It would mean they do not perceive a significant difference between GM and non-GM products. Some would perceive the absence of genetic modification as a benefit if nothing more is associated. Nonetheless, these respondents are likely to change their minds for the GM counterpart when they face a discount (the trend is not significant). The price is indeed an important factor as 81% of them consider it as being at least somewhat important (TV= 2.94 for "somewhat important" and 2.90 for "extremely important") when they decide whether or not to buy GM foods.

Another argument supporting the absence of differentiation between the two products is that they are more likely to be in favor of the voluntary labeling (TV= 2.37). In that, they echo the U.S. government; i.e., the government has a good (TV= 3.02) if not excellent (TV= 1.66<1.96) performance in food safety. The respondents in this class tend to be less informed than the average in the sample (TV= -3.44 for very well informed). Indeed, as Almås (1997) argues, when somebody believes in his elders, the chiefs or the experts, he doesn't need to choose for himself in difficult situations. They choose for him; he follows them and feels safe. However, it could also be due to a low perceived risk as, according to Cox (1967), the consumer's need for information is determined by the nature and importance of the perceived risk. Consumers will look for sources, types, and quantities of information which seem to be the most adapted to satisfy their specific needs. If they do not perceive any risk, they do not need to inquire.

With this class representing 61% of the sample, it is hard to characterize the respondents through their personal characteristics. However, it appears that African-Americans are less likely to be part of this class and therefore to have this profile. (TV= -1.97).

Class 2: Moderate Opponents (22.7%)

The second class comprises 22.7% of the sample as moderate opponents of GM foods. Whatever the arguments mentioned, these respondents remain "unwilling to consume GM foods". Moreover, they consider it extremely important that food products are labeled specifically for GM or non-GM attributes (TV= 2.63) and they support mandatory labeling (98.3%, TV=2.48).

No definite description of their attitude towards GM foods can be identified for this class. However, the fact that the only "extreme" modality (regarding their acceptance) significantly associated with their profile is "extremely unwilling to purchase GM foods if it posed a risk of causing allergic reactions" (56.9%, TV= 2.56) leads to the conclusion that their attitude is at least partially determined by health concerns. Furthermore, they are likely to consider the U.S. government performs

"fairly" with regard to food safety (46.6%, TV= 2.12), which suggests a lower level of confidence in the government than those in class 1.

In this class, two occupations seem to be over-represented: technical/ sales/ clerical (15.5%, TV= 2.10) and manager/ professional (17.2%, TV= 1.99). This class is better-off than other classes with an average income of $88,472 (Table 5); one nevertheless has to be careful with this result as the standard deviation is very high: $82,028, suggesting a big discrepancy in income between the two classes of occupations just mentioned since the average income of the household for the former is $69,500 whereas, for the latter, $116,800. Finally, these respondents are more likely to be from the Northeastern part of the U.S., which would illustrate regional differences.

Class 3: Proponents (4.69%)

The third class gathers proponents of GM foods. These respondents appear to be "extremely willing" to purchase/consume GM foods (83.3%, TV= 7.60). Nevertheless, in the case where both GM and non-GM products have the same price, they do not appear to be more likely to purchase GM foods than the rest of the sample. Indeed, they consider both products as equally good. If there are price differences, they would choose the cheapest product, showing, one more time, that people are looking for a benefit. Moreover, they consider themselves being "very well informed" (TV= 2.80) and answer correctly to the two knowledge questions related to biotechnology (TV= 2.02 and 1.34). This result suggests that these products are perceived as equivalent and therefore as substitute goods. Their choice is then determined by a benefit related to one of the products, such as price.

When considering the socio-demographic variables that might serve to better characterize this class, emphasis should be made on a seemingly higher education level (TV= 1.45 for Masters degree and 1.27 for Bachelors degree; not significant), on a middle range income ($60,000-69,999: 33.33%, TV= 2.10), as being slightly lower than the average since the highest incomes have a negative test-value. Lastly, there is a higher percentage of men in this class (TV= 1.86, see Table 4).

