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Canadian Consumers' Preferences for Food Safety and Agricultural Environment Safety

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This project applies statistical models to analyse the relative importance ratings for selected food risk issues given in January 2003 by a representative cross-Canada sample of consumers. Ratings for environmental risks that may be associated with agriculture are also assessed. Results of ordered probit econometric models that analyze the influence of respondent's socio-economic and demographic characteristics on food and environmental risk ratings indicate that these are influenced by gender, age, income, employment and location of residence. Males tended to choose lower risk ratings; residents of Quebec tended to give higher risk ratings to most of the queried food and environmental safety issues. The results suggest that measures of trust in institutions associated with the regulation and marketing of food also influence individuals' risk assessments associated with food and agriculture.

Keywords: food safety, environmental risks, risk perceptions, quantitative assessment

JEL Classification: C12, D12, I19, Q18.

Introduction

There is increasing public interest in issues of food safety and environmental sustainability. Consequently, these are subjects of policy interventions. For example, there is increasing public awareness and much debate about public policy relating to genetically modified (GM) technology in food production. This is also the case for Bovine Spongiform Encephalopathy (BSE) and a variety of other food safety issues. Along with added public interest, increasing resources have been dedicated to assessing, monitoring and informing the public about food and agricultural environmental safety issues, reflecting and contributing to public interest in these topics. In this context it is important to understand the nature and basis of people's perceptions of risks, the topic of this paper.

Overview of Previous Research

The previous literature may provide a helpful guide to the analysis in this study. Numbers of studies have been conducted on consumer attitudes and perceptions of various food safety and environmental issues. Some surveys have involved detailed analyses focused on individual issues. For example, Govindasamy and Italia (1998) focused on pesticides, Grobe et al. (1999), on hormone use; while Finke and Kim (2003) and Veeman et al. (2005) emphasize genetically modified food. Some recent studies compare attitudes to several food safety issues. Examples are the study by Nayga (1996) on US consumers' attitudes to irradiation, antibiotics, hormones and pesticides; Dosman et al. (2001) assessed Albertans' reactions to pesticides, hormones, and food additives in 1994 and 1995. Hwang et al. (2005) compared US consumers' views of different food technologies including antibiotics, pesticides, hormone use in food production, GM food, and food irradiation in 2002. As summarized below, these analyses and numbers of other previous studies have indicated that consumer attitudes toward food safety and environmental safety may be associated with differences in demographic and socio-economic factors such as gender, age, income, education level and family size (including the number and age of children).

The analysis by Nayga (1996) concluded that female main meal planners and those who were less educated, had lower income levels or were living in metro areas were more likely to consider food that had been treated with irradiation, antibiotics, hormones or pesticides to be risky. Dosman et al. (2001) concluded that household income, the number of children, respondent gender, age and voting preferences were significant influences on individuals' risk perceptions. Baker (2003) concluded that primary meal planners, women, and members of households that had young children were most likely to avoid food risks.

Numbers of studies indicate that gender is an important determinant of risk perceptions for different populations across a variety of food, environmental and other risk concerns. Thus Flynn et al.(1994) noted "perhaps women and nonwhite men see the world as more dangerous because in many ways they are more vulnerable, they benefit less from many of its technologies and institutions, and they have less power of control" (Flynn et al. 1994:1101). Finke and Kim (2003) concluded that concerns about health risks from genetically modified foods differed by gender: females were more concerned about these health risks than males. Similarly, Hwang et al. (2005) indicated that females tended to express more concern on each of eight selected food technologies than males. Dosman et al. (2001) concluded women to be more likely than men to consider food additives, food bacteria, and pesticides to be health risks. However, these types of voting statements relative to cited risk issues may not always hold in research situations that attempt to simulate trade-offs among price and particular types of food quality characteristics, for example Hu et al. (2004) concluded that young Canadian women were more likely to be "*Value-Seeking Consumers"* whose trade-offs in different stated choice situations indicated interest in value rather than indicating a major concern about the possible presence of GM food ingredients in bread.

Age is another factor that is suggested by previous research to be associated with consumers' perceptions but its influence may be complicated. Young people may be more familiar with some risks associated with new technologies, but not necessarily with all food risks since they may not have experience of situations and issues of health associated with these risks. It is also suggested that young people may see many risk situations to be less threatening than when these are seen from the perspective of older

people (Dosman et al. 2001). Nayga (1996) concluded that older main meal planners were more likely to consider antibiotics and pesticides to be food risks. Dosman et al. (2001) found that older respondents tended to perceive pesticides in food to be more risky. However, Hwang et al. (2005) found that older (> 65 years) and younger (< 30 years) respondents were less likely to express food risk concerns.

Respondents' household income and education levels have also been found to be related to risk perceptions. Some researchers have concluded that households with higher levels of income and education tend to exhibit lower risk aversion to food concerns. Govindasamy and Italia (1998) found that US respondents in households with annual incomes less than US$40,000 were more likely to be concerned about pesticides than those with higher incomes. Similarly, respondents with only a high school education were more likely to see pesticides as riskier than individuals with higher levels of education. Hwang et al. (2005) came to a similar conclusion: lower income American respondents expressed more concern about food risk issues; this was also the case for individuals with lower levels of education. However, in other studies researchers have found household income and education levels of respondents to be insignificant as factors explaining concerns for some food risk situations. Dosman et al. (2001) reported instances where household income of Alberta respondents was significant in explaining risk perceptions based on 1994 data but this was not the case for models tested on 1995 data. Education was significant for only one of three queried food risk issues.

The numbers of children in the household are believed to have an effect on respondents' risk perceptions. Dosman et al. (2001) found that the more children there were in an Alberta household, the more likely a respondent was to view specified issues as health risks. However this conclusion is not consistent across all studies and may vary with the age of children (or perhaps also with the risk issue). For example, Hwang et al. (2005) concluded that American respondents with older children (compared to no children) had lower levels of concern about food risk issues.

Lack of information has often been suggested as a reason why some people may distrust new technology, but the formation of risk perceptions is more complex than simply gaining knowledge of new technologies (Slovic 1993; Leiss and Chociolko 1994).

The issue of trust and lack of trust in the laws, regulators and organizations that are associated with controlling and limiting risky situations is believed to be associated with risk perceptions (Slovic 1993). Rosati and Saba (2004:493) followed previous studies in focusing on perceptions of *knowledge* of those controlling risks, the *honesty* and capabilities of regulators dealing with food-related hazards, and perceptions of the *concern* for the public and the health of citizens held by food safety regulators and agencies as factors that might influence food risk perceptions. These authors found that Italian respondents chose consumer associations, research institutes and environmental organizations as trustworthy information sources, and rated these to be more honest and knowledgeable about food risks and more concerned about citizens' health and safety, in contrast to ratings given for the press and government (Rosati and Saba 2004). Veeman et al. (2005) arrived at a similar conclusion for Canadian respondents, finding that industry and government are not rated as highly trusted sources of information, while researchers and consumer groups are viewed as more trustworthy. Grobe et al (1999) queried lack of trust in the US Food and Drug Administration (FDA) as a source of information on food and found this belief to have a significant impact on Americans' food risk perceptions. Those respondents who indicated a lack of trust in the FDA were more likely to be "very concerned" about food risks.

Focus of this Study

The major objective of the current study is to understand the nature of Canadian consumers' perceptions of selected food and environmental risks associated with agriculture and to assess factors that may be associated with these risk perceptions. The socioeconomic variables assessed as potential influences on individual's ratings of food and environmental risks are age, gender, education level, household income, number of young children, employment status, and whether or not respondents view different information sources to be trustworthy. It is hoped that the findings of the study will be useful in contributing to a better understanding of the food risk concerns of Canadian consumers. Such information may be helpful to policy makers, producer groups, consumer representatives and others involved in the food and agricultural sectors.

The Data and its Source

This paper analyzes the perceptions of various food and environmental risks that may be associated with agriculture. The analysis is based on data from a computer-administered Canada-wide survey of 882 participants, drawn from a representative panel of some 40,000 households maintained by a major marketing company, which was conducted in January 2003. The survey is described in Veeman et al. (2005). For the 882 people surveyed, some demographic responses were lacking. In the analysis reported here, if the respondent did not answer demographic questions, the observation was rejected. The adjusted number of observations is 646.

The language and regional balance of respondents is generally representative of the Canadian population. However, the sample somewhat over-represents respondents with higher income levels and higher educational backgrounds. For the adjusted sample, 44.1% are male, and 55.9% are female (the gender distribution of Canadian population 2002 was 49.5% for male and 50.5% for female, according to Statistics Canada (2001). The data are slightly skewed towards female respondents. However, this is reasonably representative of Canadian consumers since relatively more women than men do household food shopping.

