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# FOOD RISK PERCEPTIONS BY DIFFERENT CONSUMER GROUPS IN GERMANY[1]

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## Abstract

This paper presents an analysis of the changing food risk perceptions of German consumers over the period 1992 to 2002. We analyse the respondents' general risk attitudes and their specific perceptions of food risks. Using cluster analysis we generate a typology of four consumer types. One group is worried about natural food risks, the second does not worry about any types of food risks, the third is concerned about technical food risks and the fourth is concerned about all food risks. A multinomial logit analysis identifies factors that describe the classification of households in this grouping. General risk attitudes and knowledge about food risk are significant variables in the explanation.

Key words: cluster analysis, food safety, multinomial logit, risk perceptions, risk typology.

JEL. Classification: C24, D12, D18

## 1. Introduction

The 1990s were characterised by a large number of severe food safety crises. It is suggested that these have changed consumers' perceptions of food safety and risks in response. While large technical catastrophes were in the midst of attention after Seveso, Three Miles Island, Bhopal and Chernobyl in the 1970s and 1980s, with BSE and the advent of GM foods the risks of human technical advances upon nature have intruded our plates in the 1990s. 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 showed that the concern about food safety is particularly severe in Germany (e.g. von Alvensleben, 1999). Based on data from the Food Marketing Institute he 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 show that concern about food was highest during the second half of the 1980s and declined since then up to 1997 (von Alvensleben, 1999).

The research presented in this paper tries to improve our understanding of food risk perceptions of German consumers. To achieve this objective we pose our analysis at multiple levels. First, we develop a typology of consumers according to their food risk perceptions. We identify four clusters of consumers according to the food risks they are concerned about. We look at the development of these food risk groupings over time in order to see how food risk perceptions have changed between 1992 and 2002.

Furthermore, we are interested in identifying factors influencing the likelihood that consumers belong to any of these food risk perception groups. For one, we follow the literature on food risk perceptions and consider socio-economic factors explaining the perception of food risks. Secondly, we pose and analyse the hypothesis that consumers' perception of *food risks* is influenced by their *more general perception* of environmental and health risks. Thus we form a second consumer typology according to consumers' perception of these latter risks. As a last aspect, we consider the impact of consumers' knowledge about food risks on their perception of these risks.

We base our analysis on a series of cross-section data sets of German consumers covering the period from 1992 to 2002. 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 1900-2500 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 paper is structured as follows. After this introduction, we first give an overview of the literature on food and health risk perceptions. The following section of the paper presents the data and methods used in the analysis. Finally, we present the results of our empirical investigation. We conclude on the impliciations of our findings for German food policy.

## 2. Food risk perceptions

People have a broad conception of risk that is qualitative and complex (Slovic, 2000). In research on risk perception it has become apparent that a purely technical description of risks based only on the probability of occurrence and the severity of outcome is too narrow to understand individual risk perceptions. Starting with Starr's (1969) analysis on revealed preferences, much attention has focused on the characterization of risk through psychonometric scaling and factor analysis. For example Slovic analysed in his early work how attributes of risks influence risk perception (for a summary of this work see Slovic 1987). His results demonstrate the important role of social values in risk perception and risk acceptance. People rank risks according to technical, social and psychological qualities that are not well modelled in technical risk assessments such as uncertainty in risk assessments, perceived inequity in the distribution of risks and benefits and involuntary exposure to risks not under ones control or dreaded (Slovic 1993). In later work, looking at the cultural aspects of risk perception, he and his co-authors find that socioeconomic characteristics, voting behaviour and the level of knowledge can influence an individuals' perception of health risks (Flynn et al. 1994). In addition, it is recognized that trust plays an important role in the risk perception problem (Slovic 1993). Slovic (1993) concludes that a broader perspective including the complex mix of scientific, social, political, legal, institutional and psychological factors operating within society's risk management is necessary.

From its early stage, the risk perception literature was also concerned with food risks. Indeed, since Rachel Carson (1962) published her book *Silent Spring* pesticides have figured high in public discussions surrounding the US risk-management agenda (Reichelderfer & Hinkle, 1989). With the European rejection of genetic modified (GM) foods and the advent of BSE, as well as a number of other food safety crises,

researchers have become increasingly interested in understanding the dynamics of risk perception regarding food.

For food, psychometric results similar to those of Slovic (1987) on general health risks could be replicated. Sparks & Shepherd (1994) identify three principal components that explained most of variation in risk perception: severity, unknowness and number of people exposed. Similar results have been replicated by Fife-Schaw & Rowe (1996) and Kirk et al. (2002). Fife-Schaw & Rowe (1996) find close proximity of risk perception for growth hormones in animal production and pesticides and different microbiological hazards. It has been found that public acceptance of food risks is driven by perceptions of personal benefits (Frewer, 2003). Of particular relevance to food choice are the perceptions of risk and benefits associated with consuming certain foods (Frewer & Miles, 2001). As with other risks, the acceptance of food risks is driven by trust, where it is necessary to distinguish between trust in institutions (societal trust) and trust in information and information sources (source credibility) – for a review see Frewer (2003).

Research has been conducted in order to understand demographic differences in risk perception regarding food. For the UK, Frewer (1999) has analysed demographic aspects of risk perception and preference for public involvement in risk management. Results indicate that women, members of certain ethnic minorities and poorer people are more concerned about food risks and express greater preferences for public involvement in the risk management process. The author attributes this to a feeling of exclusion from the risk management process for these groups and their vulnerability to these risks. Hunt & Frewer (2001) find a large preference for the labelling of genetically modified food in the UK and link this preference to the desire of control over exposure to GM food.

In Canada, Dosman et al. (2001) analyse the impact of socioeconomic determinants of health and food safety related risk perceptions based on surveys of 959 households in 1994 and 953 households in 1995. They analyse risk perceptions related to bacteria, additives and pesticides in food. Their results indicate that variables such as household income, number of children, gender, age and voting preferences were strong predictors of an individual's risk perception. However, it also turns out that gender is the only variable that yields consistent results across all three classes of risks and across both years.

Nayga (1996) analyses the influence of socio-demographic factors on consumers' concern for food risks posed by technologies such as irradiation, antibiotics, hormones and pesticides. He finds that females in non-metro areas with high levels of education and income are most concerned. These results, however, cannot be

generalised to all types of food risks, as Frewer et al. (1998) find that technical hazards are highly differentiated from lifestyle hazards, in terms of both hazard control and knowledge about the hazard.

