KOREAN CONSUMERS' RISK PERCEPTIONS OF NEW AND MODIFIED FOOD TECHNOLOGIES: AN APPLICATION OF AN ORDERED LOGIT APPROACH

by

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ABSTRACT

Risk perception influences food preference and purchase decision. Perceived risk is assumed to be formed by various causes. Although previous studies have identified the relationship between risk perception and attitudes, trust, and socio-economic characteristics, these studies focused on the U.S. or the EU countries. This research focused on the risk perception of consumers in the Republic of Korea.

Data collected in Seoul in 2003 were used to estimate seven equations identifying key factors influencing risk perceptions related to food consumption. Respondents indicated the amount of subjective risk about potential risk source associated with eating foods raised or treated with new technologies. The ordered logit approach was estimated. The fear from eating contaminated foods, the degree of support for research activities, a preference toward agricultural production technology, and the technology approval process significantly influenced consumer risk perception.

INDEX WORDS: Risk perception, Agricultural technology, Survey data.

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To the memory of my father

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TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES AND MAPS

CHAPTER 1

INTRODUCTION

Background

The development of new and modifications of the existing agricultural and food technology guarantee the continuation of increases in both food output and quality. The adoption of genetically improved grain varieties leads to yield improvement and grain quality enhancement, while cattle breeding programs advance the output of dairy and beef products. Despite gains from technology development, some consumers find contributions to production through the application of new technology undesirable. Some of these technological advancements are objectionable because of their perceived risk either to the environment or to consumers' health.

Differences in risk perception persist within and across countries and cultures. For example, differences of risk perception formed two distinct levels of public acceptance of biotechnology in the European Union (EU) and the U.S. (Moon and Balasubramanian, 2004). The scope of government regulations flows directly from the public perception of food safety (Florkowski, Elnagheeb and Huang, 1998). Responding to apparent public concerns about the perceived environmental risks, the EU imposed rather restrictive regulations on all transgenic crops in any portion of the EU food system (Grossman and Endres, 2000). On the contrary, genetically modified crops could enter the U.S market without bringing noticebale public resistance (Hossain *et al.*, 2002a).

Risk perception influences consumers' decision-making behavior. Taylor (1974) described choice associated with risk as the origin of consumer behavior because without any of the consequence of their choice, consumers are asked to deal with a risk situation. For example, a consumer's purchase decision regarding a new brand of coffee can be influenced by the amount of his perceived risk associated with this unknown product. The lack of knowledge of the consequences of the selected choice is an initial assumption of the expected utility theory, which is often used to analyze the decision-making under risk.

Perceived risk is assumed to be formed by various causes. Perceived, rather than actual, risks associated with specific events can be exaggerated or underestimated. Outbreaks of food poisoning caused by microbiological contamination in the production or distribution can severely affect food demand. Recently, serious consideration has been given to the possibility of terroristic contamination in the food supply chain. Several previous studies have identified the relationship between risk perception and attitudes, trust, and socio-economic characteristics (Heiman *et al.*, 2000; Hossain *et al.*, 2002b; Moon and Balasubramanian, 2004). These studies, however, focused only on the U.S. or the EU countries. Because risk perception is also determined by cultural environment (Douglas and Wildavsky, 1983), an empirical model is needed to develop and test consumer reaction in other parts of the world.

This research focused on the risk perception of consumers in the Republic of Korea. The specific purpose is to examine Korean consumers' attitudes towards new and modified technologies applied in agricultural production and food manufacturing. During the last 50 years, the Republic of Korea has changed from a primarily agricultural to an advanced industrial economy. The increase in economic wealth nearly eliminated the food budget constraints and has brought an abundance of food choices to the table. With the launch of the WTO trading system, there has been an increase in the volume of competition between imported agricultural products and domestic foods, while mass media have informed about the desirable dietary behavior. Because consumers consider agricultural product quality to be as important as the price, the emphasis of agricultural production has been moving away from quantity to quality (Ministry of Agriculture and Forestry, 2005). Government, policy makers, producers, and food distributors have to be concerned not only with satisfying the quantity demanded of food, but must also learn how to cope with changing consumer preferences.

Problem Statement

Consumers subjective risk perception about food consumption can adversely influence the development of agricultural technology. The fragmented knowledge about the development and effects of commercial use of agricultural technology often delays or prevents the public acceptance of new technologies. Consumers, unaware of benefits of scientific advancements, may react adversely to the introduction of technology. The unbalanced communication of benefits and risks associated with widespread use of new inputs (e.g., herbicide tolerant wheat) or production techniques (e.g., the use of recombinant bovine somatotropin, rbST) has caused public resentment, delays, and even withdrawals of commercial applications.

