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Food Safety and Risk Perception in a Changing World

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FOOD SAFETY AND RISK PERCEPTION IN A CHANGING WORLD

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Abstract

This paper presents an analysis of food risk perceptions of German consumers over the eleven year period from 1992 to 2002. Using factor analysis, we analyse the respondents general risk attitudes and the specific perception of food safety risks. General risk attitude are described by variables relating to environmental, lifestyle and food risks. Food safety concerns are grouped into concern about use of biotechnology, about residues, about unhealthy eating habits, and about natural contaminants. An ordered probit analysis identifies the characteristics that explain the importance consumers attribute to these different food safety risks. The results reveal that general risk perceptions and knowledge about food safety hazards are highly significant in the explanation.

Introduction

The 1990s were characterised by a large number of severe food safety crises. In response, consumers' perceptions of food safety and risks have changed. Large technical catastrophes were in the midst of attention after Bhopal and Chernobyl in the 1970s and 1980s, but with BSE and the advent of GM foods the risks of human technical advances upon nature have intruded our plates. To many it seems that the most human need of a safe food supply has become subject to the will of food engineers and profit-seeking enterprises.

Studies in the mid-nineties show that the concern about food safety is particularly severe in Germany. Based on data from the Food Marketing Institute (FMI, 1995) von Alvensleben constructs an index of distrust in food safety and shows that Germany ranges at the top followed by Austria, Greece, the USA, and Norway. However, results of a series of consumer surveys shows that concern about food was highest during the second half of the 1980s and declined since then up to 1997 (von Alvensleben, 1999).

Interested in the changing nature of risk perceptions related to foods, the German Federal Research Centre for Nutrition in Karlsruhe conducted a survey of about 2000-2500 households every year since 1992. We use these data to analyse the importance of different sensitivities towards technological, life style, and natural risks in determining how consumers evaluate risks related to food. The objective of this paper is to analyse how consumer perceptions of food safety risks have changed during the last decade. We focus on the importance of food safety risks in comparison to other environmental and technology risks and attempt the assessment of a multitude of specific food safety risks such as those related to genetic modification, food consumption habits, food pathogens, and residues. As risk management and consumer policy build on the model of an educated and responsible consumer, we also focus on the role of knowledge about food risks in determining food risk perceptions.

The remainder of the paper is structured in four sections. First follows a brief review of the literature on food and health risk perceptions. The next section presents the data and methods used in the analysis. Finally, we present the results of our empirical investigation and conclude.

Food Risk Perceptions

The relationship between environmental and health risks are multidimensional and complex. Many factors, from individual risk perception, to public discussion and political trends are changing according to internal and external dynamics in our societies. Starting with Starr's (1969) analysis on revealed preferences, much attention has been focused on the characterization of risk through psychonometric scaling and factor analysis. In his seminal work, Slovic (1987) analysed how attributes of risks influence risk perception. Slovic has shown that people rank risks according to two

factors: *dread risk* perceived by lack of control, uneven distribution in the population, and catastrophic or fatal consequences; and *unknown risk* characterized by lack of knowledge, of control, and of observability.

In later work, Flynn, Slovic, and Mertz (1994) found that socioeconomic characteristics, voting behavior and the level of knowledge can influence an individuals' perception of health risks. Dosman et al. (2001) argue therefore, that analyses of food safety related risk perceptions should follow a multivariate approach. They analyse the impact of socioeconomic determinants of health- and food safety related risk perceptions based on surveys in 1994 and 1995 of 959 and 953 Canadian households, respectively. They analyse risk perceptions related to bacteria in food, additives in food, and pesticides in food. They found that variables such as household income, number of children, gender, age, and voting preferences were strong predictors of an individual's risk perception. However, they also show that gender is the only variable that yields consistent results across all three classes of risks and across both years.

While our study is closely related to that of Dosman et al. (2001), it is also very different in several ways. Our data set allows us to cover the much longer time period from 1992 to 2002. Thus we can explore changes in the structure of risk perceptions over time. Secondly, we obtain less detailed data on the importance that individuals attribute to risks but we cover a broader and more detailed range of risks. In consequence, we arrange the risks into different categories based on factor analysis. In addition, we describe individuals by their general risk perceptions as those being concerned about risks to natural resources, e.g., water, air and climate, about risks caused by 'modern life styles', and about risks related to food. We do so because of arguments in the literature of environmental ethics. While standard neo-classical economic analysis suggests that the private ethical system of individuals is utilitarian, the environmental ethics literature argues that there is a broad ethical basis for human behaviour. Minteer and Manning (1999) use a pragmatic approach to classify different environmental ethical systems by survey methods. Grimsrud and Wandschneider (2003) use canonical correlation analysis to identify four ethical systems, of which two are more anthropocentric in nature and one is more spiritual. These analyses show that consideration of nature is formed within ethical systems that can differ among individuals.

One of the most important aspects of human nature is the need for food. The cultural value of food has long been recognized (see Murcott, 2003). Hence the individual approach to technology, life style, food, and risks related to these issues can be important in the explanation of the individual perceptions of food risks.

Data and Methods

We base our analysis on a data set covering annual cross-sections of about 1940 to 2489 consumers in Germany during the period from 1992 to 2002. Samples were drawn independently in every year, so that a panel structure cannot be established. In the survey, consumers were asked about their assessment of alternative risks such as environmental risks, food risks, and behavioural risks. In a second section, respondents were prompted to indicate the importance they attribute to specific food risks such as pathogen contamination, residues, food consumption behaviour, alcohol consumption, genetic modification and biotechnology. In a third section, consumers were asked about their knowledge of several food safety risks and pathogens. The survey was completed by a number of questions recording households' socio-demographic characteristics. The survey design has changed several times over the years. Therefore, the dataset has been homogenized to assure consistency. Nevertheless, vital information was not collected in some years, so that we concentrate our analysis on the years 1992, 1995-1998 and 2000-2002. In December 2000, the first BSE case was detected in Germany. The subsequent series of BSE tests revealed a number of cases and triggered a crisis in the beef market. During 2001, it was quite interesting to observe how consumers' risk perceptions towards food changed and the survey was conducted twice. Thus, observations are available for April (2001-04) and November (2001-11).