Eight food safety issues (bacteria contamination, pesticide residuals, use of hormones in food production, use of antibiotics in food production, BSE (mad cow disease), food additives, use of genetic modification/engineering (GM/GE) in food production, fat and cholesterol in food) and six environmental safety issues (water pollution by chemical run-offs from agriculture, soil erosion, use of genetic modification/engineering (GM/GE) in agriculture, herbicide/pesticide resistance, adverse effects of agriculture on biodiversity, and agricultural waste disposal) were ranked by respondents from 1(high risk) to 4(almost no risk) and 5(don't know). The order of questions was randomized across respondents. The risk ranking data are summarized in Table 1. Attitudinal and demographic information were also collected as described in Veeman et al. (2005).

The percentage of respondents that categorized the various food safety issues in the " high risk" category are, in order: pesticide residuals (40%), bacteria contamination

(39%), use of antibiotics (34%), BSE (mad cow disease) (31%), use of hormones (30%), fat and cholesterol in food (24%), use of GM/GE in food production (20%), and use of food additives (13%). The percentage of respondents that assessed the various environmental safety issues to be in the "high risk" category are, in order: water pollution (61%), resistance to herbicides & pesticide (49%), agricultural waste disposal (40%), soil erosion (28%), the use of GM/GE (27%), and adverse effects of agriculture on biodiversity (26%).

As reported elsewhere (Veeman et al., 2005) the survey included attitudinal questions querying respondents about their views of the trustworthiness of the Government of Canada, the food industry, farmer associations, family and friends, research institutes, and consumer associations as sources of information about GM foods. The proportion of respondents that chose different information sources as "very trustworthy" or "trustworthy" are research institutes (for which 91.4% of respondents chose these two ratings), consumer associations (87%), the Canadian Government (62.2%), farmers' association (59.7%), family and friends (47.9), and the food industry (38.8). Another attitudinal issue that was considered in the survey involved querying respondents about the frequency with which they bought organic food. Only 8% of the respondents reported that they often bought organic food.

Based on the previous literature, the noted demographic variables and attitudinal responses are postulated to explain respondents' risk perceptions indicated by their rankings of the cited food and environmental risks. Table 2 provides a descriptive tabulation of the explanatory variables used in the study.

As explained subsequently, three different sets of models were applied to assess the influence of demographic and socioeconomic factors on the concern rankings for each of the cited eight food safety issues (bacteria contamination, pesticide residuals, use of hormones, use of antibiotics, BSE, food additives, GM/GE, fat and cholesterol), and for the cited six environmental issues (water pollution by agricultural chemical run-offs, soil erosion, herbicide/pesticide resistance, adverse effects of agriculture on biodiversity, GM/GE, agricultural waste disposal). Following Roe et al. (2004), throughout the

econometric analyses, “Don’t Know” responses to specific risk concerns were replaced by the average risk responses, across all of the sampled respondents for each issue.

Table 1. Summary Statistics for Dependent Variables of Food Safety (Percentage of responses; N=646)

	High risk	Moderate risk	Slight risk	Almost no risk	Don't know
Pesticide residuals	0.4	0.24	0.23	0.09	0.04
Bacteria contamination	0.39	0.22	0.24	0.11	0.03
Use of antibiotics	0.34	0.23	0.23	0.12	0.08
Mad cow disease	0.31	0.1	0.18	0.37	0.04
Use of hormones	0.3	0.28	0.24	0.11	0.07
Fat and cholesterol	0.24	0.39	0.26	0.1	0.01
Use of GM/GE	0.2	0.21	0.29	0.22	0.08
Food additives	0.13	0.32	0.36	0.17	0.03

Table 2. Summary Statistics for Dependent Variables of Environmental Safety (Percentage of responses; N=646)

	High risk	Moderate risk	Slight risk	Almost no risk	Don't know
Water pollution	0.61	0.28	0.07	0.02	0.01
Resistance to herbicide & pesticides	0.49	0.33	0.13	0.02	0.03
Waste disposal	0.4	0.32	0.17	0.09	0.02
Soil erosion	0.28	0.37	0.27	0.05	0.03
GM/GE on environment	0.27	0.28	0.25	0.13	0.07
Adverse effects on biodiversity	0.26	0.36	0.22	0.06	0.11

Table 3. Summary Statistics for Postulated Explanatory Variables (N=646)

	Postulated Explanatory Variables	Mean	Std	Min	Max
TGOV	Trustworthy: Canadian government 1-trust, 0-not trust	0.622	0.485	0	1
TFOOD	Trustworthy: food industry 1-trust, 0-not trust	0.379	0.486	0	1
TFARM	Trustworthy: farmers' assoc.1-trust, 0-not trust	0.594	0.491	0	1
TFAMIL	Trustworthy: family 1-trust, 0-not trust	0.485	0.500	0	1
TRESEA	Trustworthy: research inst. 1-trust, 0-not trust	0.916	0.277	0	1
TCONS	Trustworthy: consumer assoc. 1-trust, 0-not trust	0.872	0.335	0	1
MALE	1-male, 0-female	0.441	0.497	0	1
AGE	Age in years	44.344	13.578	20	79
PEOPLE	Number of people in household	2.836	1.356	1	9
CHILD	Number of children in household	0.836	1.154	0	6
UNIVER	1-university degree or graduate, 0-less than university degree	0.584	0.493	0	1
EMPLOY	Employment status, 1-working full or part time, 0 -otherwise	0.632	0.483	0	1
INCOME	Total household income, 1-less than 10,000; 2-10,000-19,999; 3-20,000-29,999; 4-30,000-39,999; 5-40,000-49,999; 6- 50,000-59,999; 7- 60,000-69,999; 8- 70,000-79,999; 9- 80,000-89,999; 10-90,000-99,999; 11-More than $100,000	6.39	2.93	1	11
ORGANIC	1-often buy organic food; 0-occasionally or almost never buy organic food	0.08	0.267	0	1
BC	1-resident of British Columbia, 0-otherwise	0.102	0.303	0	1
PRAIRIE	1-resident of Alberta, Saskatchewan or Manitoba, 0-otherwise	0.140	0.347	0	1
ON	1-resident of Ontario, 0-otherwise	0.380	0.486	0	1
QC	1-resident of Quebec, 0-otherwise	0.300	0.459	0	1
ATLANTIC	1-resident of New Brunswick, Prince Edward Island (P.E.I.), Nova Scotia and Newfoundland and Labrador., 0-otherwise	0.078	0.268	0	1

Notes: 1. after deletion of "don't know/no responses" answers to demographic questions the number of observations is 646. 2. The variables denoting "trust" were coded to include responses of "very trustworthy" and "somewhat trustworthy"; while " not very trustworthy", "not at all trustworthy and "don't know" were coded as "not trust".

Statistical Analysis

Factors Affecting Concern Rankings

Previous literature suggests that individual's concerns or risk rankings may be related to a variety of socio-economic and demographic characteristics, such as age, gender, family composition and income (for example, Dosman et. al. 2001, Baker 2003, Govindasamy et al. 2004, Grobe et al. 1999). Trust in regulatory institutions and the marketing system may also be important (for example, Slovic 1993, Grobe et al. 1999; Rosati and Saba 2004). As proxy measures of trust we use the data on respondents' assessments of the trustworthiness of information sources. We assess the influence of these and related factors as determinants of concern rankings using three selected models, as outlined below.

SUR (Seemingly Unrelated Regressions)

Following the procedure used by Roe et al. (2004) who investigated concern rankings for a variety of food technologies, we applied an initial model for which we normalized respondents' levels of concern for food and environment safety by expressing these as deviations from the means, across all concern rankings, for each individual respondent, as a procedure that focuses on the relative concern rankings of the various individuals. We apply seemingly unrelated regression (SUR) procedures to the normalized data.

The SUR approach involves a system of ordinary least square (OLS) regressions. The assumptions of the OLS procedure, such as the requirement for a normal distribution of residuals, are unlikely to be true for models with discrete dependant variables, necessitating the normalization procedure noted above.

In the analysis presented here, the SUR model is constructed as follows:

$$\hat{y}_{im} = x\,\beta_m + \varepsilon_{im} \qquad (1.1)$$

where for the eight food safety issues m =1, 2…8; and for the six environmental safety issues m =1,2,…6; i = 1,2,...646 denotes individual respondents, and $\hat{y}_{im}$ is respondent i's normalized rating of the m th food safety or environmental safety, i.e.

$$\hat{y}_{im} = y_{im} - \bar{y}_i \tag{1.2}$$

where m is the m th issue; x is a vector of socio-demographic and other characteristics of the respondent; β_m denotes the coefficients to be estimated and ε_{im} is an error term.