Class 4: Extreme Opponents (11.72%)

Respondents in this class are extremely averse to GM foods. Thus, 93.3% of them are “extremely unwilling” to consume foods produced with GMOs (TV=10.61) and 56.7% think GM foods are extremely risky for human health (TV= 7.26). Whatever the question about GM food acceptance they are asked, they remain "extremely unwilling" to consume/purchase the products. They are radically opposed to the GM technology.

Price is extremely unimportant (TV=5.4) in the purchase decision of GM foods. Moreover, given that 66.7% of them are ready to support GM labeling even if prices were higher by 5% or more, it is likely that they will not change their mind. Furthermore, they grade poorly the U.S. government in terms of performance in the food safety area (TV= 3.30).

Vegetarians are over-represented (TV= 2.62). Furthermore, respondents in this class use more often than the others, friends and family as a source of information. They also tend to be older, less educated and have lower incomes than the rest of the sample (Table 5). This is in accordance with previous social studies on risk perception. Results from numerous opinion polls (Peretti-Watel, 2002) suggest that risk perception is stronger among more modest classes, that is, among people with a lower level of education or elderly.

Discussion

From the multiple correspondence analysis and hierarchical classification, four distinct attitudes towards GM foods were extracted. These attitudes can be combined into two groups.

First, two types of attitudes in favor of GM foods can be distinguished:

(1) The majority of the surveyed sample, 61%, is composed of non-opponents of the GM technology. They have a relatively positive attitude toward GM foods to the extent that the willingness to purchase or consume is associated to some benefits. Thus, they are sensitive to added health benefits or to a decrease in price.

(2) Proponents represent 5% of the sample. They appear to be extremely favorable to GM foods. However, their choice is mainly determined by the existence of benefits. In addition, they are likely to choose the non-GM products if no benefit is associated with the GM counterpart.

Secondly, two types of opponents are found:

(1) The moderate opponents constitute 23% of the sample. They seem to be mainly worried about the perceived health risks related to GMOs.

(2) The extreme opponents, 12% of the sample, reject the biotechnology overall. Their attitudes may be due to a higher perceived risk. Indeed, besides being opposed to GMOs, they consider the U.S. government performing poorly in food safety. Moreover, as described by sociological studies on risk perception, these people tend to be older and have a lower level of education. They represent a very risk-averse part of the population.

These results suggest that people look for incentives. Indeed, acceptance is not synonymous to the purchase of GM foods. Proponents of GM foods tend to consider that both GM and non-GM products are equally good and their choices are then based on a perceived benefit associated with one of the products. These benefits can be a price discount, a health or an environmental attribute. As a consequence, the food industry should highlight the benefits brought by the added GM ingredients if available. On the other hand, and quite logically, the biggest threat for GM foods seems to be a perceived risk for human health as the majority of the households agree they would be unwilling to consume GM foods if it posed, for example, a risk causing allergic reactions for some people, as it has been demonstrated in the case of StarLink™ corn. Finally, it is in accordance with James et al. (2002) who suggest that consumers are more interested in the product attributes of the food commodity (nutritional value, taste, theoretical effects on health, etc.) than in its process attributes of the corn (GM or not).

The confidence people have in the government has also been found to be an important factor associated with the consumer acceptance of GM foods, as shown by James et al. (2002). Confidence, as

Luhmann (1998) uses it, refers to a more or less take-for-granted attitude that the familiar things will remain stable:

> "The normal case is that of confidence. You are confident that your expectations will not be disappointed: that politicians will try to avoid war, that cars will not break down or suddenly leave the street and hit you on your Sunday afternoon walk. You cannot live without forming expectations with respect to contingent events and you have to neglect, more or less, the possibility of disappointment. You neglect this because it is a very rare possibility, but also because you do not know what else to do. The alternative is to live in a state of permanent uncertainty and to withdraw expectations without having anything with which to replace them."

In fact, public institutions have regulated the risk for people. Trust in abstract systems provides for the security of day-to-day reliability. As a consequence, it is not surprising to consider that an opposition to GM foods is linked with a weaker confidence in the government in terms of its performance on dealing with food safety.