In the survey, subjects could indicate on a binary scale if they consider a given risk as important or not. Despite the limitations of a binary scale, information is available for a large number of risks. We reduce the number of dimensions in the analysis of risk perceptions by factor analysis. Factor analysis is a method to reduce the dimension of data to a number of factors that summarizes most of

the information present in the data. Since our data are binary, we are dealing with Boolean factor analysis. Underlying factors are determined in the perception of health and environmental risks and in the perception of food risks. After the factors have been decided upon, risks perceptions are linearly aggregated to form an indicator that assesses the importance of each type of risk. Alternatively, the respective factor values could have been used. However, since a pragmatic approach was necessary in the factor analysis to focus on the same factors in every year, we prefer to construct the risk perception indicators in a simple non-weighted linear manner from the original responses.

In a second step, we use an ordered probit model to identify the determinants of perceptions for four categories of food risks (Greene, 2000, pp. 875-879). A risk category is considered more important if a respondent *i* indicates to be concerned about a larger number of risks evaluated in this category. The ordered probit model is build on the assumption that risk perceptions revealed by subjects are based on some set of underlying perceptions that cannot be directly observed. Let these latent risk perceptions be described by

$$y_i^* = \beta' W_i + \varepsilon_i \tag{1}$$

where W is a vector of socio-demographic and attitudinal variables, β is a vector of parameters to be estimated, and ε_i is an error term. What is observed is the number of risks, y_i, in each category that respondent *i* considers important:

$$\begin{aligned} &y = 0 \text{ if } y^* \le 0 \\ &y = 1 \text{ if } 0 \le y^* \le \mu_1 \\ &\quad\vdots \\ &y = N \text{ if } \mu_{N-1} \le y^* \le \mu_N \end{aligned} \tag{2}$$

Here, N is the maximal number of possible risks assessed in each category. The higher the number of risks the consumer is concerned about, the more sensitive we consider that consumer regarding this type of risk. The dependent variables of risk concern thus vary according to the number of questions, *N*, asked in the respective category.

The explanatory variables considered in the model are listed and defined in table 1: The sex of the respondent (SEX), her age (AGE), the question if she is the head of the household (HHHEAD) and if she is the household keeper (partly HHKEEP1; mainly HHKEEP2), her educational attainment (EDUC1 to EDUC4), if she works (part-time WORK1; full-time WORK2), the size of the household (HHSIZE), if there are kids under the age of 14 living in the household (KIDS) and income. In addition we include variables that describe the type of risk concerns revealed regarding environmental and health risks: concern about risks to nature (ENVRISK), concern about risks related to modern life-styles (LIFESTYLE), and concern about risks posed by food and beverages (FOODRISK). Finally, we include a variable that measures the respondents knowledge about food related risks (KNOW). The construction of these latter variables will be explained in the results section, as they are constructed following the factor analysis.

Results

Factor Analysis of Environmental and Health Risk Types

The data set contains information about the assessment of general environmental and health risks. They evaluate on a binary scale if subjects consider important or not risks from/to: radio-activity, air, traffic, cigarettes, water, food & beverages, noise, climate, job-related stress, and drugs. We proceeded by using factor analysis for each of the nine annual datasets separately and for the data set jointly. The rotated principal components plot is shown in figure 1.

The results show that the risks to air, water and climate are explained by a common factor. Because our analysis focuses in particular on food safety related risks, we keep the indicator if food risks are considered important or not apart. As a last indicator we group all risks related to technology and 'the modern way of life' such as radio-activity, traffic, cigarettes, noise, job-related stress and

drugs in a third indicator. This construction of indicators as given in figure 1 is not unambiguous. However, the analyses separately done for each year suggests that this is the best fit that matches most of the data sets. For space consideration we refrain from presenting the annual results. In the later years, it also appeared quite often that the assessment of risks related to food, water, and drugs could form a third factor. This factor could be named "health risk". However, since food risks are the main focus of this work, we keep it in a separate factor.

After having grouped the risks into three categories according to this factor analysis, we proceed by summing the evaluations into indicators. This results in the variables ENVRISK (climate, water, air), LIFESTYLE (radio-activitiy, traffic, cigarettes, noise, job-related stress, and drugs) and FOODRISK (food & beverages).

We repeat the same methodology for the assessment of food-related risks. Here the survey evaluated consistently 10 different risks. Two questions were not asked consistently. For food consumption behaviour the questionnaire talked about the risk from an "unbalanced diet" in early years and from "too much food" in later years. Similarly, sometimes the questionnaire asked about risks from pesticide residues, in other years, the question referred to residues only in generic terms. We consider these two pairs as synonymous in the subsequent analysis.

Former analyses suggest that while food safety is a normal good, better educated consumers tend to more accurately assess food safety risks and hence their relative importance. This would suggest that more informed consumers are in a better position to judge and manage risks. However, the strong consumer response to the food safety crises of the last years and the strong opposition towards new food technologies seem to suggest that other, e.g., ethical, reasons motivate some of the underlying resistance against certain types of human interference with the nature of our food. Indeed, our factor analysis identifies four different factors explaining the assessment of food safety risks: (1) risks emanating from modern food technology, e.g., genetic modification and biotechnology (BIOTECH); (2) naturally occurring food hazard such as mould, spoilage, and toxins (NATURAL); (3) risks emanating from unhealthy eating habits such as excessive consumption of alcohol, food or cholesterol and consumption of raw and unprocessed foods (NUTRIONAL); (4) risks caused by the use of chemicals and drugs in production such as pesticide residues, food additives, and growth hormones (CHEMICAL).

The rotated component plot is shown in figure 2. As with the previous analysis the identification for the joint data set is not clear cut. However this data arrangement seems to best explain the risk assessment in a coherent manner, when the analysis is done for each year separately. As becomes apparent from the analysis of the joint data set in figure 2, some attributions of individual risks into certain categories are quite ambiguous. This concerns the grouping of unprocessed food into the category of NUTRITIONAL. It could alternatively be grouped into the classification of NATURAL. On the other hand it concerns the food additives that are in some years quite closely related to NUTRIONAL. The final grouping was the achievement of a pragmatic approach trying to get the most coherent and concise number of factors.