Multivariate Probit System

A multivariate probit system model is also applied for purposes of comparison with the results of the SUR model. This is the multivariate extension of the binomial probit model, available in Greene (2002, 2003), which builds on the suggestion of Lerman and Manski (1981) that multivariate normal probabilities be approximated by random sampling. The multivariate probit model extends the bivariate probit model to M equations, applying to each of the m issues, allowing information in the error terms of the individual equations to be considered in the estimation process (Greene 2003). Thus in Model 2 below, m is the m-th food concern issue. For this model version, the original ordered responses indicating the food concern ratings (the dependent variables) were converted to binary choice data. Specifically, original responses of "1-high risk" and "2-moderate risk" were converted to "0-risk" while original responses "3- slight risk" and "4- almost no risk" were coded as "1-no risk". Consequently, the dependent variables contain only two categories: "risk" and "no risk". This procedure has the disadvantage of ignoring the intensity of concerns given in the original four-level responses. The procedure has the advantage of a system approach to estimation.

Following Greene (2003), the multivariate probit model is described as:

$$y(i,m)^* = \beta_m x + \varepsilon(i,m) \tag{2.1}$$

where m=8 for eight food safety issues; m=6 for six environmental issues; i =1, 2…..646, i denotes the i-th respondent; $y(i,m) = 1$ *if* y(i,m)* > 0 ; $y(i,m) = 0$, otherwise; x denotes the socio-demographic and other characteristics of the respondent and $\varepsilon(i,m)$, m=1, 2….6 (or 8) are error terms, assumed to be normally distributed with variance 1 and correlation $r(m,1)$ (Greene 2003).

The Ordered Probit Models

A third group of models, applying ordered probit estimations, is also employed to assess the underlying effects of socio-economic and demographic factors on each risk issue. These models take particular cognizance of the ordered risk rankings of respondents, thus *a priori* these models have the advantage of fully using the ordered ranking data on risk perceptions. Following Greene (2003) these models are described as:

$$y_{mn}^{*} = x\beta + \varepsilon_{mn} \tag{3}$$

where m=8 for eight food safety issues; m=6 for six environment issues, and n =1, 2…..646, n is the n-th respondent.

Ordered probit models assume that the rating measures that are available are based on the unobserved continuous dependent variable, y*. However, instead of y*, only the categorical value, y, is observed. In our application of the individual ordered probit model, the four category values represent the four concern rankings. Specifically, the four categories are given values 0, 1, 2 and 3:

$y = 0$ if y* < μ_0 (where μ_0 equals zero) (4)

$y = 1$ if 0 <= y* < μ_1

$y = 2$ if MU1 <= y* < μ_2

$y = 3$ if MU2 <= y* < μ_3

where y is the observed choice of risk ranking categories given in the survey responses. Boundary values between the different categories are the parameters (μ) to be estimated. The μ parameters are labelled here based on the category value for which they are the lower bound. For example, μ_2 in is the lower bound for the category with value 2. We designate the lowest effective boundary value as zero. The estimated μ values follow the order $\mu_0 < \mu_1 < \mu_2 < \mu_3$. The distributions of the error terms ε are assumed to be normal (Greene 2003).

The various ordered probit Model 3 versions (based on equation 3.1) are estimated as separate regressions for each concern issue. The marginal effects show the probabilities of changes in the explanatory variables from one category value to the next. Marginal effects are computed from, and usually not equal to, the estimated coefficients. Following Greene (2003) the four probabilities that apply in this analysis are:

$$\begin{aligned}
\Pr(y=0) &= \phi(-\beta' x) \\
\Pr(y=1) &= \phi(\mu_1 - \beta' x) - \phi(-\beta' x) \\
\Pr(y=2) &= \phi(\mu_2 - \beta' x) - \phi(\mu_1 - \beta' x) \\
\Pr(y=3) &= 1 - \phi(\mu_2 - \beta' x)
\end{aligned} \tag{5}$$

For these probabilities, the marginal effects of the explanatory variables are:

$$\begin{aligned}
\frac{\partial \Pr(y=0)}{\partial x} &= -\phi(-\beta' x)\beta \\
\frac{\partial \Pr(y=1)}{\partial x} &= \left[\phi(-\beta' x) - \phi(\mu_1 - \beta' x)\right]\beta \\
\frac{\partial \Pr(y=2)}{\partial x} &= \left[\phi(\mu_1 - \beta' x) - \phi(\mu_2 - \beta' x)\right]\beta \\
\frac{\partial \Pr(y=3)}{\partial x} &= \left[\phi(\mu_2 - \beta' x)\right]\beta
\end{aligned} \tag{6}$$

Comparison of the SUR, Ordered Probit and Multivariate Probit System Analyses

Limdep 8.0 (Green 2002) was used for the analyses. The estimations for the various concern issues are displayed for each of the three model approaches in Tables 4.1 to 17.1. Thus in Table 4.1 the reported coefficients are labeled as: Model 1 (from the seemingly unrelated regression), Model 2 (multivariate probit system) and Model 3 (ordered probit analysis). The marginal effects of significant coefficients for the ordered probit models (Model 3 results) are given in each case in the separate Tables 4.2 to 17.2.

The estimation results explaining concerns for the food risk issue of bacteria in food production are given in Tables 4.1 and 4.2. For these and subsequent results we discuss only the significant coefficient estimates.

Table 4.1 Bacteria in Food: Estimated Coefficients

	SUR Parameter Estimates	t-ratio	MProbit Parameter Estimates	t-ratio	OProbit Parameter Estimates	t-ratio
Constant	-0.381	-1.656	-0.186	-0.464	0.286	0.872
TGOV	-0.1	-1.429	0.128	1.071	0.052	0.535
TFOOD	-0.179**	-2.453	-0.185	-1.502	-0.153	-1.501
TFARM	-0.021	-0.292	0.108	0.903	0.149	1.467
TFAMIL	-0.039	-0.592	-0.086	-0.767	-0.112	-1.212
TRESEA	0.149	1.253	0.307	1.42	0.517***	2.81
TCONS	0.343***	3.523	0.161	0.972	0.144	1.038
AGE	0.002	0.663	-0.005	-1.197	-0.009**	-2.421
MALE	-0.117	-1.764	0.137	1.218	0.049	0.525
CHILD	0.026	0.863	0.078	1.586	0.059	1.438
UNIVER	-0.033	-0.464	0.056	0.459	0.142	1.448
EMPLOY	0.067	0.927	-0.119	-0.988	-0.002	-0.019
INCOME	-0.016	-1.278	-0.011	-0.558	-0.007	-0.412
BORG	0.230**	2.128	-0.172	-0.881	-0.235	-1.517
BC	-0.218	-1.463	-0.362	-1.444	-0.226	-1.111
PRAIRIE	-0.075	-0.518	-0.252	-1.052	-0.178	-0.901
ON	-0.137	-1.099	-0.268	-1.293	-0.266	-1.551
QC	-0.142	-1.103	-0.501**	-2.315	-0.537***	-2.999
R Squared	0.055					
Adjusted R-squared	0.031					
Restricted LL			-1054.360		-814.688	
Chi-squared					52.066	
Observation	646		646		625	

Note: *** denotes significant at 0.01 level; **significant at 0.05 level; *significant at 0.1 level.

Table 4.2 Bacteria in Food: Estimated Marginal Effects for Model 3

	High risk	Moderate risk	Slight risk	Almost no risk
TRESEA	-0.2040	0.0306	0.1013	0.0720
TCONS	-0.0562	0.0035	0.0278	0.0248
AGE	0.0034	-0.0001	-0.0017	-0.0016
QC	0.2094	-0.0199	-0.1033	-0.0863

From results across the three models the following differences can be seen. The OLS equation suggests that TFOOD, TCONS and BORG are significant explanators of concerns about bacteria in food, but these are not significant in the ordered probit and multivariate binary probit estimations, which tend to show very consistent results. This pattern is seen also for numbers of the concern issues in the following tables. There are two possible explanations: the process of data normalization may be identifying influences that only appear or become evident when the data are adjusted for variations in concerns between individuals (because of the normalization process). Alternatively it may be that the data normalization process is insufficient to overcome the underlying discrete nature of the data. If the latter is the case, the use of the OLS will be inappropriate, since few of the assumptions of OLS will be satisfied. Because of the concern that the latter situation applies most of the following discussions for this and other sets of models focuses on Models 2 and 3.

The marginal effect of variable TRESEA (those who viewed research institutes as trustworthy) is significant and indicates the same influence as TCON: respondents who trusted information from research institutes and consumer associations were more likely to view bacteria in food as a risky issue. Residents of Quebec seemed to hold different attitudes from others on the issue of bacteria in food, tending to consider this issue to be more risky. From the marginal estimates in Table 4.2, Quebec residents were 20.9% more likely than others to consider bacteria as a "high risk" issue and 8.6% less likely to see this issue as "almost no risk". Older people were more likely to view bacteria as "high risk".