Furthermore, the results show that knowledge is an important determinant of support for the GM technology: the more informed, the more likely people are to be supportive. However, the education level is not found to be really significantly associated with the level of information or acceptance. It seems that, in our finding, the level of scientific literacy is much more relevant, that is, whether or not people answer correctly the two questions dealing with biotechnology in the survey. Hence, whereas people were asked "What is the highest grade or year of school you have completed?", it might be better to replace it by the number of high-school and/or college-level science courses taken. Indeed, Miller (2002) finds it is the strongest predictor of scientific literacy. One important implication is to give more information to people in order to increase their acceptance. Nevertheless, the experiments of Lewin (1943) suggest that a piece of information structured and oriented to stimulate the consumer's aspirations is not sufficient to induce a change in behavior. This idea has been widely examined with the recurrent failures of nutritional information campaigns. In fact, the best way to increase the acceptance is to decrease the perceived risk. In that issue, the government is to play an important role since it is in charge of the food safety regulation.

It should be emphasized that socio-demographic variables are not very important in our study. This might be due to a relatively small sample or it might also be due to an overall low perceived risk. Indeed, the age is the only variable found relevant in the case of a higher perceived risk. As argued by Schilling et al. (2002), GM foods is not a "front-runner among issues a typical American tends to think about today". People are often unaware and therefore do not think about GM foods as a high risk food item.

Men appear to be more supportive of GMOs than women. It also seems that the consumer acceptance of GM foods is likely to vary with race and region. Finally, another interesting finding is that people are more supportive of the genetic modification of plants than they are on animals. The acceptance rates for GM-fed and GM-salmon are lower than the ones found with plant products – vegetable oil and cornflakes.

Conclusions

This paper reports results from a U.S. national telephone survey on genetically modified foods. It involved a comprehensive survey dealing with behavioral intensions and stated preferences for GM vs. non-GM foods. In spite of its small sample (256 respondents), the survey covered 44 states and a fairly representative sample of the U.S. population. The data were analyzed with a multiple correspondence analysis and a hierarchical classification method.

The consumer attitude towards GM foods is found to be more complex than the usual acceptance/ rejection contrast. Proponents of GM foods are likely to choose the non- GM alternative if no benefit is perceived, and opponents seem to be more extreme in their attitude than the proponents. Our typology helps highlighting the specificities of the main tendencies among the population and is therefore valuable for the actors of the food industry.

The fact that the U.S. has implemented a voluntary labeling and that the public does not appear to be too involved in the issue suggests that producers and growers can use GM ingredients or seeds

without affecting significantly their outcomes in the U.S. However, more than 34% of the surveyed sample are estimated to be opposed to GM foods. In addition, the desire, by 89% of the surveyed respondents, for mandatory labeling implies that there is still a big potential market for non-GM foods. Nevertheless, it must be borne in mind that many studies have shown that through their claim for labels, consumers look for a means of reassurance. People want to know everything about the food they eat. They want simple and clear information, easily accessible, assuring them, in the light of food scandals (mad cow disease, *E. coli O157 H:7*, etc.), that producers have nothing to conceal (Fischler, 1990; Noussair et al., 2002).

Moreover, potential foreign markets have to be considered. Thus, even if the EU has recently revised its policy regarding GM foods, the majority of the population in that region remains opposed to genetic manipulations. Japan, Taiwan and Australia (among others) have implemented mandatory labeling and these markets also represent significant outcomes. Such a study, applied to other markets (see for example De Antoni et al, 2003 or Sylvander and Leusie, 2001), helps identify and assess the importance of target populations.

We carried out, recently, a new telephone survey with a much larger sample. This new survey will help us expanding our remarks validating the results presented in this paper.

Endnotes

[1] http://www.isaaa.org

[2] If a number cannot be resolved as a business or non-working, it is called a household number.

[3] The survey covered three types of salmon, namely non-GM salmon, GM-fed salmon (salmon raised with GM soybean meals) and GM salmon (genetically modified by laboratory scientists).

[4] Number of completed interviews divided by the number of interviews (complete plus partial) plus the number of non-interviews (refusal and break-off plus non-contacts plus others) plus all cases of unknown disposition codes.