Although it was first discovered in 1936 by a Russian scientist, the commercial application of the rbST was not approved until 1994. Even though the use of this hormone substantially increases milk production, consumers hesitated to accept rbST. According to Ott and Rendleman (2000) the use of rbST can be profitable to producers. "With milk prices at $13 per cwt an increase in herd level net return from the use of rbST of at least $100 per cow should be readily obtainable and net returns remain positive even if milk prices were to fall to $10 per cwt." However, farm profitability was not a convincing argument for the public to accept the new technology. Despite scientific proof that the rbST cannot harm human beings, people attached a great deal of importance to potential risk of the rbST. Voluntary labeling mitigated public suspicion toward the rbST (Zepeda *et al.*, 2003).

Policy makers' ignorance about consumer preferences hurts the efficiency of agricultural research programs. Furthermore, managers of research institutions, by neglecting the need to recognize and learn about the public attitudes towards new food production methods jeopardize the smooth transfer of technology to commercial users, farmers, agribusinesses, and distributors.

An investigation of public attitudes, of consumers frequently shopping for food, regarding their perceptions of agricultural and food processing technology reveals the existence of consumer subgroups and leads to the development of their profiles. Knowledge of consumer perceptions and the variations across the consumer subgroups can greatly affect educational efforts. By channeling facts based on science to specific clusters of consumers, they are more likely to form balanced opinions than in the absence of additional information. Consumer familiarity with all potential effects of technology determines the final acceptance of produced foods and the realization of returns from technology development.

Objectives

The purpose of this study is to examine Korean consumers' attitudes towards new and modified technologies applied in agricultural production and food manufacturing. Two specific objectives are:

1. To describe and interpret the results of the survey on risk perceptions and agricultural and food processing technology;
2. To identify factors that influence consumers' perception of risk associated with consumption of food raised or processed with new and modified technologies.

Findings of this study are expected to be of primary interest to decision-makers in public and private entities engaged in the development, testing, transfer, and applications of new and modified agricultural and food processing technologies. Government officials and corporate managers will gain insights about possible pitfalls of speedy commercialization of technology including the possible public resistance regarding its specific uses. Agribusinesses and farmers will be able to consider the possible public reaction in advance and may be able to avoid losses or improve returns by optimizing resource allocation. Consumer views will be recognized and will contribute to the decision-making process influencing the use of desired technologies in food production.

Organization of Study

Chapter 2 presents a review of literature related with the topic of this study. Chapter 3 is divided into three subsections. The section Conceptual framework discusses the economic theory as the basis of the model. The Data and Estimation procedure sections outline the data and econometric model used in this study, respectively. Chapter 4 describes estimation results. Implications from the study are presented in chapter 5.

CHAPTER 2

LITERATURE REVIEW

The literature of risk perception associated with agricultural production and food manufacturing has been rapidly increasing in recent years. Studies on risk perception were reported by psychologists, environmentalists, legal experts, political scientists, and economists. Consumer response to risk resulting from food handling, preparation and consumption has been addressed by home economists and food scientists. To agricultural economists the topic is of particular interest because risk perceptions have become increasingly important with the rapid development of biotechnology, the continued use of pharmaceuticals in livestock production, and widespread pesticide use. Outbreaks of food poisoning caused by microbiological contamination in the production and the supply chain have raised public awareness through incidents publicized in the media. More recently, the possible introduction of contaminants into the food supply chain through acts of terrorism has been seriously considered.

From the large body of literature on risk perception, this study examines published reports focused on food and agriculture. The literature in this area can be divided into papers where the primary objective was to provide insights about risk perception with regard to agricultural technology, and papers, which examined risks associated with food consumption. These papers originated from various sources, including academic institutions, government agencies, private research institutes, and international organizations.

The review of the literature pertinent to this study is organized as follows. First, the review includes general articles reporting the definition of risk perception and its characteristics.

Next, the focus of the review shifts to articles about risk perception that report results from empirical studies in agricultural production and food consumption.