It may be of interest to note the following Government of Canada statement *"Pesticides are products that are developed to control, destroy or inhibit the activities of pests. Some pesticide products are available for domestic use, while a larger number are available for commercial and restricted uses. All pesticide products are highly regulated at all levels of government."* (Health Canada 2005). The estimation results relating to herbicide/pesticide residuals as a food risk are given in Tables 5.1 and 5.2. In the estimation of pesticide risk rankings, consistently significant variables are TGOV, MALE, UNIVER, BORG and QC, indicating that those who trust information from the

Canadian Government were more likely than others to see pesticide use as being less risky.

Women were more likely than men to be concerned about pesticide residues in food. From Table 5.2 it is seen that females were 6.7% more likely to see pesticide residues as "high risk" than were males. This feature may relate to the general tendency for women to be the primary grocery shopper and the main meal maker in their households and it may reflect different perceptions of risk. This result is consistent with conclusions from several previous studies (Govindasamy and Italia 1998; Nayga 1996; Dosman et al. 2001).

Respondents who often bought organic food were 24.9% more likely than those that did not to see pesticide residues in food as a "high risk" issue. Residents of Quebec viewed pesticide residues in food as more risky than did other Canadians. Being a Quebec resident increased the probability of expressing pesticide residues as a "high risk" issue.

Table 5.1 Herbicide/Pesticide Residuals: Estimated Coefficients

	SUR Parameter Estimates	t-ratio	MProbit Parameter Estimates	t-ratio	OProbit Parameter Estimates	t-ratio
Constant	-0.172	-0.886	0.051	0.125	0.448	1.379
TGOV	0.068	1.145	0.249**	1.999	0.307***	3.096
TFOOD	0.019	0.306	0.058	0.461	0.054	0.533
TFARM	-0.037	-0.611	0.099	0.795	0.123	1.199
TFAMIL	0.049	0.878	-0.097	-0.838	0.003	0.029
TRESEA	-0.198	-1.962	-0.061	-0.278	0.048	0.272
TCONS	0.094	1.146	-0.114	-0.687	-0.079	-0.570
AGE	0.000	0.088	-0.005	-1.065	-0.007	-1.864
MALE	0.051	0.907	0.182	1.583	0.174*	1.846
CHILD	-0.021	-0.846	0.010	0.189	0.049	1.186
UNIVER	0.031	0.516	0.217	1.746	0.189*	1.910
EMPLOY	0.121	1.990	0.073	0.574	0.100	0.981
INCOME	-0.025**	-2.415	-0.029	-1.348	-0.013	-0.738
BORG	-0.132	-1.441	-0.800***	-3.534	-0.634***	-3.898
BC	0.052	0.409	-0.247	-0.921	-0.144	-0.699
PRAIRIE	0.002	0.019	-0.189	-0.750	-0.183	-0.923
ON	0.065	0.615	-0.157	-0.712	-0.165	-0.968
QC	-0.155	-1.423	-0.563**	-2.459	-0.573***	-3.213
R Squared	0.039					
Adjusted R-squared	0.013					
Restricted LL			-1054.360		-793.650	
Chi-squared					79.312	
Observation	646		646		623	

Note: ***significant at 0.01 level; **significant at 0.05 level; *significant at 0.1 level.

Table 5.2 Pesticide Residuals: Estimated Marginal Effects of Model 3

	High risk	Moderate risk	Slight risk	Almost no risk
TGOV	-0.1196	0.0139	0.0648	0.0410
MALE	-0.0672	0.0056	0.0367	0.0248
UNIVER	-0.0727	0.0056	0.0398	0.0274
BORG	0.2488	-0.0597	-0.1275	-0.0616
QC	0.2238	-0.0365	-0.1186	-0.0686

The estimation results relating to the use of hormones in food production are given in Tables 6.1 and 6.2. From Table 6.1 only TRARM and BORG are significant in both the ordered probit and multivariate probit system models. From these results, respondents who trust farmers' associations were more likely to consider use of hormones as less risky. The other results are similar to the estimations of risk rankings for pesticide residuals in food. If the respondent often bought organic food, s/he was 29.1% more likely to view than others to see this as a "high risk" issue. Quebec residents perceived greater risks than others from the use of hormones in food production.

Table 6.1 Use of Hormones in Food: Estimated Coefficients

	SUR Parameter Estimates	t-ratio	MProbit Parameter Estimates	t-ratio	OProbit Parameter Estimates	t-ratio
Constant	-0.142	-0.695	0.103	0.266	0.379	1.147
TGOV	-0.010	-0.162	0.171	1.480	0.189	1.906
TFOOD	0.095	1.457	0.045	0.369	0.170	1.664
TFARM	0.082	1.276	0.331***	2.711	0.283***	2.762
TFAMIL	-0.009	-0.156	-0.128	-1.161	-0.118	-1.260
TRESEA	0.003	0.031	0.177	0.827	0.382**	2.078
TCONS	-0.006	-0.075	-0.184	-1.129	-0.145	-1.053
AGE	0.000	-0.027	-0.007	-1.627	-0.009**	-2.355
MALE	0.037	0.621	0.245**	2.176	0.141	1.474
CHILD	0.018	0.684	0.075	1.489	0.067	1.606
UNIVER	-0.049	-0.778	0.111	0.928	0.072	0.722
EMPLOY	-0.066	-1.037	-0.190	-1.540	-0.147	-1.444
INCOME	0.005	0.474	-0.001	-0.047	0.024	1.349
BORG	-0.236**	-2.450	-0.700***	-3.454	-0.757***	-4.615
BC	0.012	0.091	-0.345	-1.307	-0.165	-0.778
PRAIRIE	0.049	0.378	-0.119	-0.482	-0.015	-0.075
ON	-0.049	-0.442	-0.349	-1.601	-0.175	-1.000
QC	0.063	0.546	-0.420	-1.894	-0.274	-1.510
R Squared	0.028					
Adjusted R-squared	0.002					
Restricted LL			-1054.360		-785.708	
Chi-squared					89.302	
Observation	646		646		592	

Note: denotes ***significant at 0.01 level; **significant at 0.05 level; *significant at 0.1 level.

Table 6.2 Use of Hormones in Food: Estimated Marginal Effects for Model 3

	High risk	Moderate risk	Slight risk	Almost no risk
TFARM	-0.1019	-0.0019	0.0597	0.0442
TRESEA	-0.1442	0.0129	0.0819	0.0494
AGE	0.0031	0.0001	-0.0018	-0.0014
BORG	0.2905	-0.0537	-0.1559	-0.0809
QC	0.1000	-0.0007	-0.0583	-0.0410

Estimation results relating to the use of antibiotics in food production are given in Tables 7.1 and 7.2.

Table 7.1 Use of Antibiotics: Estimated Coefficients

	SUR Parameter Estimates	t-ratio	MProbit Parameter Estimates	t-ratio	OProbit Parameter Estimates	t-ratio
Constant	-0.368	-1.631	-0.168	-0.436	0.089	0.269
TGOV	0.020	0.292	0.180	1.547	0.114	1.129
TFOOD	0.092	1.291	0.102	0.856	0.214**	2.062
TFARM	0.030	0.430	0.239	1.992	0.265**	2.542
TFAMIL	0.048	0.743	-0.033	-0.301	-0.029	-0.304
TRESEA	0.048	0.409	0.145	0.695	0.280	1.527
TCONS	-0.028	-0.299	-0.177	-1.071	-0.161	-1.144
AGE	0.004	1.440	-0.001	-0.304	-0.005	-1.212
MALE	0.060	0.923	0.284***	2.585	0.282***	2.936
CHILD	0.034	1.159	0.047	0.960	0.071	1.680
UNIVER	0.006	0.093	0.261**	2.208	0.166	1.645
EMPLOY	0.011	0.160	-0.007	-0.057	-0.073	-0.696
INCOME	0.001	0.081	-0.012	-0.575	0.024	1.328
BORG	-0.176	-1.669	-0.700***	-3.675	-0.640***	-3.923
BC	0.047	0.323	-0.351	-1.345	-0.052	-0.250
PRAIRIE	-0.038	-0.270	-0.204	-0.807	-0.063	-0.315
ON	-0.036	-0.295	-0.377	-1.698	-0.190	-1.087
QC	-0.012	-0.099	-0.532**	-2.353	-0.466**	-2.563
R Squared	0.018					
Adjusted R-squared	-0.009					
Restricted LL			-1136.928		-785.708	
Chi-squared					89.302	
Observation	646		646		592	

Note: ***significant at 0.01 level; **significant at 0.05 level; *significant at 0.1 level.