The so formed indicators are summarized in table 3. The average score for LIFESTYLE varies slightly above the value of 2 with peaks in 1995 and 2000. The importance of ENVRISK assessing risk to water, air, and climate seems to become less and less important over the years. As to FOODRISK, we observe a decline from 1995, when 36.1% of the respondents considered this risk important to 2000 when only 25.9 % of the respondents found that risk important. The assessment of food risks then jumps up with the advent of the BSE crisis in April 2001, when almost 50% of the respondents seem to be anxious about food risks. This behaviour seems to suggest a selective public perception of risks that certainly depends, at least partly, on media coverage.

Regarding the different type of food risks, trends are not clearly discernable. Chemical risks are becoming less important in the second half of the 1990s and rise in importance in the year 2000. Nutritional risk has seen a peak in 1995 and in 2000. Contamination through natural hazards has declined in importance apart from the year 2000, where it has seen a peak. Overall it seems that consumers seem to be more concerned about the different types of food risks in the year 2000.

Ordered Probit Model

Results for the ordered probit model are given in tables 4-7. The knowledge variable is used as an additional explanatory variable. In the questionnaire, respondents could indicate the food pathogens they have heard about. Since the number and type of pathogens varied in each and every year, we constructed the variable KNOW as the part in total knowledge responses possible. Thus, a respondent could obtain a maximum score of 1, when she had heard about all pathogens and received a score of zero if she hadn't heard of any. At the bottom of each table we report the number of right predictions, the log-likelihood value of the unrestricted estimation and the association chi^2 statistic. According to these diagnostics, all models give a good fit. The chi^2 statistic is significant at the 0.01 level and the percentage of correct predictions varies between 34.7 % and 81.6 %.

We first turn to the assessment of risks emanating from biotechnology and gene technology applications in food production (**BIOTECH**). In many of the estimations, the socio-economic variables are not significant. However, we keep them in all years to make a consistent comparison possible.

If the variable SEX is significant then its parameter is negative. Thus, male respondent seem to consider the risk from biotechnology as being less important. The same applies to the variable AGE. The fact of being the household head or household keeper does not seem to contribute much to the explanation of the individual risk assessment. The same applies to WORK1 and WORK2. The educational variables are often significant and suggest that the better educated (EDUC1-EDUC4) consider BIOTECH risks as more important. Increasing household size diminishes the likelihood of importance attributed to this type of risk whereas INCOME has a positive impact on the risk assessment.

The variables that assess the risk type by which the consumer can be described (ENVRISK, LIFESTYLE and FOODRISK) are very often positive and significant in the estimation. That is, people concerned about the environment, about the risks of modern life styles, and about risks posed by foods all consider biotechnology and genetically modified organisms as risky. Finally, the variable KNOW is also often significant. Interestingly, while the sign of this variable has been positive and significant in 1992, 1995, 1996, and 2000, it has become negative and significant in the spring of 2001 and in 2002. In the remaining three years, the parameter estimate was not significant. This suggests that while knowledge about food risks had increased the probability of a high BIOTECH score during the 1990s, the impact has turned into a negative one over the last three years.

We turn to the results of the model analysing the assessment of **chemical risks** in table 5. Income and education are the only socio-economic variables that significantly contribute in a coherent manner over the years to the explanation. Both increase the probability of a high score. The education variables are as before not always matched by parameters that suggest that continuously higher types of education will lead to a continuously higher probability. All risk types are again almost always significantly contributing to the explanation, making a higher assessment also for this risk more likely. However, the risk type with the largest parameter is almost always the one that describes the concern about food risks. The link to risk of modern life or environmental risks is much weaker. Also in the seven estimations, when it is significant, the knowledge variable has a positive sign.

Considering the risk caused by **nutritional behaviour** (the results are given in table 6), age has a positive and significant impact in two years. This reflects probably the fact that with age the risks of overweight and high cholesterol consumption become more important. Part-time work, on the other hand, decreases the risk assessment, maybe because respondent working partly are also working in the household. Income consistently has a negative impact up to 2000, where it turns positive. This may reflect that the health impact of unhealthy eating habits begins being recognized as an important public-health risk. The same change of sign is observed in the knowledge variable. The risk assessment correlates positive with the type of consumer being concerned about the risks of the modern way of life and negatively with the risk type being concerned about risks posed by foods & beverages. This indicates that those showing that they are concerned about food risks associate those more with risk coming from the food itself and not from what one is doing with that food.

The last model estimated concerns the risk from **natural contaminants**. Being the household head or household keeper (HHKEEP2) negatively influences the probability to give a high valuation to that risk. Those responsible in the household seem to be convinced that food handling is appropriate to

minimize the risk. Higher levels of education also diminish the probability to give a high evaluation. In comparison to the previous three models, higher levels of education seem to consistently lead to ever lower risk evaluations from EDUC1 to EDUC4.

Full-time participation in the labour market also reduces the assessment of risk as does income. The risk types are often significant in the explanation. However, people concerned about risks posed to the environment or risks of food and beverage consumption attribute lower importance to the risks from natural food contaminants. It is the consumer who is concerned about the risks caused by the modern way of life that attributes a higher score to the assessment of these risks. Knowledge again is highly significant in the explanation and the relation to the degree of importance is always positive. The general tendencies obtained from the ordered probit analyses are summarized in table 8.

Conclusions

In this paper we have analysed food risk perception using nine large cross sections of German consumers covering the eleven-year period from 1992 to 2002. According to our results from factor analysis, food risks are grouped into four different categories. Furthermore, we describe consumers by general risk attitude variables relating to environmental, lifestyle and food risks. Across food risk categories some consistent observations can be made. People concerned about risks to the environment are more likely to worry about the use of biotechnology and gene technology applications in food production. They are also more concerned about chemical contamination. They are, however, less concerned about natural contaminations of food. The environmental-risk type among consumers thus seems to better be able to cope with risks posed by natural contaminants and less with those that are posed by human interference with nature.

Consumers concerned about the risks stemming from modern lifestyles, on the other hand, are concerned about all four types of food risks. And those that indicate in a general question to be concerned about risks posed by food and beverages are more anxious about biotechnology and chemical risks and less about risks from natural contaminants or nutritional behaviour.