[5] In the general case of Q categorical variables, there are Q(Q-1)/2 possible two-way marginal cross-tabulations of pairs of variables; in our case, we have 30 categorical modalities.

[6] The inertia (or moment of inertia) is defined as the sum of the quantities rd^2 where r is the mass of an object and d is the distance from the centroid. The inertia of a cloud of points is the sum of the inertias of all the points, or the weighted sum of squared distances from the points to their respective centroids. The total inertia is the same in both row and column cloud of points. It is a measure of the dispersion of the categorical modalities in multidimensional space. The higher the inertia, the more spread out they are.

[7] The two questions assessing the knowledge of the respondents regarding biotechnology and GMOs are the following:
Non- GM soybeans do not contain genes while GM soybeans do. (True, False)
By eating GM foods, a person's genes could be altered. (True, False)

[8] Note that the curve displayed on Figure 3 does not exhibit the usual "horseshoe" shape. It is due to a bad representation of the modality "somewhat willing to consume GM foods even if it posed a risk of causing allergic reactions for some people" on the second axis.

[9] The test statistics for testing the null hypothesis that the projection of the modality j on the factor axis α is not different than on the other factor axis is the so-called Test-Value (TV) expressed as

$$TV = \hat{\Phi}_{\alpha j}\sqrt{\frac{n-n_j}{(n-1)n_j}}$$

Where $\hat{\Phi}_{\alpha j}$ is abscissa of category j on the factor axis α; n_j is number of individuals who chose the modality j; n is total number of individuals. TV has a standard normal distribution. For a significance level (α = 5%), the critical value of the test statistics is $Z_{1-\alpha/2} = 1.96$. See Lebart et al.(1984) for more details.

[10] For testing the association between modality and class, the Test-Value (TV) is given as:

$$TV = \frac{\overline{X_k} - \overline{X}}{S_{\overline{X_k}}}$$

Where $\overline{X_k}$ is the mean of the modality X in the class k; $\overline{X}$ is the mean of the modality X in the sample; $S_{\overline{X_k}}$ is the standard deviation of the modality X in the class k.

The null hypothesis (H_0) is that there is no significant difference between $\overline{X_k}$ and $\overline{X}$. For example, we can use this test to examine if the proportion of men in the class 1 is significantly different from the proportion in the sample, that is, if the modality "male" is characteristic of the class 1. Again the TV has a standard normal distribution.

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Table 1. Age composition of the sample and the U.S. population aged 20 years and more.

Age	U.S. Population (2002)	Sample	z-statistic	Significance
20 to 24 years	9.25%	2.34%	-7.23711	S
25 to 34 years	19.25%	20.70%	0.56838	NS
35 to 44 years	21.99%	16.80%	-2.19951	S
45 to 54 years	19.74%	28.13%	2.95667	S
55 to 59 years	7.38%	6.25%	-0.74281	NS
60 to 64 years	5.71%	6.25%	0.35528	NS
65 and over	16.69%	19.53%	1.13630	NS
Total	100.00%	100.00%		

NS: there is no difference between the population and the sample at a 5% level of significance.
S: there is a difference between the population and the sample at a 5% level of significance.

Source: U.S. Census Bureau, 2002 Census of Population (http://www.census.gov)

Table 2. Answers to "How willing are you to consume foods produced with GM ingredients?"

Answers to the Question	Sample Distribution	Distribution Among Males	Distribution Among Females
Extremely willing	4.7%	8.6%	3.5%
Somewhat willing	38.3%	43.1%	36.9%
Neither willing nor unwilling	13.7%	8.6%	15.2%
Somewhat unwilling	23.8%	19.0%	25.3%
Extremely unwilling	16.4%	12.1%	17.7%
Don't know	3.1%	8.6%	1.5%
Total	100.00%	100%	100%

Source: Primary Data

Table 3. Sample distribution among the four classes related to acceptance of GMOs

Class	Sample Distribution	Percentage
Class 1	156	60.94%
Class 2	58	22.66%
Class 3	12	4.69%
Class 4	30	11.72%