Table 7.2 Use of Antibiotics: Estimated Marginal Effects for Model 3

	High risk	Moderate risk	Slight risk	Almost no risk
TFOOD	-0.0789	-0.0015	0.0392	0.0412
TFARM	-0.0994	0.0019	0.0497	0.0479
MALE	-0.1040	-0.0013	0.0516	0.0537
BORG	0.2494	-0.0413	-0.1219	-0.0862
QC	0.1777	-0.0124	-0.0884	-0.0769

The significant variables from Model 3 for risk rankings regarding the use of antibiotics in agriculture are similar to those for the use of hormones. The signs of the estimated marginal effects tended to be similar for both these risk issues.

The estimation results relating to the food risk issue of BSE (mad cow disease) are given in Tables 8.1 and 8.2. As background to this issue it is of interest to note that prior to this survey, for which data were collected in January 2003, only one case of BSE had been found in Canada, in 1993. This was identified as a beef cow that had been imported from Britain in 1987 and the incident was not given great publicity. Canadian beef was still considered safe at that time (Ollis 2005).

Table 8.1 BSE (mad cow disease): Estimated Coefficients

	SUR Parameter Estimates	t-ratio	MProbit Parameter Estimates	t-ratio	OProbit Parameter Estimates	t-ratio
Constant	0.601**	2.242	1.039***	2.615	0.964***	2.827
TGOV	0.130	1.606	0.313***	2.709	0.283***	2.808
TFOOD	-0.353***	-4.156	-0.353***	-2.868	-0.366***	-3.412
TFARM	0.084	0.998	0.098	0.810	0.220**	2.094
TFAMIL	0.003	0.033	-0.080	-0.728	-0.087	-0.902
TRESEA	0.016	0.114	0.161	0.847	0.132	0.745
TCONS	0.034	0.300	-0.201	-1.233	0.003	0.024
AGE	-0.003	-0.833	-0.012***	-2.763	-0.011***	-2.969
MALE	-0.087	-1.128	0.102	0.920	0.086	0.878
CHILD	-0.022	-0.624	0.034	0.641	0.014	0.328
UNIVER	0.179**	2.176	0.256**	2.119	0.335***	3.264
EMPLOY	0.111	1.330	0.036	0.297	-0.026	-0.244
INCOME	-0.013	-0.875	-0.016	-0.800	0.012	0.692
BORG	0.241	1.915	-0.017	-0.097	-0.145	-0.947
BC	-0.054	-0.311	-0.051	-0.182	-0.204	-0.916
PRAIRIE	0.020	0.117	-0.111	-0.402	-0.077	-0.354
ON	-0.194	-1.335	-0.319	-1.345	-0.361	-1.900
QC	-0.478***	-3.183	-0.788***	-3.286	-0.743***	-3.796
R Squared	0.087					
Adjusted R-squared	0.062					
Restricted LL			-1136.928		-794.824	
Chi-squared					90.482	
Observation	646		646		617	

Note: ***significant at 0.01 level; **significant at 0.05 level; *significant at 0.1 level

Table 8.2 BSE (mad cow disease): Marginal Effects for Model 3

	High risk	Moderate risk	Slight risk	Almost no risk
TGOV	-0.0981	-0.0124	0.0038	0.1067
TFOOD	0.1278	0.0154	-0.0058	-0.1374
TFARM	-0.0759	-0.01	0.0023	0.0835
AGE	0.0038	0.0005	-0.0001	-0.0043
UNIVER	-0.1115	-0.017	-0.0003	0.1288
QC	0.268	0.021	-0.0254	-0.2636

Table 8.1 indicates that the variables TGOV, TFOOD, AGE, UNIVER and QC tend to be significant influences on choices of risk ratings for BSE. Those expressing more confidence in information from the Canadian Government were less likely to perceive BSE as a high risk, but those with more confidence in the trustworthiness of the food industry saw BSE as "high risk". Respondents with a university education tended to express less concern about the food risk issue of BSE. Respondents who lived in Quebec perceived BSE to be more risky than did other respondents.

Estimation results relating to the use of food additives are given in Tables 9.1 and 9.2

Table 9.1 Food Additives: Estimated Coefficients

	SUR Parameter Estimates	t-ratio	MProbit Parameter Estimates	t-ratio	OProbit Parameter Estimates	t-ratio
Constant	0.137	0.630	0.853**	2.088	1.391***	4.412
TGOV	0.012	0.178	0.339***	2.884	0.276***	2.908
TFOOD	0.156**	2.263	0.206	1.635	0.147	1.478
TFARM	-0.076	-1.116	0.098	0.785	0.105	1.068
TFAMIL	0.108	1.730	-0.074	-0.644	0.008	0.087
TRESEA	0.068	0.604	-0.054	-0.260	0.192	1.168
TCONS	-0.124	-1.348	-0.517***	-2.782	-0.270**	-2.017
AGE	-0.004	-1.457	-0.014***	-3.120	-0.012***	-3.275
MALE	0.071	1.132	0.370***	3.229	0.325***	3.559
CHILD	-0.056	-1.998	-0.031	-0.598	-0.005	-0.123
UNIVER	-0.158**	-2.357	-0.017	-0.138	-0.032	-0.335
EMPLOY	-0.114	-1.672	-0.227*	-1.860	-0.213**	-2.175
INCOME	0.028**	2.375	0.039	1.915	0.027	1.609
BORG	-0.125	-1.224	-0.536***	-2.985	-0.671***	-4.503
BC	0.130	0.918	-0.080	-0.317	0.046	0.228
PRAIRIE	0.022	0.161	-0.306	-1.232	-0.124	-0.632
ON	0.104	0.878	-0.223	-1.030	-0.080	-0.475
QC	0.423***	3.466	0.010	0.044	0.137	0.783
R Squared	0.081					
Adjusted R-squared	0.056					
Restricted LL			-1136.928		-817.521	
Chi-squared					82.460	
Observation	646		646		628	

Note: ***significant at 0.01 level; **significant at 0.05 level; *significant at 0.1 level.

Table 9.2 Food Additives: Estimated Marginal Effects for Model 3

	High risk	Moderate risk	Slight risk	Almost no risk
TGOV	-0.0553	-0.0542	0.0472	0.0623
TCONS	0.0459	0.0598	-0.0359	-0.0698
AGE	0.0022	0.0024	-0.0019	-0.0027
MALE	-0.0612	-0.0671	0.0508	0.0775
EMPLOY	0.0397	0.0447	-0.033	-0.0514
BORG	0.1717	0.0866	-0.1421	-0.1162

From Table 9.1, TGOV, TCONS, AGE, MALE, EMPLOY and BORG are all significant in both the ordered probit and multivariate probit estimations. Respondents who trusted information from the Canadian Government were more likely to view the use of food additives as less risky. Some of these results (for MALE and AGE) are consistent with the earlier study by Dosman et al. (2001). Men perceived the use of food

additives to be less risky than women; the older were respondents, the higher the probability that they perceived the use of food additives to be highly risky. The number of children in the household was expected to influence respondent's risk perceptions. However, this variable is not significant in our study, although it was a significant influence in the study by Dosman et al. (2001). Our results show that those respondents who often bought organic food were more likely than others to perceive food additives to be risky.

Estimation results relating to the use of GM/GE in food production are given in Tables 10.1 and 10.2:

Table 10.1 Use of GM/GM in Food Production: Estimated Coefficients

	SUR Parameter Estimates	t-ratio	MProbit Parameter Estimates	t-ratio	OProbit Parameter Estimates	t-ratio
Constant	0.126	0.516	0.335	0.835	0.690**	2.089
TGOV	0.088	1.189	0.347***	2.981	0.348***	3.527
TFOOD	0.171**	2.210	0.184	1.473	0.242**	2.354
TFARM	-0.023	-0.304	0.203	1.695	0.161	1.571
TFAMIL	-0.082	-1.171	-0.241**	-2.114	-0.186**	-1.994
TRESEA	0.001	0.008	0.152	0.728	0.243	1.360
TCONS	-0.391***	-3.779	-0.537***	-3.240	-0.475***	-3.323
AGE	0.008***	2.874	0.003	0.595	0.000	0.028
MALE	0.042	0.593	0.235**	2.012	0.329***	3.487
CHILD	-0.012	-0.368	0.074	1.397	0.057	1.372
UNIVER	0.130	1.742	0.253**	2.045	0.325***	3.224
EMPLOY	-0.175**	-2.292	-0.334***	-2.632	-0.280***	-2.708
INCOME	0.030**	2.285	0.022	0.995	0.027	1.527
BORG	-0.086	-0.752	-0.477***	-2.676	-0.690***	-4.335
BC	-0.139	-0.876	-0.419	-1.635	-0.182	-0.866
PRAIRIE	0.075	0.485	-0.180	-0.689	0.022	0.105
ON	0.100	0.754	-0.208	-0.922	-0.026	-0.148
QC	-0.077	-0.560	-0.534**	-2.300	-0.364**	-1.990
R Squared	0.092					
Adjusted R-squared	0.067					
Restricted LL			-777.010		-815.744	
Chi-squared					130.015	
Observation	646		646		595	

Note: ***significant at 0.01 level; **significant at 0.05 level; *significant at 0.1 level.