Siegrist (2003) analyses consumers' assessment of different food hazards in Switzerland. In a principal component analysis he identifies two components. Food risks that can be classified as natural hazards (e.g. cholesterol in food, listeria in cheese, salmonella in poultry and eggs) load high on the first component. Other hazards like food irradiation, antibiotics, gene technology and heavy metals in fish are associated with modern technologies and load high on the second component. It is interesting to note that mad cow disease loaded much higher on the first (natural risk) than on the second component (technical risk). Results also indicate that a negative attitude towards technology increases the perception of technical food risks. Women are found to perceive food risks as more severe, and this applies to natural and technical food risks alike. People holding left-wing political opinions perceive technological food risks somewhat higher than right-wing people. And subjects of lower socio-economic status perceive somewhat more dangers than wealthier people.

While our study is closely related to those explaining food risk perception as a function of socio-economic variables such as Dosman et al. (2001), Frewer (1999) or Siegrist (2003), 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 broad and detailed range of risks. In consequence, we construct a typology of consumers according to food risk perceptions. In addition, we describe individuals by their general risk perceptions of general environmental/health risks.

Such a risk typology of consumers based on their perception of environmental/health risks appears highly relevant to our analysis because of arguments that can be found in the literature on 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 & Menning (1999) use a pragmatic approach to classify different environmental ethical systems by survey methods. Grimsrud & 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.

We pose the hypothesis that such ethical systems are also relevant regarding risk perceptions. 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. We argue that not only the type of risk determines how consumers perceive risks, but also their own view and believe system of what type of risk is acceptable on a broader basis. We model this wider believe system based on consumers' perception on environmental / health risks and analyse, in addition to the effects of socio-demographics, its influence on consumers' perception of food risks. Our empirical results thus present a test of this hypothesis.

## 3. Data and methods

We base our analysis on a data set covering annual cross-sections of about 1900 to 2500 consumers in Germany during the period from 1992 to 2002. Samples were drawn independently in every year, therefor a panel structure cannot be established. The survey instrument consisted of four sections. In the first section, consumers were asked about their assessment of environmental and health 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. A list of the risks evaluated in the first and second section of the survey is provided in Table 1. In a third section, consumers were asked about their knowledge of several food risks and food 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 and therefore the datasets have been homogenized to assure consistency.[1] Nevertheless, vital information was not collected in some years, so that we concentrate our analysis on the years 1992, 1995-1996, 1998 and 2000-2002. During 2000, increasing evidence suggested a link between BSE and the human new-variant Creutzfeldt-Jakob disease (nvCJD). In November of that year 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. Following this crisis, it was decided 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 all other years, the survey was conducted in November.

[1] This homogenization mostly concerned redefining categories of categorical variables.

In the survey, subjects could indicate on a binary scale if they consider a given risk as important or not. Although a binary scale can only convey limited information, it has the advantage that it prompts the respondent to make a clear statement about being concerned or not. In addition, it speeds up the filling of the questionnaire, so that a large number of risks could be considered in the survey. We use this information to construct two consumer typologies according to their perceptions of environmental /health risks and food risks.

### *3.1 Cluster analysis of households according to their assessment of environmental/health risks and food risks*

The data set contains information about the assessment of both environmental/health and food related risks. The questions posed and the risks evaluated are shown in Table 1. Two of these were not asked consistently. For "unbalanced diet" the questionnaire mentioned this risk only until 1995 and used the expression "too much food" from then on. Similarly, the questionnaire asked about risks from "pesticides" up to 1996, in later years, the question referred only in generic terms to residues in food. We consider these two pairs as synonymous in the subsequent analysis.[2]

To reveal clusters of risk assessment groups concerning environmental/health and food risk categories, respectively, the households were clustered according to the above mentioned ten and twelve assessment criteria. We carried out the cluster analysis with the data set jointly, that means that we pooled all eight available datasets. The applied type of classification is the K-means-cluster-analysis appropriate for large data stets. It is similar to the hierarchic classification, but both the number of clusters and temporary cluster centres have to be fixed in advance. Final cluster centres are determined by an iterative procedure where classification is done by linkage based on Euclidian distances between single cases and the temporary cluster centres (see Godehardt, 1990). The number of clusters has been specified based on the interpretability of the results. Specifically, we attempted the analysis varying the number of predetermined clusters between two and six. Regarding the interpretability of the results, four clusters gave the most appropriate solution in both cases.

[2] It is not possible to assess if this synonymous treatment is really appropriate. A comparison of the shares of consumers concerned about these risks before and after the question reformulation shows significant differences. However, the assessment may have shifted over time which may explain these differences. We assume that the formulations are semantically sufficiently close to justify such a synonymous treatment.

*Multinominal Logit Model*

The cluster analysis groups consumers and their food risk perceptions into four different risk types. In a second step, we estimate a multinomial logit model to identify the determinants of this grouping of food risk perceptions. The multinomial logit model is appropriate to explain choices based on individual-specific, as opposed to choice-specific, data (Greene, 2000, pp. 875-879).

We label the clusters of consumers according to their *food risk* perception as $j = 0,1,2,3$. The multinomial logit model then estimates the probability for individual *i* to belong to cluster *j* as

$$(1) \qquad \Pr(Y_i = j) = \frac{e^{\beta_j' x_i}}{\sum_{k=0}^{3} e^{\beta_j' x_i}} \qquad j = 0,1,2,3$$

The clusters are explained based on the individual-specific explanatory variables $x_i$ for each cluster, so that a vector of estimated parameters results for each cluster $j = 1,2,3$.[3] The estimation is done by maximization of the likelihood function.

The coefficients of the model are difficult to interpret. We thus chose to not report the estimated parameters but the marginal effects of each explanatory variable that results as

$$(2) \qquad \boldsymbol{\delta}_j = \partial \Pr_j / \partial \mathbf{x} = \Pr_j \left( \boldsymbol{\beta}_j - \overline{\boldsymbol{\beta}} \right)$$

where $\overline{\boldsymbol{\beta}} = \sum_{j=0}^{3} \Pr_j \boldsymbol{\beta}_j$. It is evident that neither the magnitude nor the sign of the marginal effects need to be equal to that of the estimated coefficients.