Source: Primary Data

Table 4. Gender characteristics by class

Gender	Class 1	Class 2	Class 3	Class 4	Total sample
Men	21.8%	20.7%	50.0%	20.0%	22.7%
Women	78.2%	79.3%	50.0%	80.0%	77.3%

Source: Primary Data

Table 5. Demographic characteristics by class

Class	Statistics	Age	Education Level	Income
Class 1	Mean	48.4	13.7	70,743
	Median	47.0	13.0	50,000
	Standard Deviation	15.9	1.97	77,220
Class 2	Mean	46.9	14.2	88,472
	Median	46.0	15.0	65,000
	Standard Deviation	14.8	2.0	82,028
Class 3	Mean	48.3	14.5	51,000
	Median	48.5	15.0	50,000
	Standard Deviation	13.4	2.3	20,766
Class 4	Mean	52.5	12.7	57,389
	Median	49.5	12.5	52,000
	Standard Deviation	18.4	2.0	41,982
Total sample	Mean	48.0	14.0	72,046
	Median	47.0	13.0	54,000
	Standard Deviation	15.9	5.4	73,992

Source: Primary Data

Figure 1. Data matrices

Z=

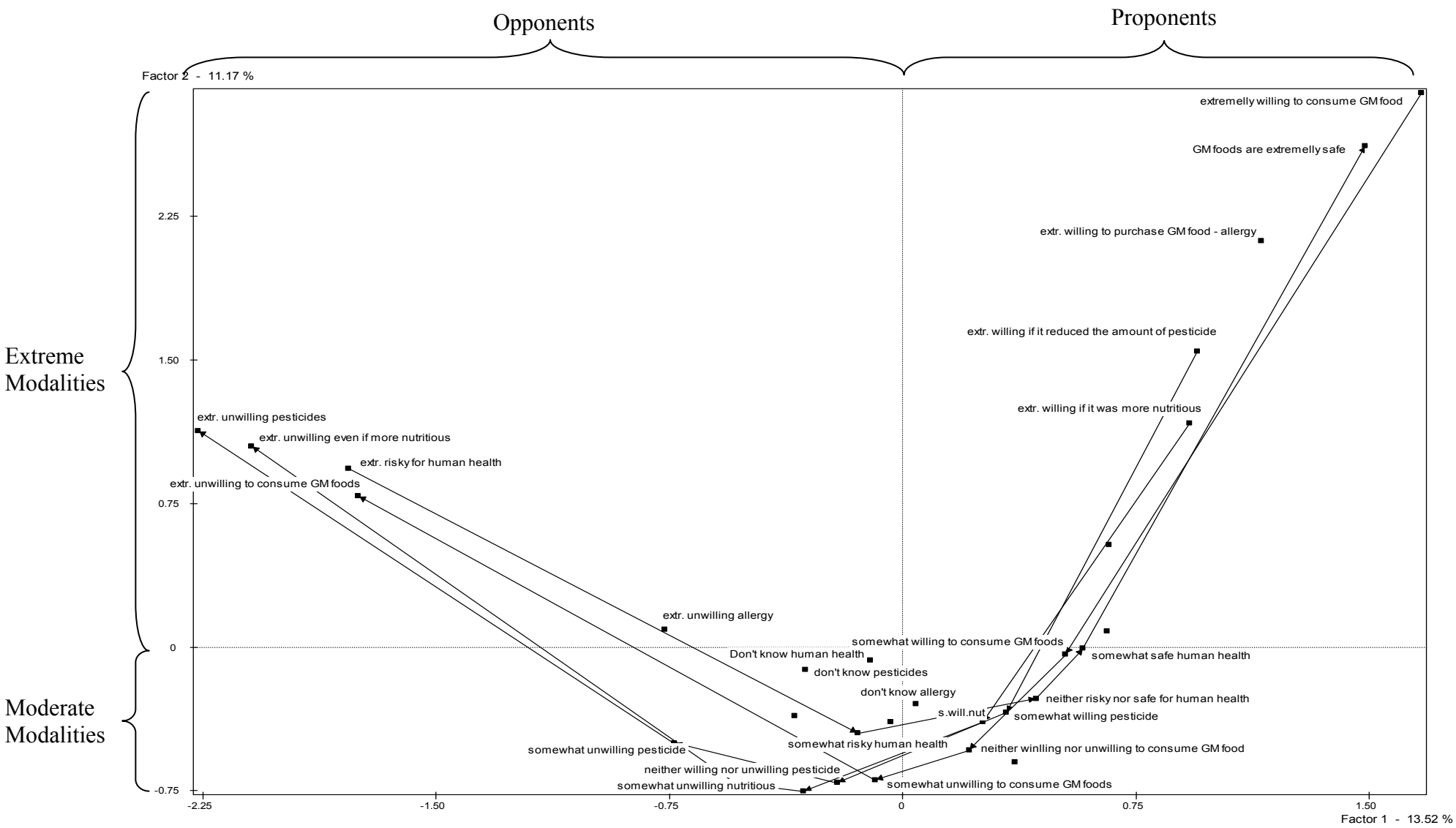
	Question1						…	Question k					
ID	m1	m2	m3	m4	m5	m6	…	m1	m2	m3	m4	m5	m6
1	1	0	0	0	0	0	…	0	0	0	0	0	1
2	0	0	1	0	0	1	…	0	0	0	0	1	0
⋮													
i	0	1	0	0	0	0	…	0	0	0	1	0	0
⋮													
n	0	1	0	0	0	0	…	1	0	0	0	0	0