Regarding the parameter estimates for the socio-demographic variables, our results are somewhat contrary to those found in the literature. Sex, which has repeatedly been identified as a robust predictor of risk perceptions (Dosman et al., 2001; Boecker, 2002), is rarely significant in our models. However, our analyses show that income and education has a positive impact on the importance attributed to risk from biotechnology and chemical contamination. The relationship, however, is negative for natural contaminants.

In addition, we observe a new rise in concerns about food safety risks in 1995. This contrasts with the findings of von Alvensleben who shows a continuous decline in food safety concerns over the 1990s until 1997.

One contribution of this analysis is the inclusion of an indicator of knowledge about food safety risks. The results reveal the interesting aspect that knowledge has changed its impact on the assessment of risks from biotechnology over the years. This suggests that better consumer information may work and reduce the apprehension towards new technologies. However, concerning risks from chemical and natural contaminants the relation is positive. This might suggest that the causality between these variables is reversed. Those being concerned about these risks look for information about possible contaminants and are thus better informed.

This hypothesis may also explain why the sign of the parameter to KNOW in the model of nutritional risk has changed sign beginning in 2001. Concern about nutrition risks has reached a new dimension in the public-health discussion in Germany and is recognized by a different type of consumer. Further analyses should thus recognize the endogeneity of knowledge and use estimation methods that can take it into account. A method to test and to accommodate the possible endogeneity of explanatory variable in ordered probit models has been suggested by Pudney and Shields (2000).

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Table 1. Variable Definition

Name	Definition
Explanatory Variables	
SEX	0 = female, 1 = male
AGE	years
HHHEAD	=1 if respondent is household head, = 0 otherwise
HHKEEP1	=1 if respondent is also household keeper, = 0 otherwise
HHKEEP2	=1 if respondent is principal household keeper, = 0 otherwise
EDUC1	=1 if respondent has 10 years of school and professional training, = 0 otherwise
EDUC2	=1 if respondent has a middle school degree, = 0 otherwise
EDUC3	=1 if respondent has 13 years of schooling, = 0 otherwise
EDUC4	=1 if respondent has visited university, = 0 otherwise
WORK1	=1 works part-time, = 0 otherwise
WORK2	=1 works full-time, = 0 otherwise
HHSIZE	Number of persons living in the household
KIDS	= 1 if children under the age of 14 are living in the household, 0 otherwise
INCOME	Monthly household net income in DM: 1 = <999, 2 = 1000-1249 , 3 = 1250-1499, 4 = 1500-1749, 5 = 1750-2000, 6 = 2000-2249, 7 = 2250-2499, 8 = 2500-2749, 9 = 2750-2999, 10 = 3000-3499, 11 = 3500-3999, 12 = 4000-4499, 13 = 4500-4999, 14 = 5000-5999, 15 = 6000-10000, 16 = more than 10000
ENVRISK	Indicator variable if respondent considers environmental risks as important
LIFESTYLE	Indicator variable if respondent considers civilization risks as important
FOODRISK	=1 if respondent considers risks from food as important, 0 = otherwise
KNOW	% of food pathogens recognized.
Dependent Variables	
BIOTECH	Indicator variable if respondent considers risk from use of biotechnology and genetically modified organisms as important (integer variable of value between 0 and 2)
CHEM	Indicator variable if respondent considers risk from chemical residues in food as important (integer variable of value between 0 and 3)
NUTR	Indicator variable if respondent considers risk from nutritional behaviour as important (integer variable of value between 0 and 4)
NATURAL	Indicator variable if respondent considers risk from microbial contamination as important (Integer variable of value between 0 and 3)

Table 2. Summary Statistics

	1992	1995	1996	1997	1998	2000	2001-04	2001-11	2002
Number of Observations	2489	2615	2086	2245	2211	2195	1989	1940	2084
SEX	.501	0.466	0.456	0.447	0.454	0.433	0.430	0.450	0.419
	(.500)	(0.499)	(0.498)	(0.497)	(0.498)	(0.496)	(0.495)	(0.498)	(0.494)
AGE	42.212	45.265	44.779	43.654	43.323	45.728	46.136	46.212	45.299
	(17.164)	(17.071)	(17.638)	(16.661)	(17.011)	(17.618)	(17.355)	(17.421)	(16.980)
HHHEAD	.591	0.656	0.622	0.682	0.688	0.594	0.654	0.643	0.657
	(.492)	(0.475)	(0.485)	(0.466)	(0.463)	(0.491)	(0.476)	(0.479)	(0.475)
HHKEEP1	.207	0.195	0.163	0.203	0.200	0.137	0.171	0.194	0.178
	(.405)	(0.397)	(0.370)	(0.402)	0.400)	(0.344)	(0.377)	(0.395)	(0.382)
HHKEEP2	.538	0.603	0.647	0.682	0.631	0.638	0.640	0.629	0.651
	(.499)	(0.489)	(0.478)	(0.466)	(0.483)	(0.481)	(0.480)	(0.483)	(0.477)
EDUC1	.589	0.436	0.418	0.395	0.423	0.390	0.433	0.426	0.397
	(.492)	(0.496)	(0.493)	(0.489)	(0.494)	(0.488)	(0.496)	(0.495)	(0.489)
EDUC2	.051	0.228	0.281	0.302	0.296	0.329	0.315	0.321	0.350
	(.221)	(0.420)	(0.450)	(0.459)	(0.457)	(0.470)	(0.465)	(0.467)	(0.477)
EDUC3	.083	0.111	0.101	0.136	0.121	0.084	0.089	0.091	0.094
	(.276)	(0.315)	(0.301)	(0.343)	(0.326)	(0.277)	(0.286)	(0.288)	(0.292)
EDUC4	.038	0.078	0.065	0.075	0.075	0.064	0.058	0.072	0.063
	(.191)	(0.269)	(0.246)	(0.263)	(0.264)	(0.244)	(0.234)	(0.259)	(0.243)
WORK1	.082	0.087	0.098	0.105	0.114	0.118	0.115	0.127	0.127
	(.274)	(0.282)	(0.297)	(0.306)	(0.318)	(0.322)	(0.319)	(0.333)	(0.333)
WORK2	.464	0.510	0.499	0.499	0.536	0.474	0.472	0.479	0.472
	(.499)	(0.500)	(0.500)	(0.500)	(0.499)	(0.499)	(0.499)	(0.500)	(0.499)
HHSIZE	2.468	2.362	2.405	2.319	2.361	2.394	2.374	2.338	2.311
	(1.174)	(1.139)	(1.271)	(1.181)	(1.219)	(1.213)	(1.216)	(1.191)	(1.189)
KIDS	.233	0.249	0.239	0.261	0.163	0.235	0.232	0.231	0.221
	(.423)	(0.433)	(0.427)	(0.439)	(0.370)	(0.424)	(0.422)	(0.422)	(0.415)
INCOME	9.074	9.134	9.112	9.088	9.453	3.997	10.044	10.080	9.049
	(3.776)	(3.699)	(3.806)	(3.960)	(3.906)	(1.443)	(3.800)	(3.645)	(3.803)
ENVRISK	.994	1.078	0.907	0.882	0.939	0.911	0.782	0.729	0.821
	(.945)	(1.005)	(0.931)	(0.920)	(0.934)	(0.917)	(0.926)	(0.897)	(0.906)
LIFESTYLE	2.183	2.620	2.206	2.169	2.027	2.645	2.099	1.895	2.041
	(1.445)	(1.636)	(1.440)	(1.380)	(1.435)	(1.596)	(1.590)	(1.493)	(1.558)
FOODRISK	.275	0.361	0.358	0.304	0.272	0.259	0.482	0.294	0.417
	(.447)	(0.480)	(0.480)	(0.460)	(0.445)	(0.438)	(0.500)	(0.456)	(0.493)
KNOW	.155	0.132	0.119	0.970	0.054	0.123	0.143	0.094	0.100
	(.134)	(0.128)	(0.123)	(1.421)	(0.075)	(0.125)	(0.131)	(0.092)	(0.097)
BIOTECH	.261	0.516	0.500	0.286	0.343	0.507	0.232	0.214	0.211
	(.555)	(0.712)	(0.665)	(0.533)	(0.548)	(0.674)	(0.477)	(0.452)	(0.471)
CHEM	1.174	1.293	1.135	1.066	0.904	1.210	1.135	1.055	1.147
	(.923)	(0.947)	(0.858)	(0.832)	(0.801)	(0.895)	(0.832)	(0.862)	(0.852)
NUTR	.736	0.793	0.558	0.351	0.479	0.590	0.352	0.414	0.341
	(.915)	(1.010)	(0.840)	(0.597)	(0.699)	(0.890)	(0.593)	(0.652)	(0.601)
NATURAL	1.021	0.879	0.778	0.789	0.662	0.974	0.749	0.725	0.754
	(.911)	(0.938)	(0.855)	(0.777)	(0.727)	(0.906)	(0.755)	(0.758)	(0.783)