The explanatory variables considered in the model are listed and defined in Table 2: The gender and age of the respondent, if the household is located in formerly Eastern Germany, the size of the city where the household lives, the question if the respondent participates in household keeping and is the head of the household, the educational attainment measured in dummy variables (medium education if at least ten years of schooling and higher education if respondent attended university; both variables equal zero if the respondent had less than 10 years of formal schooling), if the respondent is employed, the size of the household, if there are kids under the age of 14 living in the household and monthly household net income.

[3] Because of identification, no parameter vector is estimated for $j = 0$.

We also include a variable that measures the respondent's knowledge about food-related risks. In the questionnaire, respondents could indicate the food pathogens they had heard about. Since the number and type of pathogens varied in each and every year, we constructed the variable "knowledge" as the part in total knowledge responses possible. Thus, a respondent could obtain a maximum score of 1, when he/she had heard about all pathogens and received a score of zero if he/ she hadn't heard of any. We use a time trend (T) and the time trend in quadratic form ($T^2$) to allow for changing food risk perception groupings over time.

Finally, we also include the risk type of the respondent revealed in the cluster analysis regarding environmental/health risks: The resulting groups are a first cluster that is concerned about radioactivity, a second cluster that is concerned about civilization risks, and a third being concerned about all types of risks. As these clusters are modeled using dummy variables we defined the baseline cluster as the fourth group of respondents not concerned about any type of environmental / health risks. Summary statistics of the explanatory variables over the eight yearly samples and the entire sample are provided in Table 3.

We use these explanatory variables in the explanation of the perception of food risks. The categories of the latter, the dependent variable in the multinomial model, are a cluster of people concerned about natural food risks, about no food risks, about technical food risks and about all food risks. The choice of these clusters, as well as the clusters of consumers according to their perception of environmental /health risks, is motivated in the results section regarding cluster analysis.

## 4. Results

### *4. 1 Cluster Analysis*

With respect to the environmental/health classification the following four clusters resulted: The first household group assesses no risk as important (35.7% of the entire sample over all years are in this group), for the second group of households the risk of radioactivity is most important (31.1%), for the third radioactivity, cigarettes and job-related stress (18.4 %) and for the fourth household group all risks are important (14.8%).

Table 4 helps in the interpretation of the formed clusters. The share of respondents being concerned about a particular environmental/ health risk group is shown for each of the four clusters. It appears that German consumers are still highly concerned about radioactivity. 55.7 % of the total sample said to worry

about this issue, which explains that radioactivity is such a dominant theme in the cluster analysis: it appears in two of the identified clusters. Concern about radioactivity may be an issue of particular importance in Germany, because of Chernobyl and the political discussion about nuclear weapons in the 1980s. Indeed the abandonment of nuclear energy has been a long standing demand of the German Greens and in 2002, the German government has decided the phasing out of all nuclear electric power stations. To say it in the terms of Slovic, the risk of radioactivity may symbolically stand for a non-controllable, involuntary and dreaded risk.

As for the cluster not being concerned about any risk, Table 4 makes evident, that no particular issue is raised in a systematic manner. In the cluster of people concerned about all risks many of the risks are mentioned by more than 75% of respondents in the group.

Although radioactivity figures high in the second and third cluster, both are kept as separate clusters. This is because in the first group, radioactivity stands out as the most important risk. The third cluster of consumers is quite different. Not only radioactivity figures high in the concern, but also job-related stress, risk from cigarettes and even noise. This pattern suggests that this group of respondents is concerned about risks posed by the "modern way of life" and in the following we will hence refer to this cluster as the cluster being concerned about *civilization risks*. The last cluster consists of consumers who consider all environmental/health risks as being of concern. These may be the 15% of "worried" people who are concerned about everything.

Concerning the food related risks another four groups are identified (Table 5). The first household group assesses moulds as most important (34.9% of the entire sample), the second group is not worried about any risks (30.1%), the third household group assesses residues from pesticides and growth hormones as most important (29.7%) and the fourth group is worried about all food risks (5%).

The evaluation of each food risk by these clusters is also shown in Table 5. In the first cluster moulds are of high concern but also spoiled foods figure relatively highly in this group. We thus name this first cluster respondents being concerned about *natural food risks*. The second cluster consists of people not being concerned about any particular type of risk. In the third cluster we find people who are more than average concerned about pesticides (100%), growth hormones (50.2%) and also slightly more than average concerned about food additives (26.4%) and genetic modification (25.3%). This cluster may be interpreted as the type of people who are concerned about *technical risks* in food production. Concern over and

resistance to food technology in Europe has been well documented (Frewer, 1999) and is a common concern in the discussion of gene technology in food production or industrialized agriculture.

Finally, we identify a fourth cluster of people who are concerned about all types of food risks. Only risks from unprocessed food are not as highly evaluated as all the other potential risks by this group, but still relatively high in comparison to the rest of the sample.

Table 5 also shows the importance attributed by German consumers to residues from pesticides (49.4% of the overall sample consider this as a significant risk) and growth hormones (39.1%). Almost half of the sample considers these as issues of concern. Maybe somewhat surprising is the fact that consumers seem to be almost equally concerned about moulds (39.6%). But as made evident by the cluster analysis, the people concerned about moulds are different from those who worry about pesticides residues. In this first cluster "natural risks", people concerned about moulds but also about spoiled food are overrepresented in comparison to the entire sample. It thus seems suitable to refer to this first cluster as the group of people being concerned about natural food risks and to the third as the group concerned about technical risks. Such a grouping concurs with the results found by Siegrist (2003).

Figure 1 and 2 show how the shares of households in different clusters changed in the period from 1992 to 2002. With respect to the environmental/health risk groups it is obvious that the shares of households in each group do not change much over the years. Figure 1 indicates that the group "no risks" gains in importance and the group "all risks" declines. Also the worry about radioactivity decreases as time passes after the Chernobyl catastrophe of 1986. Using a linear time trend to explain the percentage of these groups, we only find a significant effect for the cluster being concerned about radioactivity. The parameter to the linear time trend is -0.681 (Std. Error = 0.287) and significant at the 5% level.[4]

Regarding the food related risk groups, Figure 2 shows that the importance of the group "all food risks" decreased over time. Simultaneously the worry about "natural food risks" increases. The linear time trend parameter to the latter is 0.819 (Std. Error = 0.355) and significant at the 5% level, while the linear time trend parameter to the former equals -1.099 (Std. Error=0.407) and is significant at the 1% level. It is interesting to speculate about the relation between the perception of natural food risks and BSE. Siegrist (2003) has found that Swiss consumers view BSE as a natural food risk. This may explain the time trend we

[4] In this preliminary analysis, it has been recognized that the sum of the percentages represented by all clusters has always to sum to 100%. The time trend has been estimated in a linear equation system imposing this identity constraint.

observe for the cluster of consumers concerned about natural food risks. The data at hand unfortunately do not allow to verify this hypothesis as BSE was not evaluated in the survey. For the other two clusters of households, i.e. those concerned about technical risks and those not concerned about food risks, no significant trend can be discerned.