Merriam-Webster dictionary (online) defined risk as “the chances of injury, damage, or loss; someone or something that creates or suggests a hazard.” This broad dictionary definition, however, is insufficient for specific academic research. For this purpose, risk can be defined in a different way. In agricultural risk management, risk is defined as “uncertain consequences, particularly exposure to unfavorable consequences” (Hardaker *et al.*, 2004). Risk is composed of two key elements: ‘uncertainty’ and ‘something bad’ (United States Department of Agriculture, 2000). The uncertainty inherent in risk is outcome related. The outcome maybe a desirable one, but it may not be desirable at all. If something desirable happened, it was not a risky situation. Consequently, if a bad event was guaranteed to occur, it was not a risk but a certainty.

The risk can play a role only when perceived by human beings. Risk perception belongs in the area of cognition. A discrepancy between the actual risk and the perceived risk often exists. For the same risk source, each individual can show a different response. Moreover, the risk assessment of ordinary people can be different from that of “scientific” experts (Slovic, 1990). The public can tell large risks from small ones (Groth, 1998). However, this difference does not mean their risk perceptions are irrational, but instead that the risk perception of the public is based on different methodologies or values from those applied by experts (Trautman, 2001).

Risk perception is formed not only by personal characteristics but through an interaction or communication among all members of the society. Risk communication is defined as “an exchange of information about the likelihood and consequences of adverse events” (Johns Hopkins Bloomberg School of Public Health, 2005). Proper communication among consumers, producers, government agencies, and media helps to shape perceptions in proportion to the risk.

The communication theory provides ideas about factors influencing risk perception such as the attitude. Groth (1998) suggested the trust as an important factor. The attitude of codex officials and consumer activists toward each other can lead to different conclusions about the risk. Wåhlberg and Sjöberg (2000) reported the role of the media, one of many available information sources, in influencing the public's risk perception. Even though media are one of the information sources, they can influence the risk perception. Using case studies Wåhlberg and Sjöberg showed concrete examples of factors responsible for forming risk perceptions.

A number of studies addressed consumers' risk perceptions in the area of biotechnology applications in food production and the issue of labeling such foods. Hine and Loureiro (2002) identified socio-demographic characteristics that influence consumer preference for mandatory labeling of genetically modified (GM) products. Hine and Loureiro hypothesized that well-informed consumers were not as concerned about the mandatory labeling of GM foods as were the less-informed consumers. Their study analyzed consumer response toward the application of biotechnology to enhance a desired attribute of the product, for example, by increasing the nutritional content and flavor of potatoes. Older people with a higher social status were more likely to accept this biotechnology application than younger people. With regard to the acceptance of biotechnology decreasing pesticide application, the elderly were more likely to accept biotechnology than younger consumers, but female respondents were less likely than males to support biotechnology applications.

Hossain *et al.* published a series of public perception studies. Using data from the national survey, Hossain *et al.* (2002a) analyzed how the public acceptance of the application of biotechnology was related to consumers' socio-demographic characteristics. They divided the application of agricultural biotechnology into two categories, i.e., plant and animal genetic modification. Respondents viewed the use of biotechnology in plant production more favorably than in animal production. Respondents' risk perception varied according to their educational attainment, knowledge of science, and trust in government. Younger and well-educated people were more supportive of plant biotechnology than older or less educated respondents. However, age and education were not significant in the equation modeling biotechnology acceptance in animal production. Results from another paper (Hossain *et al.*, 2002b) suggested that consumer personal characteristics significantly influenced their views of various biotechnology issues. Age, gender, race, education, religious views, shopping habits and political views were found to be statistically significant variables in models depicting biotechnology acceptance.

Zepeda *et al.* (2003) developed a system approach linking demand and risk perception in cases of rbST application in milk production. Their consumer utility function of milk consumption incorporated risk as a variable. By using this approach, they could derive milk demand mathematically as a function of income, price, demand for other goods, and self-protection activity. Some examples of self-protection activities in the case of milk consumption were "buying milk identified as exclusively from a non treated cow," "reducing milk consumption," or "eliminating milk from diet." Besides the milk demand equation, a risk perception equation and a self-protection activity equation were developed. The self-protection activities were modeled as a function of risk perception and labeling. The risk perception was assumed to be a function of outrage, attitudes, and demographics. Socio-demographic variables influenced consumer demand only indirectly through the perception of risk. The findings confirmed that outrage, attitudinal factors, and socio-demographic factors significantly influenced risk perception. Labeling was suggested as a method to mitigate consumers' risk perception toward rbST milk.