Table 10.2 Use of GM in Food Production Marginal Effects for Model 3

	High risk	Moderate risk	Slight risk	Almost no risk
TGOV	-0.0935	-0.0437	0.0419	0.0953
TFAMIL	0.0482	0.025	-0.0204	-0.0527
TCONS	0.1022	0.0749	-0.0239	-0.1533
MALE	-0.0836	-0.0451	0.0337	0.095
UNIVER	-0.0809	-0.0456	0.0313	0.0951
EMPLOY	0.0697	0.0394	-0.0271	-0.082
BORG	0.2198	0.0483	-0.1171	-0.151
QC	0.1002	0.0435	-0.0467	-0.097

From Table 10.1, Model 3 indicates that TGOV, TFAMIL, TCONS, MALE, EMPLOY, BORG and QC are all significant influences on respondent's risk assessment regarding the use of GM/GE in food production. Viewing the Canadian Government as trustworthy tended to reduce concern about genetically modified/engineered (GM/GE) food. Having trust in information from family and consumer associations was likely to increase respondents' concern for GM/GE production as a food risk. Men tended to exhibit less concern than women on this issue. Respondents who were fully or partly employed saw this issue to be more risky than those who were not fully employed. Respondents who often bought organic food, lived in BC, or lived in Quebec were more likely than others to perceive GM/GE to be a "High risk" food issue.

Estimation results relating concern rankings for fat and cholesterol in food are given in Tables 11.1 and 11.2:

Table 11.1 Fat and Cholesterol: Estimated Coefficients

	SUR Parameter Estimates	t-ratio	MProbit Parameter Estimates	t-ratio	OProbit Parameter Estimates	t-ratio
Constant	0.199	0.800	0.216	0.547	1.516***	4.829
TGOV	-0.208***	-2.764	-0.033	-0.282	-0.001	-0.015
TFOOD	-0.001	-0.019	0.048	0.400	0.003	0.030
TFARM	-0.038	-0.491	0.043	0.355	0.139	1.426
TFAMIL	-0.077	-1.086	-0.265**	-2.332	-0.184**	-2.057
TRESEA	-0.088	-0.680	0.136	0.620	0.043	0.263
TCONS	0.079	0.751	-0.097	-0.591	-0.088	-0.670
AGE	-0.007***	-2.615	-0.017***	-3.772	-0.017***	-4.953
MALE	-0.057	-0.789	0.189	1.624	0.167	1.843
CHILD	0.033	1.037	0.088*	1.687	0.085**	2.151
UNIVER	-0.107	-1.410	0.059	0.486	0.037	0.383
EMPLOY	0.045	0.580	-0.125	-0.980	-0.033	-0.335
INCOME	-0.010	-0.774	-0.015	-0.688	-0.020	-1.184
BORG	0.285**	2.443	-0.137	-0.694	-0.122	-0.839
BC	0.170	1.057	0.200	0.761	0.094	0.467
PRAIRIE	-0.054	-0.347	-0.012	-0.048	-0.186	-0.952
ON	0.148	1.095	0.300	1.333	0.023	0.135
QC	0.378***	2.718	0.304	1.304	0.088	0.505
R Squared	0.080					
Adjusted R-squared	0.055					
Restricted LL			-777.010		-825.05	
Chi-squared					53.932	
Observation	646		646		639	

Note: ***significant at 0.01 level; **significant at 0.05 level; *significant at 0.1 level.

Table 11.2 Fat and Cholesterol: Marginal Effects

	High risk	Moderate risk	Slight risk	Almost no risk
TFAMIL	0.0568	0.011	-0.0382	-0.0297
AGE	0.0054	0.0011	-0.0036	-0.0028
CHILD	-0.0263	-0.0052	0.0177	0.0138

In the estimation of the models analyzing risk rankings for fat and cholesterol in food, only TFAMIL, AGE, and CHILD are significant. Those who trusted information from their families, or were older, were more likely to view fat and cholesterol to be risky. Families with more children perceived fat and cholesterol to be less risky; this result is contrary to the general conclusion by Dosman et al. (2001) that respondents with children in their households perceive more health risks.

Turning to the analysis of environmental risk rankings associated with agriculture, these results are given in Tables 12.1 through 17.2. The first analysis reported, in Tables 12.1 and 12.2, concerns environmental risk seen to be associated with water pollution by chemical run-offs from agriculture. It is relevant to note that water pollution issues had received much public attention previous to the collection of this data set.

Table 12.1 Water Pollution from Agriculture: Estimated Coefficients

	SUR Parameter Estimates	t-ratio	MProbit Parameter Estimates	t-ratio	OProbit Parameter Estimates	t-ratio
Constant	-0.34**	-2.04	-1.134	-1.835	-0.215	-0.609
TGOV	-0.01	-0.21	0.291	1.567	0.260**	2.419
TFOOD	-0.11**	-2.13	0.198	1.188	0.110	0.991
TFARM	0.02	0.36	0.054	0.270	0.090	0.792
TFAMIL	0.08	1.64	-0.018	-0.107	-0.031	-0.304
TRESEA	-0.12	-1.37	0.130	0.349	0.125	0.637
TCONS	0.09	1.22	-0.127	-0.533	-0.100	-0.679
AGE	0.00	-1.82	-0.008	-1.109	-0.008**	-1.989
MALE	-0.07	-1.38	-0.208	-1.117	0.073	0.714
CHILD	-0.02	-0.88	0.051	0.683	0.030	0.672
UNIVER	0.03	0.50	-0.011	-0.059	0.119	1.102
EMPLOY	0.19***	3.65	0.226	1.169	0.268**	2.392
INCOME	-0.02	-1.71	-0.025	-0.751	-0.032	-1.693
BORG	0.12	1.59	-0.338	-1.015	-0.516***	-2.766
BC	0.02	0.15	-0.113	-0.298	0.066	0.299
PRAIRIE	0.10	1.00	0.165	0.459	0.130	0.609
ON	0.11	1.20	0.110	0.347	0.181	0.979
QC	-0.10	-1.11	-0.330	-0.953	-0.466**	-2.355
R Squared	0.073					
Adjusted R-squared	0.048					
Restricted LL			-966.020		-596.147	
Chi-squared					71.758	
Observation	646		646		635	

Note: ***significant at 0.01 level; **significant at 0.05 level; *significant at 0.1 level.

Table 12.2 Water Pollution: Marginal Effects of Model 3

	High risk	Moderate risk	Slight risk	Almost no risk
TGOV	-0.097	0.0595	0.0275	0.0099
AGE	0.003	-0.0018	-0.0009	-0.0003
EMPLOY	-0.0996	0.0613	0.0282	0.0102
BORG	0.1766	-0.1188	-0.0439	-0.0138
QC	0.1685	-0.107	-0.0457	-0.0159

As shown in Table 12.1, EMPLOY is significant in the estimation of the SUR and Ordered Probit models, but no independent variable is significant in the Multivariate probit system result. Respondents employed full or part time were less likely than others to consider agricultural water pollution to be highly risky. Respondents who frequently bought organic food were more likely to see water pollution from agriculture to be risky. Quebec residents also tended to see this issue as risky.

The analysis reported in Tables 13.1 and 13.2 applies to the environmental risk of soil erosion from agriculture.