The general trends observed in Figure 2 are interrupted in 2000 when a sudden rise in the group concerned about all food risk group occurred whereas the share of consumers not concerned about any food risks declined. Although the first BSE case in Germany was only detected at the end of November of that year, a link between BSE and the human new-variant Creutzfeldt-Jakob disease (nvCJD) was increasingly evidenced. Also the EU was regulatory very active during that year deciding on mandatory BSE tests in April 2000 and introducing traceability on beef. These discussion were widely discussed in Germany and likely increased consumers awareness of food risks in general.

### *4.2 Multinomial Logit Model*

The estimated multinomial logit model is highly significant. The likelihood ratio test statistic of significance of all parameters jointly against the null hypothesis that estimates the model with a constant only is 2317 and is significant at any conventional level ($\chi^2$-distributed with 20 degrees of freedom). The model correctly predicts 40.1% of the observations. Since the parameter estimates of the multinomial logit model cannot be interpreted directly, we immediately turn to the marginal effects reported in Table 6.[5]

First we discuss the socio-demographic variables. Female respondents are significantly more likely to belong to the cluster of consumers being concerned about natural food risks. Other studies on risk perception show that men tend to judge risks as smaller and less problematic (for a review in the general risk literature see Slovic, 2000 or Davidson and Freudenburg, 1996; in food risks this result has been found in e.g. Dosman et al. 2001; Siegrist, 2003; Böcker, 2003). This difference has been attributed to two underlying factors. One is related to biological and social factors: women are socialized to nurture and maintain life. The second is that men have more power and control than do women (Flynn et al. 1994) and trust in institutions (Davidson and Freudenberg, 1996). Slovic (2000) finds for US subjects that this difference is only present for white men and women but not for non-white men and women. He concludes that white males see less risk because they can create, manage, control and benefit more from major technologies and activities. Böcker (2003) has

[5] Parameter estimates are available from the corresponding author upon request.

shown for the perception of food risks that the difference between male and female subjects is no longer significant if one takes into account experience with food poisoning.

Older people are less likely to be in the cluster “no food risks” or to be concerned about technical food risks, but they are more likely to be concerned about natural food risks. This may be a rational reaction. First, as Böcker (2003) has shown, people with experience of food poisoning are more concerned about these hazards. Being older, consumers are more likely to have been subject to food poisoning before. Secondly, older people are more vulnerable to natural food hazards and food poisoning and hence may be more concerned about these risks.

Households located in formerly Eastern Germany are more likely to be concerned about all food risks or about natural risks. At the same time they are less likely to be in the cluster “no food risks” or “technical food risks”. Although the disparity of risk perceptions between consumers in formerly Eastern and Western Germany is thought to have diminished (Oltersdorf, 2002), we still pick up a significant difference in our analysis after accounting for other determinants and a time trend.

People living in larger cities are more likely to be concerned about technical food risks but are less likely to belong to the cluster of people being concerned about all types of food risks or natural food risks. On the one hand living in larger cities puts consumers at a larger distance to the process of food production. More distanced to the actual way in which food is produced, people may be more sceptical of these unfamiliar technologies and of the risks they perceive as being posed by them. This concurs with results in Fox et al. 1994. On the other hand, people in larger cities are less exposed to the risks of nature and hence more accepting of natural hazards in food production.

Similarly, respondents being involved in household keeping are less likely to belong to the group of respondents who are concerned about natural food risks, and more likely to be concerned about technical food risks. The literature on risk perceptions helps to explain this result. Being a household keeper, the respondent feels confident to be able to manage such an obvious natural food risk as the development of moulds on food. In the risk perception literature, this has been identified as ‘optimistic bias’ (Miles & Frewer 2003). On the other hand, technical food risks such as residues are not detectable by the consumer, so that he/she may be more concerned about this type of risk.

The same effects are observed for consumers heading a household. In addition, these consumers are less likely to be concerned about all types of risks. A person heading the household may feel more responsible

towards the well-being of its member. This may lead to a different perception of ones self-efficacy in dealing with these risks.

Marginal effects for education are significant for reducing the likelihood to be concerned about natural food risks and have a positive effect for being concerned about technical food risks. Also higher education (having attended university) shows larger marginal effects on those risks than medium education levels.

Work-force participation and household size do not show any significant effects. The fact that kids under the age of 14 years are present in the household makes it less likely that the respondent is not concerned about any type of food risk. However, it does not significantly raise the probability to belong to any of the other three clusters.

Higher income makes it less likely to belong to the cluster of people concerned about natural food risks or to those who worry about all sorts of food risks. However, they are more likely to be concerned about technical food risks. The results on the effect of household keeping, education and income on the perception of natural food hazards may be explained by an increased perception of self-efficacy in dealing with these types of risk. For technical food risks, the results seem to contradict the hypothesis that people of higher socio-economic status feel more involved in societal risk management and hence are less concerned about risks posed to them by adopted technologies. However, this result may also indicate that the concern about these risks and the need for protection from these risks is a normal good and the desire of avoiding these risks increases with socio-economic status, e.g. income and education. Indeed, our results replicate those found in Nayga (1996) for technical food risks.

Increasing knowledge about food risks has significant effects on all clusters expect for the cluster technical food risks. However, the causality between these variables is not necessarily clear. While more knowledge seems to make people more worried, it may also be the worried people who seek more information and who are thus better informed. In the estimation we have interacted the knowledge variable with a time trend. It turns out that the change in this relationship over time is highly significant.