Table 3. Development of Risk Assessments

	1992	1995	1996	1997	1998	2000	2001-04	2001-11	2002
ENVRISK	0.994	1.078	0.907	0.882	0.939	0.911	0.782	0.782	0.821
LIFESTYLE	2.183	2.620	2.206	2.169	2.027	2.645	2.099	2.099	2.041
FOODRISK	0.275	0.361	0.358	0.304	0.272	0.259	0.482	0.482	0.417
BIOTECH	0.261	0.516	0.500	0.286	0.343	0.507	0.232	0.232	0.211
CHEMICAL	1.174	1.293	1.135	1.066	0.904	1.210	1.135	1.135	1.147
NUTRITIONAL	0.736	0.793	0.558	0.351	0.479	0.590	0.352	0.352	0.341
NATURAL CONT.	1.021	0.879	0.778	0.789	0.662	0.974	0.749	0.749	0.754

Table 4. Results of Biotechnology Risk Model Estimates[a]

	1992		1995		1996		1997		1998		2000		2001-04		2001-11		2002	
Constant	-1.116	***	-0.933	***	-0.551	**	-0.783	***	-0.768	***	-0.714	***	-0.826	***	-1.010	***	-0.465	*
SEX	-0.057		0.055		-0.140	*	0.059		-0.141	*	-0.153	*	0.031		0.040		-0.174	*
AGE	-0.003		-0.001		-0.003		-0.006	**	-0.002		0.000		-0.004		-0.007	**	-0.011	***
HHHEAD	0.000		0.028		0.062		-0.061		0.074		0.013		0.093		0.031		0.111	
HHKEEP1	0.146		-0.034		0.155		0.246	**	-0.039		-0.037		-0.016		0.031		0.176	
HHKEEP2	0.051		0.039		0.078		0.002		-0.134		-0.058		-0.046		-0.014		0.062	
EDUC1	0.104		0.031		0.192	**	0.360	***	-0.101		0.135		-0.117		0.314	**	-0.062	
EDUC2	0.025		0.017		0.166	*	0.667	***	-0.005		0.156	*	0.053		0.306	**	-0.023	
EDUC3	0.072		0.007		0.037		0.583	***	0.047		0.261	**	-0.172		0.431	**	-0.009	
EDUC4	0.450	***	0.148		-0.019		0.618	***	0.144		0.285	**	-0.090		0.311	*	0.172	
WORK1	0.234	**	0.040		0.007		0.034		0.064		-0.070		0.159		0.037		-0.144	
WORK2	-0.046		0.109		-0.033		-0.149	*	0.099		0.081		-0.109		-0.032		-0.238	**
HHSIZE	-0.109	**	-0.011		0.052		-0.159	***	-0.082	**	0.048		-0.014		-0.082	*	-0.055	
KIDS	0.084		-0.047		-0.213	**	0.292	***	0.227	**	-0.132		-0.034		0.125		-0.030	
INCOME	0.023	**	0.003		-0.010		0.018	*	0.036	***	-0.011		0.018		0.027	**	0.031	***
ENVRISK	0.098	***	0.157	***	0.070	**	0.081	**	0.178	***	0.145	***	0.084	**	-0.053		0.161	***
LIFESTYLE	0.045	**	0.057	***	0.045	**	-0.030		-0.023		0.067	***	0.010		0.058	**	0.003	
FOODRISK	0.139	**	0.098	*	0.058		0.029		0.290	***	0.060		0.305	***	0.036		0.039	
KNOW	0.570	***	1.323	***	0.796	***	0.009		0.182		0.749	***	-1.057	***	-0.574		-1.866	***
Mu(1)	0.792	***	0.887	***	1.086	***	1.115	***	1.346	***	1.071	***	1.186	***	1.262	***	1.040	***
% right pred.	79.85		62.34		60.30		75.37		69.13		59.64		79.24		80.22		81.64	
Log Likelihood	-1408.7		-2127.4		-1684.9		-1398.2		-1494.9		-1927.9		-1131.7		-1033.8		-1084.2	
Chi-Square	84.386		250.061		53.016		105.4		129.264		109.661		69.420		40.520		80.383	

[a] One, two and three asterisks indicate significance at the 0.1, 0.05 and 0.01 level.