Table 13.1 Soil Erosion: Estimated Coefficients

	SUR Parameter Estimates	t-ratio	MProbit Parameter Estimates	t-ratio	OProbit Parameter Estimates	t-ratio
Constant	0.02	0.10	-0.429	-1.050	0.307	0.959
TGOV	-0.07	-1.22	0.171	1.408	0.177	1.844
TFOOD	-0.04	-0.66	0.163	1.290	0.098	0.974
TFARM	-0.03	-0.55	-0.093	-0.754	-0.070	-0.704
TFAMIL	0.02	0.40	-0.038	-0.335	-0.035	-0.382
TRESEA	-0.02	-0.20	0.045	0.206	0.308	1.779
TCONS	0.12	1.61	-0.088	-0.537	-0.092	-0.696
AGE	0.00	-0.41	-0.004	-0.860	-0.003	-0.738
MALE	-0.01	-0.26	0.191	1.645	0.202**	2.201
CHILD	0.03	1.39	0.081	1.593	0.092**	2.260
UNIVER	-0.01	-0.24	-0.065	-0.531	0.000	-0.001
EMPLOY	-0.02	-0.43	-0.016	-0.127	-0.040	-0.405
INCOME	0.00	0.48	-0.011	-0.543	-0.014	-0.854
BORG	-0.09	-1.05	-0.544**	-2.418	-0.513***	-3.370
BC	0.24**	2.05	0.213	0.794	0.192	0.937
PRAIRIE	-0.03	-0.25	0.034	0.130	-0.099	-0.494
ON	0.03	0.34	0.149	0.646	0.126	0.738
QC	0.27***	2.61	0.184	0.774	0.108	0.607
R Squared	0.049					
Adjusted R-squared	0.023					
Restricted LL			-966.020		-773.953	
Chi-squared					40.446	
Observation	646		646		622	

Note: denotes ***significant at 0.01 level; **significant at 0.05 level; *significant at 0.1 level.

Table 13.2 Soil Erosion: Marginal Effects of Model 3

	High risk	Moderate risk	Slight risk	Almost no risk
MALE	-0.0682	-0.0047	0.0515	0.0213
CHILD	-0.0312	-0.0018	0.0234	0.0095
BORG	0.1901	-0.0265	-0.1254	-0.0382

The only significant variable in both the ordered probit and multivariate probit estimations is BORG. MALE and CHILD are significant in the ordered probit estimation. Female respondents and those who often buy organic food were more likely to perceive soil erosion as "High risk" for the environment. Those without children in the household tended to see soil erosion as "High risk" for the environment.

The analyses reported in Tables 14.1 and 14.2 relate to views of environmental risk from the use of genetically modified/engineered crops.

Table 14.1 GM/GE as an Environmental Risk: Estimated Coefficients

	SUR Parameter Estimates	t-ratio	MProbit Parameter Estimates	t-ratio	OProbit Parameter Estimates	t-ratio
Constant	0.02	0.07	-0.294	-0.745	0.077	0.237
TGOV	0.14**	2.00	0.333***	2.813	0.346***	3.518
TFOOD	0.11	1.52	0.219	1.769	0.355***	3.485
TFARM	-0.03	-0.42	0.056	0.448	0.037	0.366
TFAMIL	-0.10	-1.42	-0.280**	-2.444	-0.166	-1.788
TRESEA	0.04	0.31	0.195	0.895	0.362**	2.008
TCONS	-0.18	-1.74	-0.332**	-2.000	-0.302**	-2.184
AGE	0.01**	2.30	0.000	-0.063	0.001	0.407
MALE	0.06	0.94	0.247**	2.193	0.373***	3.942
CHILD	0.02	0.75	0.053	1.044	0.075	1.809
UNIVER	0.21***	2.85	0.221	1.827	0.247**	2.455
EMPLOY	-0.20***	-2.65	-0.304**	-2.461	-0.264**	-2.568
INCOME	0.03**	2.20	0.021	1.037	0.015	0.842
BORG	-0.31***	-2.79	-0.846***	-3.936	-0.759***	-4.765
BC	-0.02	-0.16	-0.024	-0.087	-0.012	-0.057
PRAIRIE	-0.04	-0.25	-0.083	-0.322	-0.082	-0.408
ON	0.05	0.40	0.108	0.478	0.089	0.508
QC	-0.05	-0.38	-0.277	-1.192	-0.268	-1.482
R Squared	0.086					
Adjusted R-squared	0.061					
Restricted LL			-966.020		-811.850	
Chi-squared					124.721	
Observation	646		646		601	

Note: denotes ***significant at 0.01 level; **significant at 0.05 level; *significant at 0.1 level.

Table 14.2 GM/GE as an Environmental Risk: Marginal Effects of Model 3

	High risk	Moderate risk	Slight risk	Almost no risk
TGOV	-0.1164	-0.0145	0.0669	0.064
TFOOD	-0.1134	-0.0239	0.0648	0.0725
TCONS	0.0919	0.0267	-0.0519	-0.0667
MALE	-0.1207	-0.0225	0.0691	0.0741
UNIVER	-0.0795	-0.0158	0.0457	0.0496
EMPLOY	0.0846	0.0173	-0.0486	-0.0533
BORG	0.2817	-0.0291	-0.1519	-0.1007

Variables TGOV, MALE, EMPLOY, and BORG are significant in both the ordered probit and multivariate probit models. These variables were also significant in the estimation of models assessing GM/GE food safety risk ratings. Respondents who trusted information from government tended to view GM/GE as a less risky environmental issue.

The analysis reported in Tables 15.1 and 15.2 applies to environmental risk from resistance to herbicides/pesticides.

Table 15.1 Resistance to Herbicides & Pesticides: Estimated Coefficients

	SUR Parameter Estimates	t-ratio	MProbit Parameter Estimates	t-ratio	OProbit Parameter Estimates	t-ratio
Constant	-0.35**	-1.96	-1.126	-2.209	-0.005	-0.016
TGOV	0.03	0.59	0.217	1.423	0.205**	2.001
TFOOD	0.03	0.46	0.305**	2.027	0.253**	2.388
TFARM	-0.02	-0.30	0.121	0.715	0.046	0.434
TFAMIL	0.03	0.52	-0.168	-1.209	-0.203**	-2.084
TRESEA	0.08	0.86	0.284	0.941	0.250	1.345
TCONS	-0.03	-0.43	-0.399**	-2.186	-0.158	-1.109
AGE	0.00	1.81	0.006	1.092	-0.002	-0.609
MALE	0.04	0.71	0.262	1.948	0.232**	2.387
CHILD	-0.01	-0.61	0.030	0.476	0.041	0.963
UNIVER	0.00	0.07	0.036	0.250	0.026	0.252
EMPLOY	0.07	1.23	0.113	0.715	0.055	0.529
INCOME	-0.02**	-2.08	-0.047	-1.759	-0.027	-1.528
BORG	0.04	0.47	-0.493	-1.543	-0.531***	-3.078
BC	-0.13	-1.09	-0.449	-1.407	0.022	0.103
PRAIRIE	-0.11	-1.00	-0.103	-0.366	-0.027	-0.132
ON	-0.02	-0.17	-0.043	-0.170	0.068	0.378
QC	-0.23***	-2.30	-0.459*	-1.675	-0.475**	-2.504
R Squared	0.033					
Adjusted R-squared	0.007					
Restricted LL			-980.699		-663.673	
Chi-squared					68.343	
Observation	646		646		627	

Note: Denotes ***significant at 0.01 level; **significant at 0.05 level; *significant at 0.1 level.

Table 15.2 Resistance to Herbicides & Pesticides: Marginal Effects of Model 3

	High risk	Moderate risk	Slight risk	Almost no risk
TGOV	-0.0815	0.0381	0.0361	0.0073
TFOOD	-0.1008	0.0438	0.0468	0.0101
TFAMIL	0.0809	-0.037	-0.0364	-0.0075
MALE	-0.0924	0.0412	0.0423	0.0089
BORG	0.2036	-0.1135	-0.0773	-0.0128
QC	0.1864	-0.0938	-0.0779	-0.0147

From Table 15.1, QC is significant in both the ordered probit and multivariate probit estimation of resistance to herbicides and pesticides. Male respondents, those who buy organic food often, and those who live in Quebec were more likely to consider this issue to be risky.

The analysis reported in Tables 16.1 and 16.2 applies to the respondents' concerns about adverse effect of agriculture on biodiversity.

Table 16.1 Adverse Effects of Agriculture on Biodiversity: Estimated Coefficients

	SUR Parameter Estimates	t-ratio	MProbit Parameter Estimates	t-ratio	OProbit Parameter Estimates	t-ratio
Constant	0.24	1.12	-0.414	-1.041	0.446	1.367
TGOV	-0.07	-1.11	0.166	1.404	0.210**	2.102
TFOOD	0.13*	1.87	0.247**	2.022	0.317***	3.049
TFARM	-0.03	-0.46	-0.009	-0.075	0.026	0.251
TFAMIL	-0.18***	-2.81	-0.241**	-2.114	-0.188**	-1.990
TRESEA	-0.04	-0.39	0.105	0.495	0.155	0.877
TCONS	-0.10	-1.14	-0.180	-1.126	-0.145	-1.034
AGE	0.01**	2.20	0.002	0.507	-0.002	-0.598
MALE	-0.07	-1.18	0.102	0.901	0.276***	2.909
CHILD	0.00	0.15	0.075	1.463	0.088**	2.113
UNIVER	-0.06	-0.94	-0.081	-0.695	-0.004	-0.039
EMPLOY	-0.03	-0.51	-0.002	-0.016	-0.016	-0.153
INCOME	0.02	1.72	-0.003	-0.154	-0.005	-0.290
BORG	0.00	-0.04	-0.273	-1.426	-0.313**	-2.025
BC	0.04	0.29	-0.134	-0.526	0.082	0.391
PRAIRIE	0.14	1.05	0.164	0.682	0.049	0.239
ON	-0.10	-0.81	-0.126	-0.600	-0.087	-0.496
QC	0.11	0.91	-0.095	-0.437	-0.138	-0.757
R Squared	0.051					
Adjusted R-squared	0.026					
Restricted LL			-980.699		-728.896	
Chi-squared					52.276	
Observation	646		646		584	

Note: ***significant at 0.01 level; **significant at 0.05 level; *significant at 0.1 level.