To illustrate the effect over time, we present it graphically in Figure 3. Looking at the overall effect of knowledge over time, we see that the food safety crises over the last years have had their effects. Those respondents who know many of the pathogens are more likely to belong to the clusters of “worried about food” people. Good news seems to be that they are more likely to worry about food risks that experts consider of actual “risk nature”, such as natural food risks, and less about technical food risks that are by and

large under control such as those from residues. In a way, the result is in so far not surprising as most risk specific knowledge questions prompted respondents to indicate if, or not, they had heard about specific food pathogens. Referring to Parry et al. (2004), our result may suggest that differences in experience with and knowledge about natural food risks may reduce the optimistic bias of risk perceptions and heighten consumers' perception of these risks.

Looking now at the clustering of respondents according to the general environmental /health risk typology, we first remind the reader that the left out dummy is that accounting for the cluster of respondents who are not concerned about any of those risks. Belonging to any other cluster lowers the probability of belonging to the cluster of consumers who are not concerned about any type of food risks. It raises in particular the probability of being concerned about natural food risks or all types of food risks. The marginal impact on the probability to be concerned about natural food risks is most increased by being in the cluster concerned about radioactivity. The negative impact on the probability of not being concerned about any food risks is largest for the cluster being concerned about all environmental/health risks. Being concerned about all environmental/ health risks increases, however, most increases the probability to be also concerned about all food risks. Being worried about all environmental/health risks is the only cluster significant in raising the probability to be also concerned about technical food risks. They are the "worried people" who are concerned about food technologies.

Looking at the result for time trend variables, the importance of accounting for socio-demograghic variables, knowledge and the risk typology on environmental/ health risks becomes apparent. Here the time trend is modelled using a linear and a quadratic term for higher flexibility.

As in the preliminary analysis on Figure 2, we do not identify a significant impact of time on the probability of being in the cluster "no food risks". In contrast to the preliminary analysis, though, it becomes less likely over time to be in the group of consumers concerned about natural food risk (marginal impact on linear time trend is larger in absolute terms than that of the quadratic). The disparity between these two results can be explained by the impact being explained by knowledge about safety risks.

The likelihood of being concerned about all food risks declines over time; the effect concurs with the preliminary analysis based on Figure 2. However in contrast to that figure, the likelihood of being in the cluster concerned about technical food increases significantly over time.

Looking at the marginal effects across clusters, it becomes evident that the cluster of people concerned about natural food risks counts likely more females than males and rather older than younger people. People in bigger cities and those involved in housekeeping and with higher income and education are less likely to belong to this group. As to the environmental/ health risk clusters, belonging to any of the groups but being concerned about nothing also raises the probability to be concerned about natural food risks.

Younger respondents located in formerly Western Germany, without kids and with low knowledge about food risks are more likely to belong to the group of respondents who are not concerned about any food risks. The fact of being worried about all types of environmental/health risks makes them less likely to belong to this group.

The cluster of people being concerned about technical food risks is somewhat different. Being younger, coming from larger cities in the old federal states and heading the household with a higher income and educational attainment makes it more likely to be worried about these types of risks. Controlling for all these variables, the likelihood of being in this cluster has increased over time.

Regarding the cluster being worried about all food risks, results are pretty similar. Obviously those concerned about all types of environmental/ health risks have a larger probability to be also concerned about all types of food risks.

## 5. Conclusions

In this paper we have analysed food risk perception using eight large cross sections of German consumers covering the eleven-year period from 1992 to 2002. According to our results from a cluster analysis, respondents are grouped into four clusters according to their food risk perceptions. Furthermore, we describe consumers by clusters based on their general risk attitude variables relating to no environmental and health risks, to radioactivity – a non controllable risk, risks from radioactivity, cigarettes and job related stress – risks posed by modern civilization – and finally those who are concerned about all sorts of risks. Belonging to the cluster "radioactivity", i.e. being concerned about the non-controllable risk, increases the probability of belonging to the cluster being concerned about natural food risk. The probability of being in the cluster "all food risks" is in particular increased by being concerned about all environmental/health risks. These results illustrate that a general risk typology of consumers can be of importance in the understanding consumers' specific perceptions of food risks.

Over time the share of consumers being concerned about all types of food risks has declined. It seems that people have become more discerning in the risks that they are concerned about. This is supported by the fact that the knowledge variable plays a significant role in the explanation of the clusters and that its role has shifted over time. Although food safety experts may be happy to recognize that more consumers recognize the risks of natural food hazards, e.g. moulds, the number of consumers being concerned about technical food risks has increased over time after accounting for socio-demographic, knowledge and environmental and health risk variables.

The perception of technical food risks shows the relevance of the consumer risk typologies. While knowledge about food safety risks and being concerned about radioactivity or civilisation risks have no significant impact on the probability to be in the cluster labelled technical food risks, we identify the young, affluent and well-educated, who are concerned about all environmental/health risks as the most likely to be in this group. For this type of consumers, risk communication may not present a successful strategy for increasing the acceptance of technical food risks. It may be rather that acceptance of such risks is a-priori excluded by these people who exhibit strong concern about technical risks and all environmental/health risks.

The results on the cluster being concerned about natural food risks show on the other hand the discerning nature of this consumer type. Knowledge about food risks increases their awareness. Finally those concerned about all food risks are highly correlated to those being concerned about all environmental/health risks. Here, we may just have identified a group of worried people.

For policy makers our study suggests that risk communication may make people more discerning about food risks. However, consumers' general perception of risks will have to be taken into account if such a strategy is to be successful. Studies cited in our literature review showed that, to improve acceptance of risks, policy makers have to increase consumers trust in risk management institutions, heighten their involvement in the risk management process or increase the perceived benefits e.g. of new food technologies.

For those consumers being concerned about technical food risks, development of label and differentiated consumer goods may be a choice. The analysis suggests that this concern is somewhat of a life-style choice. Helping consumers to express this choice may improve the efficiency of markets and the satisfaction people gain in making choices over which they feel to have control.