R=

Q. 1	…	Q. k
1	…	6
3	…	5
⋮	⋮	⋮
2	…	4
⋮	⋮	⋮
2	…	1

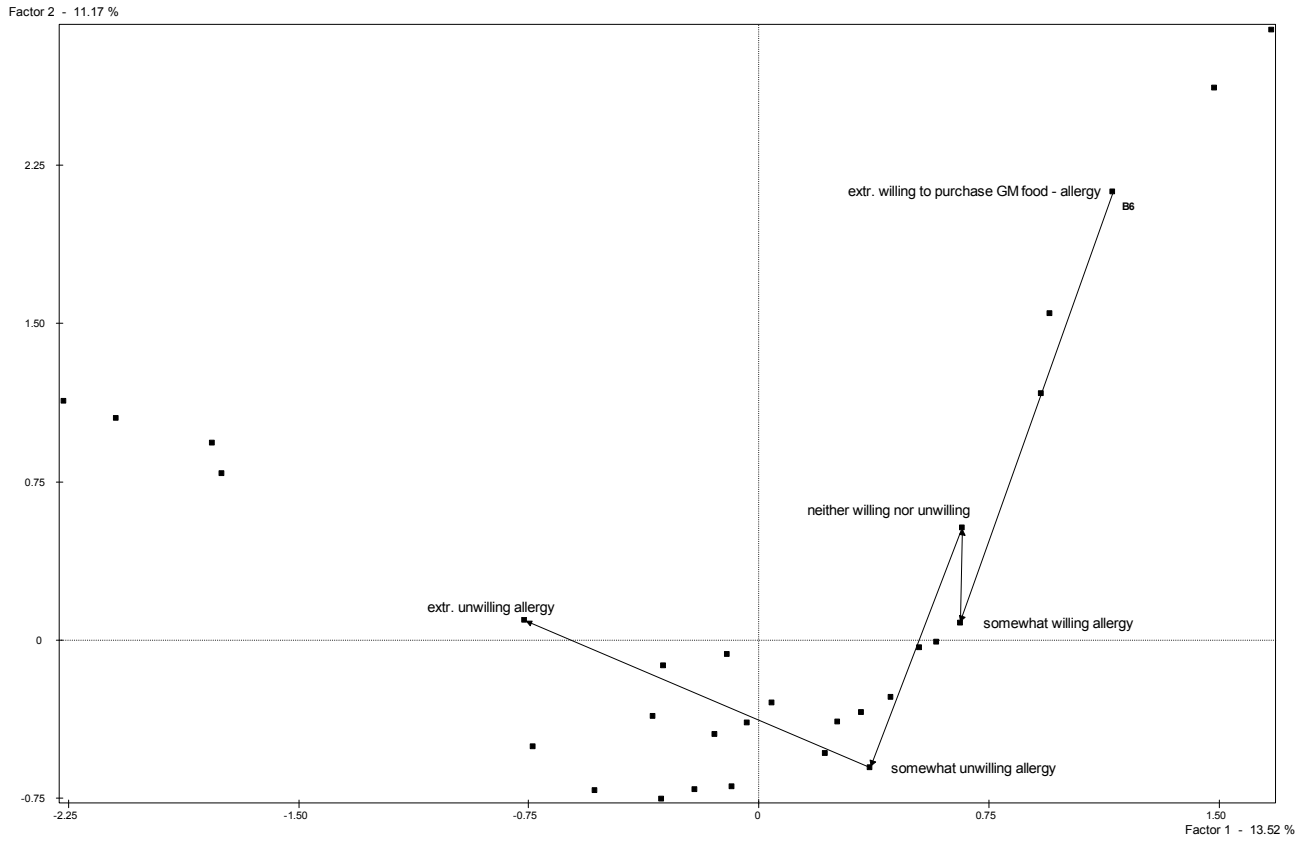
m : categorical modality

Figure 2. Two-dimensional display of the active variables using factors 1 and 2.



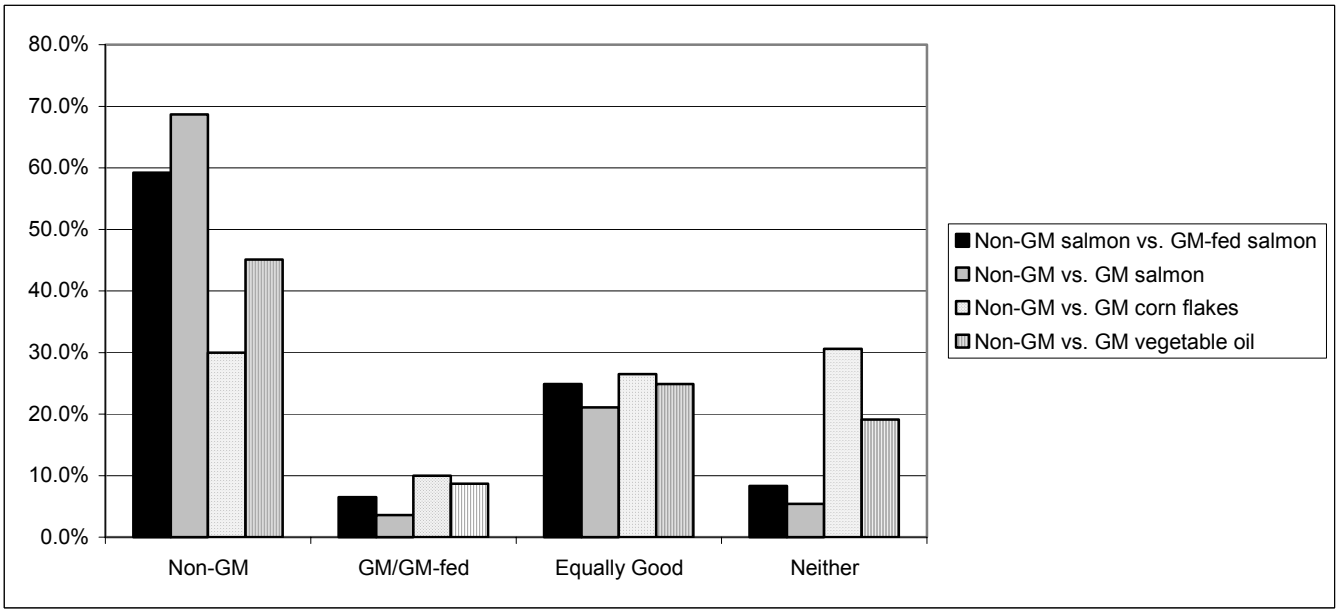
Source: Primary Data

Figure 3. Two-dimensional display of the variable "How willing would you be to consume GM foods if it posed a risk of causing allergic reactions for some people" using factors 1 and 2



Source: Primary Data

Figure 4. Stated purchase preferences under the same price scenarios, four product pairs



Source: Primary Data