Table 5. Results of Chemical Risk Model Estimates[a]

	1992		1995		1996		1997		1998		2000		2001-04		2001-11		2002	
Constant	0.317	*	-0.010		-0.156		0.355	*	-0.100		-0.259		0.113		-0.176		-0.321	
SEX	-0.022		-0.021		-0.050		-0.054		0.043		0.018		-0.050		0.015		0.068	
AGE	-0.005	***	0.003		-0.001		0.000		-0.002		0.001		0.000		0.003		0.004	*
HHHEAD	0.016		-0.111		0.140	*	-0.028		0.020		0.100		0.004		-0.045		0.028	
HHKEEP1	-0.069		0.089		-0.010		-0.098		-0.032		0.098		-0.021		0.038		0.159	*
HHKEEP2	-0.007		-0.012		0.016		-0.012		0.030		0.133		-0.052		-0.034		0.141	
EDUC1	0.027		0.191	***	0.124		-0.135		0.141		-0.014		0.271	***	0.208	**	0.047	
EDUC2	0.033		0.176	**	0.092		-0.051		0.147		0.014		0.269	***	0.171	*	0.212	**
EDUC3	0.295	***	0.174	*	0.173		0.140		0.386	***	0.158		0.271	**	0.389	***	0.088	
EDUC4	0.143		0.221	**	0.172		-0.138		0.079		0.214	*	0.389	***	0.189		0.095	
WORK1	0.074		0.182	**	-0.079		0.040		0.033		0.083		0.091		0.079		0.024	
WORK2	0.026		0.232	***	-0.080		0.107		-0.126	*	0.022		0.018		0.056		-0.047	
HHSIZE	-0.043		-0.044		0.053		-0.056	*	0.004		0.050		-0.007		-0.035		0.003	
KIDS	-0.004		0.078		-0.017		-0.011		0.018		-0.196	**	0.010		0.186	**	0.021	
INCOME	0.013		-0.007		0.020	**	0.018	**	0.016	*	0.012		0.003		0.005		0.018	**
ENVRISK	0.115	***	0.138	***	0.163	***	0.089	***	0.088	***	0.076	***	0.149	***	0.155	***	0.027	
LIFESTYLE	0.072	***	0.091	***	0.106	***	0.038	**	0.053	***	0.081	***	-0.001		0.050	***	0.046	***
FOODRISK	0.254	***	0.074		0.238	***	0.428	***	0.293	***	0.178	***	0.327	***	0.340	***	0.498	***
KNOW	0.921	***	1.378	***	0.271		0.031	*	-0.024		1.639	***	0.707	***	1.061	***	1.392	***
Mu(1)	1.086	***	1.043	***	1.232	***	1.180	***	1.138	***	1.036	***	1.193	***	1.079	***	1.200	***
Mu(2)	2.059	***	2.030	***	2.362	***	2.459	***	2.479	***			2.481	***	2.308	***	2.439	***
% right pred.	39.28		38.07		44.16		42.51		45.54		39.54		44.14		42.42		42.60	
Log Likelihood	-2900.3		-3083.7		-2272.3		-2526.8		-2393.1		-2671.4		-2326.7		-1033.8		-2368.5	
Chi-Square	76.634		250.061		151.619		156.766		108.832		212.566		143.664		40.520		203.477	

[a] One, two and three asterisks indicate significance at the 0.1, 0.05 and 0.01 level.

Table 6. Results of Nutrition Behaviour Risk Model Estimates[a]

	1992		1995		1996		1997		1998		2000		2001-04		2001-11		2002	
Constant	-0.400	**	-0.429	**	-0.667	***	-0.562	**	-0.552	**	-0.622	***	-0.519	**	-0.519	**	-0.587	**
SEX	0.053		0.110		0.019		-0.063		0.013		0.055		-0.021		-0.021		-0.096	
AGE	0.004	**	0.001		-0.002		0.002		0.007	***	-0.001		0.002		0.002		-0.003	
HHHEAD	-0.161	**	-0.068		0.033		0.027		-0.039		0.048		-0.004		-0.004		0.031	
HHKEEP1	0.159	**	-0.015		0.134		0.209	**	0.175	**	0.041		-0.135		-0.135		-0.058	
HHKEEP2	0.012		0.043		0.086		-0.039		0.096		0.045		-0.019		-0.019		-0.143	
EDUC1	0.030		0.008		0.083		0.036		-0.110		0.039		-0.129		-0.129		0.195	*
EDUC2	-0.068		-0.179	**	0.033		-0.090		-0.038		0.015		-0.060		-0.060		0.013	
EDUC3	0.139		-0.133		0.024		0.047		-0.137		0.136		-0.168		-0.168		0.360	***
EDUC4	0.101		-0.072		-0.191		0.053		0.052		-0.357	***	-0.195		-0.195		0.412	***
WORK1	-0.195	**	0.157		0.000		-0.056		0.149		-0.167	*	-0.049		-0.049		-0.188	*
WORK2	-0.018		0.023		0.041		-0.022		0.132		-0.063		0.060		0.060		-0.140	
HHSIZE	0.032		0.020		0.067	*	0.051		-0.011		0.025		-0.022		-0.022		-0.011	
KIDS	0.000		-0.102		-0.118		-0.096		-0.057		-0.073		-0.043		-0.043		0.093	
INCOME	-0.009		-0.022	***	-0.006		-0.006		-0.007		-0.016	*	0.028	**	0.028	**	0.029	***
ENVRISK	-0.027		0.068	***	0.029		-0.037		-0.080	**	0.045		-0.026		-0.026		-0.063	*
LIFESTYLE	0.097	***	0.134	***	0.093	***	-0.009		0.019		0.068	***	0.039	*	0.039	*	0.070	***
FOODRISK	-0.102	*	-0.002		-0.137	**	-0.142	**	-0.226	***	-0.040		-0.094		-0.094		-0.157	***
KNOW	0.723	***	0.997	***	0.514	**	0.002		0.395		1.973	***	-1.120	***	-1.120	***	-0.592	
Mu(1)	0.927	***	0.863	***	0.922	***	1.013	***	0.999	***	0.865	***	1.070	***	1.070	***	1.110	***
Mu(2)	1.691	***	1.547	***	1.662	***	2.304	***	1.987	***	1.497	***	1.891	***	1.891	***	1.873	***
Mu(3)	2.228	***	2.035	***	2.026	***					2.061	***						
% right pred.	49.81		49.86		60.61		71.09		62.49		60.87		70.64		66.28		71.45	
Log Likelihood	-2661.6		-2849.8		-1899.9		-1634.2		-1922.7		-2200.3		-1493.9		-1571.4		-1488.159	
Chi-Square	76.634		180.235		53.217		31.843		58.989		164.111		31.382		33.410		64.384	