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**Table 1. Environmental /health risks and food risks assessed in the questionnaire**

| Environmental /health risks | Food risks |
|---|---|
| *Health questions are mentioned daily in the media. Which, do you fear, pose personal risks to your health?* | *Risks regarding the quality of food or regarding nutrition are also often mentioned. Which ones are according to you particularly risky for the people in our country?* |
| Radioactivity | Pesticides and other residues in food |
| Cigarettes | Moulds |
| Traffic | Growth hormones |
| Air | Spoiled foods |
| Climate | Food additives |
| Food & beverages | Genetic modification |
| Job-related stress | Alcohol |
| Noise | Unbalanced diet |
| Drugs | Cholesterol |
| Water | Biotechnology |
| | Toxins |
| | Unprocessed foods |

## Table 2. Variable definitions

| Name | Definition |
|---|---|
| **Explanatory Variables** | |
| Gender | 0 = male, 1 = female |
| Age | Age of the respondent in years |
| Geographic location | = 1 if household is located in formerly Eastern Germany, = 0 if household is located in rest of Germany |
| City size | Household located in a city of ….. inhabitants: 1 = less than 4999; 2 = 5000-19999; 3 = 20000-49999; 4 = 50000-99999; 5 = 100000-499999; 6 = more than 500000 |
| Household keeper | =1 if respondent participates in household keeping, = 0 otherwise |
| Household head | =1 if respondent is household head, = 0 otherwise |
| Medium Education | =1 if respondent has at least 10 years of school but not visited university, = 0 otherwise |
| Higher education | =1 if respondent has attended university, = 0 otherwise |
| Employed | =1 if respondent is employed, = 0 otherwise |
| Household size | 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 = less than 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 |
| Knowledge | % of food pathogens recognized |
| T | Time trend T = 0 in 1992 … T = 10 in 2002 |
| $T^2$ | Square of T |
| Cluster radioactivity | =1 if respondent belongs to the cluster of consumers concerned only about risk from radioactivity, 0 otherwise |
| Cluster civilization risk | =1 if respondent belongs to the cluster of consumers concerned about risk from radioactivity, cigarettes and job-related stress, 0 otherwise |
| Cluster all risk | =1 if respondent belongs to the cluster of consumers concerned about all environmental and health risks, 0 otherwise |
| **Dependent Variable (Y)** | |
| Y = Natural food risks | Respondent is concerned about natural risks in food, in particular moulds |
| Y = No food risks | Respondent is not concerned about any food-related risks |
| Y = Technical food risks | Respondent is concerned about technical risks in food such as residues from pesticides and hormones in animal production |
| Y = All food risks | Respondent is concerned about all food-related risks |

**Table 3. Summary Statistics of Explanatory Variables**

| Variable | Description | Total | 1992 | 1995 | 1996 | 1998 | 2000 | 2001-04 | 2001-11 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of Observations | | 16781 | 2337 | 2435 | 1927 | 2141 | 2102 | 1932 | 1886 | 2021 |
| Gender | % female | 54.6% | 49.9% | 53.6% | 53.9% | 54.4% | 56.8% | 56.7% | 54.9% | 57.9% |
| Age | Mean<br>(Std. Dev.) | 44.92<br>(17.30) | 42.58<br>(17.12) | 45.46<br>(17.09) | 44.99<br>(17.65) | 43.33<br>(16.92) | 45.65<br>(17.55) | 46.27<br>(17.39) | 46.20<br>(17.42) | 45.32<br>(17.00) |
| Geographic location | % formerly Eastern Germany | 19.9% | 18.1% | 20.7% | 20.3% | 18.3% | 19.4% | 21.8% | 18.5% | 22.1% |
| City size | Mean<br>(Std. Dev.) | 2.83<br>(1.84) | 3.07<br>(1.91) | 1.44<br>(1.11) | 3.21<br>(1.81) | 3.24<br>(1.79) | 3.17<br>(1.79) | 3.29<br>(1.83) | 3.16<br>(1.82) | 2.31<br>(1.74) |
| Household keeper | % | 80.2% | 74.6% | 80.0% | 81.0% | 83.2% | 77.5% | 81.1% | 82.3% | 82.7% |
| Household head | % | 64.1% | 59.9% | 65.8% | 63.3% | 69.0% | 59.5% | 65.3% | 64.5% | 65.8% |
| Medium education | % | 37.4% | 24.0% | 33.1% | 37.5% | 41.4% | 41.1% | 39.9% | 41.2% | 44.1% |
| Higher education | % | 8.1% | 16.0% | 7.9% | 6.4% | 7.4% | 6.1% | 5.8% | 7.1% | 6.4% |
| Employed | % | 48.3% | 51.9% | 47.9% | 47.1% | 50.7% | 46.4% | 46.3% | 47.6% | 47.6% |
| Household size | Mean<br>(Std. Dev.) | 2.37<br>(1.20) | 2.44<br>(1.17) | 2.34<br>(1.13) | 2.38<br>(1.27) | 2.36<br>(1.21) | 2.39<br>(1.21) | 2.36<br>(1.21) | 2.34<br>(1.20) | 2.31<br>(1.19) |
| Kids | % | 22.5% | 23.3% | 24.9% | 23.5% | 16.3% | 23.5% | 22.6% | 23.1% | 22.3% |
| Income | Mean<br>(Std. Dev.) | 9.40<br>(3.76) | 9.07<br>(3.78) | 9.13<br>(3.70) | 9.11<br>(3.81) | 9.45<br>(3.91) | 9.59<br>(3.61) | 9.84<br>(3.66) | 10.08<br>(3.64) | 9.05<br>(3.80) |
| Knowledge | Mean<br>(Std. Dev.) | 0.12<br>(0.12) | 0.16<br>(0.13) | 0.13<br>(0.13) | 0.12<br>(0.12) | 0.05<br>(0.07) | 0.12<br>(0.13) | 0.14<br>(0.13) | 0.09<br>(0.09) | 0.10<br>(0.10) |
| Cluster-no risk | % | 35.7% | 35.3% | 30.2% | 34.3% | 35.3% | 27.1% | 39.3% | 44.4% | 42.2% |
| Cluster radioactivity | % | 31.1% | 35.4% | 28.0% | 36.6% | 30.9% | 32.4% | 29.7% | 29.4% | 26.1% |
| Cluster civilisation risk | % | 18.4% | 15.7% | 20.1% | 17.4% | 20.5% | 23.7% | 16.1% | 16.0% | 17.3% |
| Cluster all risk | % | 14.8% | 13.5% | 21.6% | 11.7% | 13.4% | 16.8% | 14.9% | 10.1% | 14.4% |