Table 16.2 adverse effect of agriculture on biodiversity: Marginal Effects of Model 3

	High risk	Moderate risk	Slight risk	Almost no risk
TGOV	-0.071	-0.0009	0.0486	0.0232
TFOOD	-0.1029	-0.0091	0.073	0.039
MALE	-0.0909	-0.0053	0.0637	0.0326
CHILD	-0.0292	-0.0013	0.0203	0.0101
BORG	0.1111	-0.0102	-0.0713	-0.0297

From Tables 16.1 and 16.2, TFOOD and TFAMIL are significant in the ordered probit analysis. For those who trusted information from food industry more, or were male or with children the probabilities of viewing agriculture to be “high risk” for biodiversity decreased, while the probabilities of expressing “almost no risk” increased.

The analysis reported in Tables 17.1 and 17.2 relates to the environmental risks of agricultural waste (e.g. animal manure) disposal.

Table 17.1 Agriculture Waste Disposal: Estimated Coefficients

	SUR Parameter Estimates	t-ratio	MProbit Parameter Estimates	t-ratio	OProbit Parameter Estimates	t-ratio
Constant	0.41**	2.13	0.144	0.342	0.741**	2.320
TGOV	-0.03	-0.44	0.174	1.312	0.153	1.570
TFOOD	-0.12	-1.94	0.126	0.930	0.032	0.320
TFARM	0.09	1.51	0.124	0.901	0.166	1.649
TFAMIL	0.15***	2.64	0.059	0.482	0.071	0.776
TRESEA	0.06	0.62	-0.007	-0.032	0.232	1.334
TCONS	0.10	1.25	-0.079	-0.466	-0.084	-0.628
AGE	-0.01***	-5.03	-0.018***	-3.630	-0.017***	-4.639
MALE	0.05	0.95	0.316**	2.551	0.233**	2.516
CHILD	-0.03	-1.07	0.033	0.621	0.021	0.508
UNIVER	-0.16***	-2.71	-0.162	-1.255	-0.149	-1.512
EMPLOY	0.00	-0.04	-0.081	-0.614	-0.074	-0.737
INCOME	-0.02	-1.68	-0.036	-1.575	-0.012	-0.724
BORG	0.24***	2.66	-0.082	-0.388	-0.293	-1.849
BC	-0.15	-1.18	-0.293	-0.998	-0.136	-0.656
PRAIRIE	-0.07	-0.55	-0.112	-0.415	-0.004	-0.022
ON	-0.08	-0.77	0.053	0.232	-0.043	-0.250
QC	0.01	0.08	0.004	0.017	-0.066	-0.369
R Squared	0.102					
Adjusted R-squared	0.077					
Restricted LL			-980.699		796.654	
Chi-squared					59.438	
Observation	646		646		637	

Note: ***significant at 0.01 level; **significant at 0.05 level; *significant at 0.1 level.

Table17.2 Agriculture Waste Disposal: Marginal Effects of Model 3

	High risk	Moderate risk	Slight risk	Almost no risk
AGE	0.0065	-0.0012	-0.003	-0.0024
MALE	-0.09	0.015	0.041	0.0341

MALE and AGE are significant in the ordered probit and multivariant probit estimations of the risks of agricultural waste (e.g. animal manure) disposal. Men and

younger people were more likely to view agricultural waste disposal as being less risky to the environment.

Comments on the Results Overall

The model results outlined here suggest that socio-economic and demographic influences affect respondents' risk ratings for food and for environmental risks of agriculture. Our results also suggest that measures of trust in institutions associated with the regulation and marketing of food tend to influence individuals' risk assessments. Many of our findings are consistent with conclusions of other researchers. Men were less likely than women to perceive high risks for many of the food safety and environment safety issues. Age is significant as a determinant of risk perceptions for food safety for additives and for fat and cholesterol content of food, with older respondents seeing these as riskier issues. Age was also significant in risk perceptions relating to agricultural waste disposal: older respondents were more concerned with this issue.

We find the number of children in respondents' households to be significant only in estimation of the riskiness of fat and cholesterol in food. The more children there are in respondents' households, the less risky they perceive this issue to be. This result is contradictory to the general conclusion of Dosman et al. (2001) that the more children there were in a household, the more likely the respondent was to perceive specified issues as health risks to members of the household. Her surveys were conducted in 1994 and 1995, more than eight years ago, suggesting that risk perceptions of those with children may have changed, perhaps due to changes in attitudes to food technologies or perhaps due to the pressures of other concerns and other risk issues.

Respondents with higher education levels consider both BSE and GM/GE to be less risky issues than do other respondents. Perhaps these respondents view themselves to know more or to be in more control about these food safety issues than those with lower levels of education or income. However, those who are fully or partly employed view GM/GE to be more risky, both as a food and environmental risk. Respondents with higher income levels tend to express more concern about herbicides/pesticide resistance than is the case for lower income respondents.

Relative to the trust proxy variables, respondents who trust the Canadian Government tend to express less risk for most of the cited issues. Even so, those who trust food industry information tend to assess BSE as a more risky issue, while those who express trust in information from family and friends are more likely to see fat and cholesterol, GM/GE (both for food and the environment), and agricultural waste disposal as higher risks. Lastly, Quebec residents are more likely to perceive more risk in most of the cited food and environment issues.

Conclusions

In considering the assumptions, nature and results of the three different models used in this study we note numbers of instances in which the SUR models are somewhat at variance with those of the other two models. The SUR models tend to show somewhat more frequent instances of significant influences than those from the ordered probit and multivariate binary probit estimations, which tend to have very consistent results. There are two possible explanations: the process of data normalization undertaken for the SUR models may be identifying influences that only appear or become evident after adjusting the data for variations between individuals (because of the normalization process). Alternatively it may be that the data normalization process is insufficient to overcome the underlying discrete nature of the data. If the latter is the case, the use of the SUR model is inappropriate, since few of the assumptions of OLS will be satisfied. Because of the concern that the latter situation applies, and because the characteristics of the ordered probit model are particularly relevant to the characteristics of the underlying data set, we conclude that the most appropriate model for the analyses reported here is the ordered probit model i.e. Model 3 in the preceding tables. The analyses reported here give a general understanding of Canadian respondents' attitudes towards the cited food and environmental risks associated with agriculture. We find gender, age, income and employment to have appreciable impacts on risk attitudes and conclude that trust in the food regulators and the marketing system are also significant influences on risk perceptions of various food and environmental safety issues. Males generally tend to express less concern for all of the food and environmental safety issues. Older respondents tend to see food additives, fat and cholesterol, and agricultural waste disposal

as more risky. The more children there are in respondents' households, the less likely is there to be a concern about the food risk issue of fat and cholesterol. Respondents with higher education levels are less likely to consider BSE and GM/GE as high food risks. However, those who are full or part-time employed are more likely to view GM/GE to be highly risky. Those with higher incomes are more likely to see resistance to herbicides and pesticides as an agricultural risk. Moreover, Quebec residents are more likely to perceive risk for most of the cited food and environment issues.

Nonetheless, it is important to note the risk rankings by respondents summarized in Table 1, which indicate that significant numbers of Canadians see some food risk issues as highly risky and others as less risky. The high risk issues for food are pesticide residuals (40% view this as a high risk issue), bacteria contamination (39%), use of antibiotics (34%), BSE (mad cow disease) (31%), and use of hormones (30%). Agriculture was seen to be a major environmental risk for several specific issues. These are: water pollution (61% saw this to be in the "high risk" category), resistance to herbicides & pesticide (49%), and agricultural waste disposal (40%).

Finally, this study analyzed data collected in early 2003. A small number of BSE cases have been found in Canada since then. Our future research will extend the analysis given here in order to assess any changes in attitudes relating to risk assessments. Specifically a similar analysis will be conducted on a comparable set of data that were collected in 2005 and comparisons will be made between the 2003 and 2005 data sets. In this analysis, particular attention will be paid to any changes in attitudes to food risks that may have occurred since early 2003.

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