[a] One, two and three asterisks indicate significance at the 0.1, 0.05 and 0.01 level.

Table 7. Results of Natural Contaminants Risk Model Estimates[a]

	1992		1995		1996		1997		1998		2000		2001-04		2001-11		2002	
Constant	-0.308	*	-0.279		0.248		0.024		0.234		0.312	*	0.268		-0.076		0.366	*
SEX	0.007		0.086		0.082		0.015		-0.019		0.031		-0.024		-0.055		-0.104	
AGE	0.007	***	0.003		0.000		0.003		0.003		0.002		0.000		0.002		0.004	**
HHHEAD	-0.104		-0.070		-0.089		0.006		-0.093		-0.115		-0.149	*	0.025		-0.178	**
HHKEEP1	-0.094		0.007		0.108		-0.125		-0.091		0.000		0.087		0.026		-0.105	
HHKEEP2	0.061		0.028		0.030		0.003		-0.153	*	-0.055		-0.038		0.023		-0.221	**
EDUC1	0.027		-0.160	**	-0.176	**	-0.016		-0.058		-0.017		0.113		-0.022		-0.210	**
EDUC2	-0.083		-0.358	***	-0.149	*	-0.241	**	-0.131		-0.033		-0.110		-0.034		-0.194	**
EDUC3	-0.157		-0.456	***	-0.291	***	-0.435	***	-0.365	***	-0.179		-0.030		-0.036		-0.191	
EDUC4	-0.255	*	-0.278	**	-0.298	**	-0.213	*	-0.329	**	-0.527	***	-0.143		0.067		-0.457	***
WORK1	0.016		-0.022		-0.108		0.058		-0.085		-0.100		-0.281	***	0.021		0.050	
WORK2	0.046		-0.041		-0.148	*	-0.040		-0.006		-0.024		-0.206	**	-0.191	**	0.058	
HHSIZE	0.022		0.062	*	0.012		0.114	***	0.032		-0.087	**	-0.035		0.026		0.060	
KIDS	0.002		-0.056		-0.025		-0.179	**	0.006		0.172	**	0.092		-0.161	*	-0.053	
INCOME	0.007		-0.025	***	-0.019	**	-0.026	***	-0.031	***	-0.013		-0.008		-0.014		-0.039	***
ENVRISK	0.009		-0.038		-0.027		-0.077	***	-0.084	***	-0.028		-0.076	**	0.017		-0.043	
LIFESTYLE	0.119	***	0.178	***	0.060	***	0.173	***	0.153	***	0.082	***	0.121	***	0.114	***	0.120	***
FOODRISK	0.042		-0.039		0.002		-0.130	**	-0.141	**	0.007		-0.181	***	-0.144	**	-0.143	***
KNOW	0.607	***	2.065	***	1.110	***	0.008		0.826	**	2.229	***	1.233	***	1.563	***	1.345	***
Mu(1)	0.955	***	0.969	***	0.949	***	1.096	***	1.156	***	1.032	***	1.119	***	1.140	***	1.041	***
Mu(2)	2.056	***	1.769	***	1.917	***	2.648	***	2.685	***	2.009	***	2.856	***	2.497	***	2.617	***
% right pred.	39.24		34.68		47.79		46.88		51.28		41.78		47.61		47.30		47.50	
Log Likelihood	-2858.7		-2813.6		-2163.9		-2289.9		-2117.6		-2605.1		-2041.1		-1949.0		-2116.2	
Chi-Square	121.601		327.1		65.580		171.320		115.209		219.500		141.109		110.421		134.371	

[a] One, two and three asterisks indicate significance at the 0.1, 0.05 and 0.01 level.

Table 8. Summary of Impacts identified in the Ordered Probit Analysis

	Biotech	Chemical	Nutritional	Natural
SEX	–			
AGE	–		+	
HHHEAD				–
HHKEEP1			+	
HHKEEP2				–
EDUC1	+	+		–
EDUC2	+	+		–
EDUC3	+	+		–
EDUC4	+	+		–
WORK1			–	
WORK2				–
HHSIZE	–			
KIDS				
INCOME	+	+	– → +	–
ENVRISK	+	+		–
LIFESTYLE	+	+	+	+
FOODRISK	+	+	–	–
KNOW	+ → –	+	+ → –	+