**Table 4. Percentage of respondents concerned about different environmental/health risks in for each identified cluster**

| | Cluster | | | | |
|---|---|---|---|---|---|
| **Type of risk** | **No risks** | **Radioactivity** | **Civilization risks** | **All risks** | **Entire Sample** |
| **Total cases** | **5997** | **5213** | **3093** | **2478** | **16781** |
| **% of total cases** | **35.7 %** | **31.1 %** | **18.4 %** | **14.8 %** | **100.0 %** |
| Radioactivity | 0.0 % | 100.0 % | 68.2 % | 82.0 % | 55.7 % |
| Cigarettes | 27.5 % | 34.5 % | 60.0 % | 76.6 % | 42.9 % |
| Traffic | 30.9 % | 30.4 % | 33.2 % | 88.5 % | 39.7 % |
| Air | 32.1 % | 30.8 % | 18.9 % | 89.0 % | 37.7 % |
| Climate | 27.0 % | 32.0 % | 25.6 % | 83.9 % | 36.7 % |
| Food & beverages | 30.1 % | 27.3 % | 19.7 % | 74.3 % | 33.8 % |
| Job related stress | 14.1 % | 0.0 % | 100.0 % | 66.5 % | 33.3 % |
| Noise | 12.6 % | 14.2 % | 33.9 % | 74.9 % | 26.2 % |
| Drugs | 14.1 % | 19.7 % | 24.5 % | 58.0 % | 24.2 % |
| Water | 10.2 % | 10.5 % | 5.2 % | 54.2 % | 15.9 % |

**Table 5. Percentage of respondents concerned about different food risks for each identified cluster**

| | Cluster | | | | |
|---|---|---|---|---|---|
| **Type of food risk** | **Natural food risks** | **No food risks** | **Technical food risks** | **All food risks** | **Entire Sample** |
| **Total cases** | **5862** | **5051** | **4986** | **882** | **16781** |
| **% of total cases** | **34.9 %** | **30.1 %** | **29.7 %** | **5.3 %** | **100.0 %** |
| Pesticides | 42.7 % | 0.0 % | 100.0 % | 90.5 % | 49.4 % |
| Moulds | 100.0 % | 0.0 % | 0.3 % | 87.4 % | 39.6 % |
| Growth hormones | 26.6 % | 35.0 % | 50.2 % | 87.3 % | 39.1 % |
| Spoiled foods | 40.5 % | 28.8 % | 19.3 % | 88.0 % | 33.2 % |
| Food additives | 16.6 % | 25.2 % | 26.4 % | 66.2 % | 24.7 % |
| Genetic modification | 12.0 % | 30.2 % | 25.3 % | 72.6 % | 24.6 % |
| Alcohol | 10.6 % | 21.6 % | 9.6 % | 52.0 % | 15.8 % |
| Unbalanced diet | 8.1 % | 21.0 % | 11.7 % | 55.8 % | 15.5 % |
| Cholesterol | 9.3 % | 18.2 % | 9.2 % | 65.5 % | 14.9 % |
| Biotechnology | 3.6 % | 13.2 % | 7.5 % | 55.2 % | 10.4 % |
| Toxins | 7.8 % | 9.3 % | 5.1 % | 54.0 % | 9.9 % |
| Unprocessed foods | 5.0 % | 9.9 % | 4.6 % | 46.7 % | 8.5 % |

**Table 6. Estimates of Marginal Effects – Results of the Multinomial Logit Model**

| | Natural food risks | | No food risks | | Technical food risks | | All food |
|---|---|---|---|---|---|---|---|
| Gender (female) | 0.0229 | ** | -0.0062 | | -0.0136 | | -0.0031 |
| Age | 0.0017 | *** | -0.0008 | *** | -0.001 | *** | 0.0001 |
| Geographic location (Eastern Germany) | 0.0631 | *** | -0.0254 | ** | -0.0414 | *** | 0.0036 |
| City size | -0.0073 | *** | 0.0030 | | 0.0060 | *** | -0.0018 |
| Household keep | -0.0190 | * | -0.0056 | | 0.0203 | * | 0.0042 |
| Household head | -0.0254 | ** | 0.0094 | | 0.0228 | ** | -0.0068 |
| Medium Education | -0.0253 | *** | -0.0027 | | 0.0289 | *** | -0.0009 |
| Higher education | -0.0317 | ** | -0.0095 | | 0.0453 | *** | -0.0041 |
| Employed | -0.0024 | | 0.0035 | | -0.0008 | | -0.0002 |
| Household size | 0.0035 | | 0.0006 | | -0.0052 | | 0.0011 |
| Kids | 0.0103 | | -0.0262 | ** | 0.0176 | | -0.0018 |
| Income | -0.0036 | ** | -0.0005 | | 0.0048 | *** | -0.0007 |
| Knowledge | 0.1638 | ** | -0.3081 | *** | 0.0714 | | 0.0730 |
| Knowledge × T | -0.0126 | | 0.0328 | | -0.038 | | 0.0178 |
| Knowledge × $T^2$ | 0.0047 | | -0.0085 | ** | 0.0047 | | -0.0010 |
| Cluster radioactivity | 0.1133 | *** | -0.1336 | *** | 0.0089 | | 0.0114 |
| Cluster civilization risks | 0.1112 | *** | -0.1332 | *** | -0.0004 | | 0.0225 |
| Cluster all risks | 0.0876 | *** | -0.1575 | *** | 0.0271 | ** | 0.0427 |
| T | -0.0201 | *** | 0.0057 | | 0.0155 | ** | -0.0011 |
| $T^2$ | 0.0023 | *** | -0.0003 | | -0.0014 | ** | -0.0006 |

Significance of the marginal effects at the 0.1 level is denoted by *, at the 0.05 level by ** and at the 0.01 level by ***.

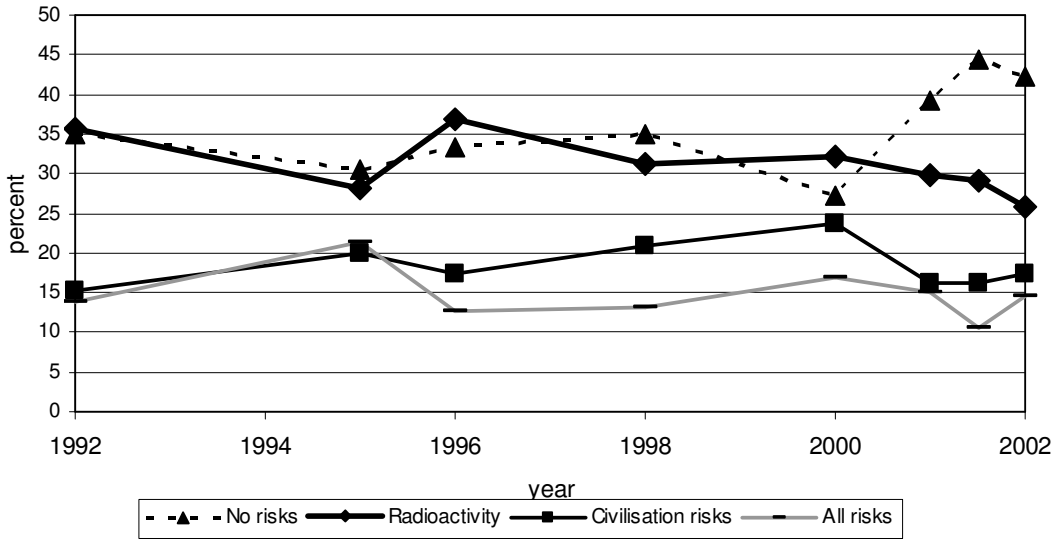


**Figure 1. Share of households in different environmental/health risk groups from 1992 to 2002**

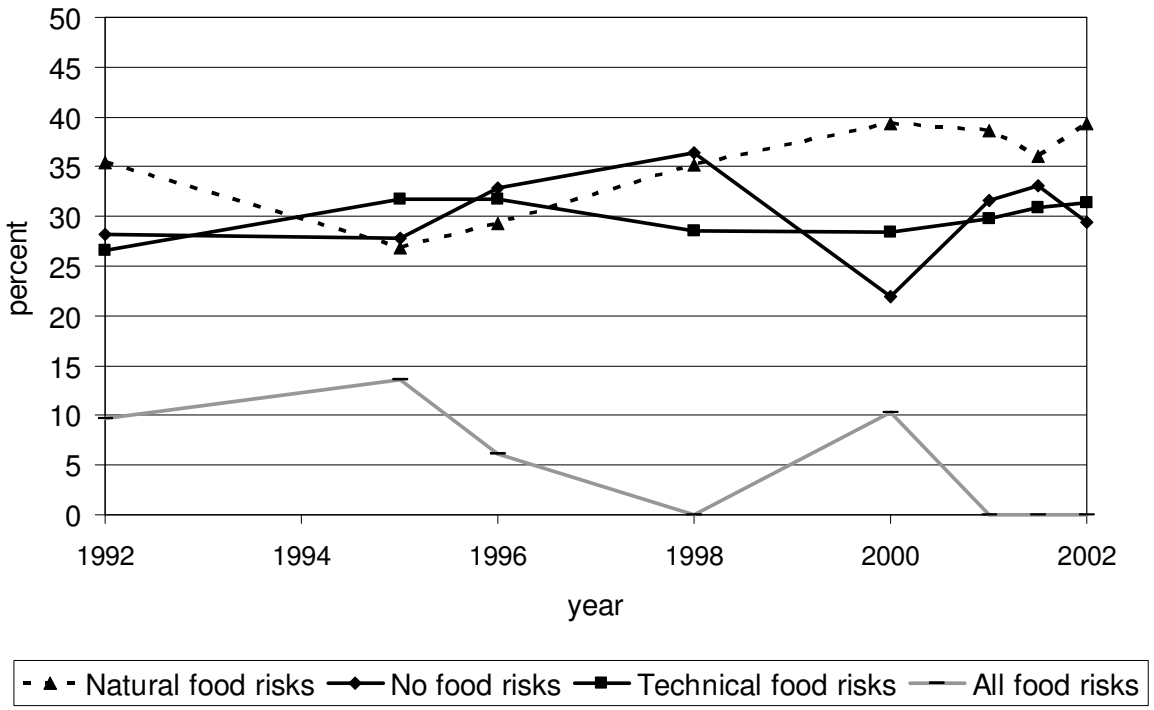


**Figure 2. Share of households in different food risk groups from 1992 to 2002**

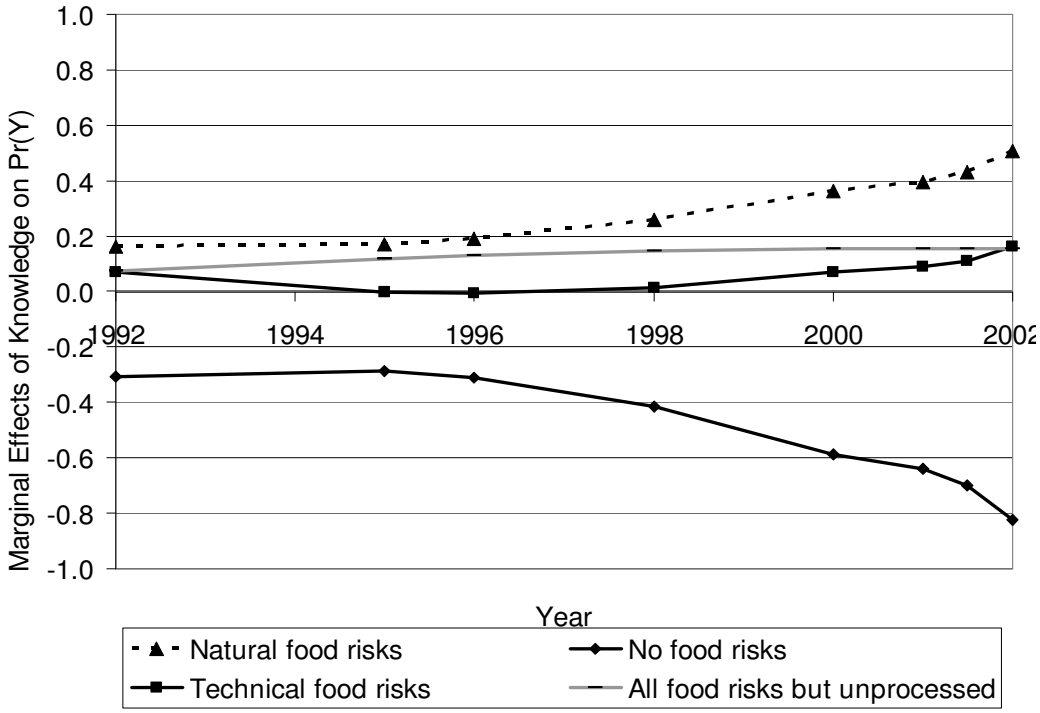


**Figure 3. Change in the probability to belong to the clusters in dependence of knowledge variable over time**