Figure 1. Rotated Factor Analysis – Health Risk Categories

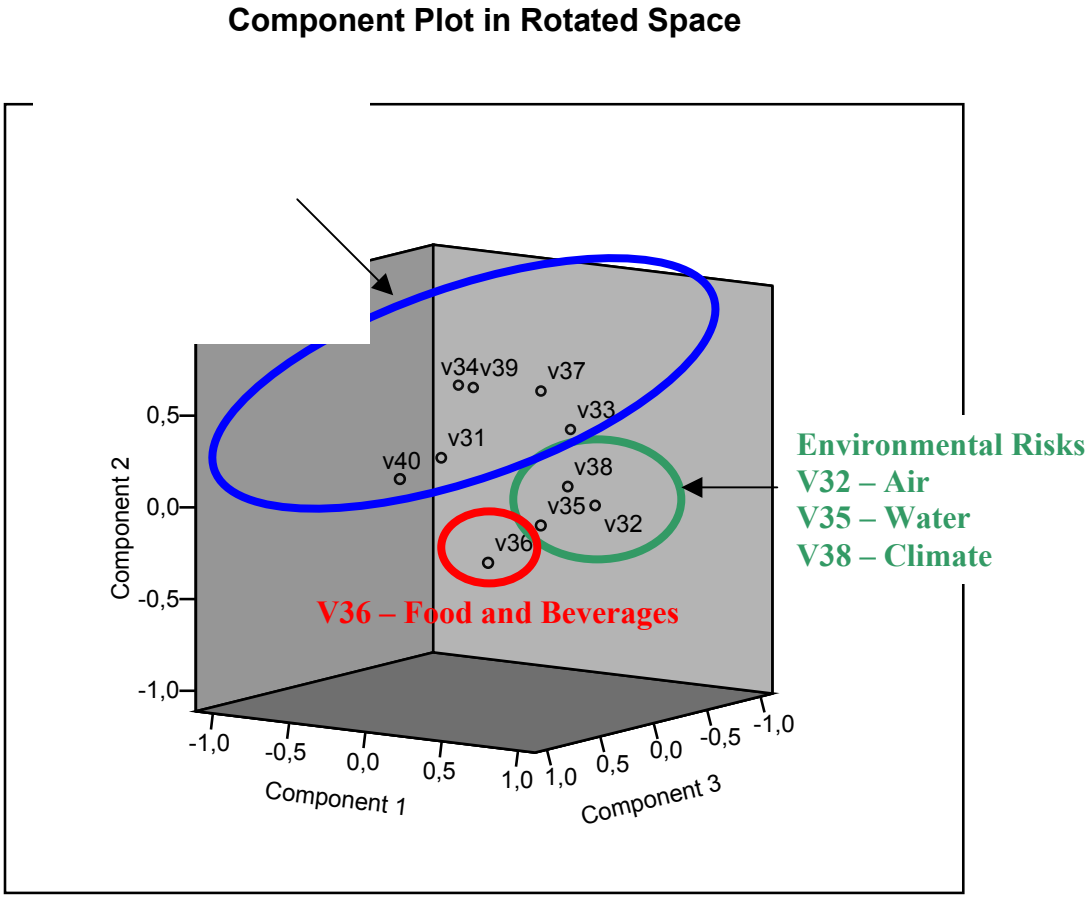
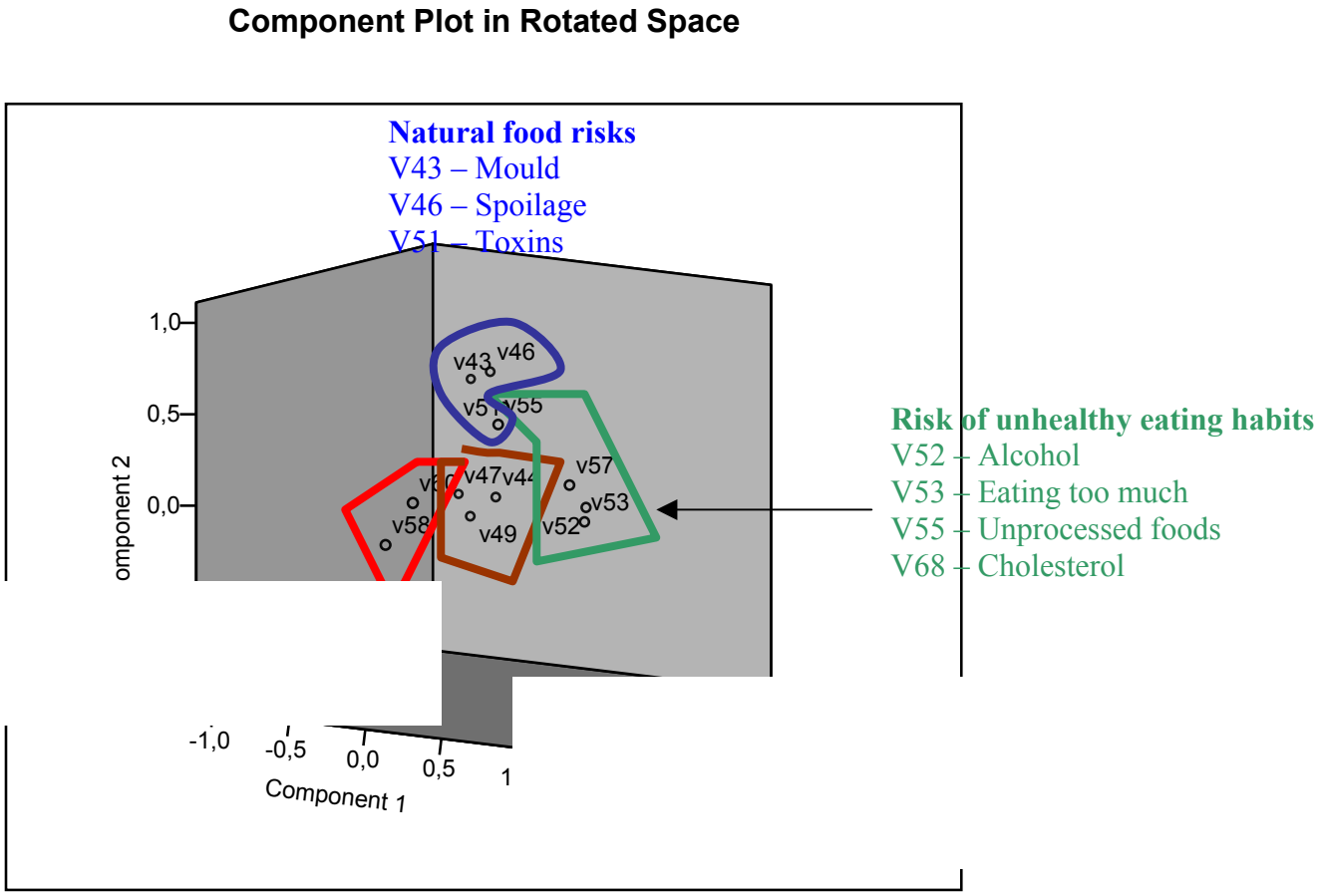
Figure 2. Rotated Factor Analysis – Food Risk Categories