The relevance of labeling to risk perception was also supported by Moon and Balasubramanian (2004) who found that voluntary labeling helped consumers to reveal their real preferences. The attitude toward agrobiotechnology was the dependent variable. Explanatory variables included consumers trust in regulatory agencies, the awareness of agrobiotechnology, outrage toward agrobiotechnology, and socio-demographic variables, e.g., education, age, gender, and income. Risk perception was hypothesized to link these two sets of variables. The revealed effects of independent variables on the attitude toward biotechnology were significantly different with and without considering risk perceptions, respectively. In addition, the study compared consumer concerns between two countries. The United Kingdom consumers were more likely to be concerned about negative attributes of biotechnology than were the U.S. consumers.

Chen and Chern (2002) combined a risk perception model with a willingness-to-pay estimation. In demand analysis, risks perceived by consumers take concrete shape through the willingness-to-pay for food products. Chen and Chern established the logistic regression dependent variable where the binary variable was the choice of a non-genetically modified (GM) food. The result showed that risk perceptions, the opinion about labeling, and price influenced consumer acceptance of biotechnology. Respondents perceiving risk from GM foods were less likely to buy them. With regard to the willingness-to-pay, respondents were willing to pay a premium for differentiating non-GM products.

Previous studies suggested effective modeling approaches and the selection of variables to explain consumers' risk perception, but the investigations were focused on the U.S. or European countries. This study expands the existing literature by examining the consumer's risk perception of food consumption to industrialized countries of Asia. Specifically, survey data collected in the Republic of Korea are used to identify factors responsible for the perception of risk stemming from the application of agricultural and food processing technology.

CHAPTER 3

METHODOLOGY

The Conceptual Framework

Consumers attach importance to the methods used to raise and manufacture foods because they perceive that the agricultural and industrial processes affect the wholesomeness of the marketed products. Therefore, consumer risk perceptions associated with specific agricultural technologies may influence the decision to select or reject food produced using those technologies. Although many consumers derive special satisfaction from eating food products knowing they are safe, the degree of satisfaction is difficult to measure and largely unobservable. The concept of satisfaction is defined in economic theory as utility. To tackle the abstract nature of utility, applied economists have measured it indirectly in empirical studies.

Consumer food choices demonstrate preferences of a risky product selection among available bundles. The ability to order sets of bundles implies that consumer preferences are consistent with several assumptions. Hardaker *et al.* (2004) listed four axioms, namely, ordering, transitivity, continuity, and independence, as relevant to the decision-making process. The axioms ensure the consistency of consumer preferences. Once the four axioms are satisfied, it is possible to say that there exists the utility function U associated with a single utility value $U(a_j)$ with the risky prospect represented by symbol a_j. In this study, a consumer is assumed to be able to distinguish between alternatives, and always select the one, which leads to a higher degree of utility (or satisfaction).

Let U represents the utility resulting from the selection of item *x* produced by a specific technology, where *m* is a composite commodity of all other goods:

$$U = u(x, m) \tag{1}$$

The introduction of the risk concept changes the utility function. The recognition of the presence of risk means the outcome from consuming food *x* is not fixed. The expected utility associated with each possible outcome should be considered. Each consumer's selection could generate satisfaction or cause a loss of satisfaction.

The perceived risk by consumer, *r*, is the function of subjective probability of an adverse outcome, e.g., food poisoning, from consuming:

$$r = r(Z) \tag{2}$$

where Z is a vector of variables influencing the degree of consumer risk perception. For a risk averse individual, the consumption of *x* associated with a high-risk perception leads to lower degree of expected utility. For example, the wide dissemination of information about food poisoning or detrimental health effects of excessive fat intake can lead to increased risk perception resulting from food consumption. The effect of risk perception on utility is negative, $\frac{\partial u}{\partial r} < 0$.

Suppose that U^o and U^n represent utilities associated with two choices of 'occurrence of adverse outcome' and 'non-occurrence of adverse outcome' from an application of a specific agricultural technology in food production. U^o can occur with the subjective probability of $(1 - r(Z))$, which implies that if a consumer perceived a risk as a certain event $(r(Z) = 1)$, an adverse outcome will never take place. Similarly U^n can occur with the probability of $r(Z)$.

The expected utility function is:

$$EU = (1 - r(Z)) \cdot U^0(x,m) + r(Z) \cdot U^n(x,m) \tag{3}$$

Consumers will select a commodity *x* if the expected utility of their risk perception is larger than zero.

Once the utility function is known, it is possible to derive a demand function for a product perceived as risky. A practical outcome of an applied study is a measure of the effect of risk and price on demand. This research, focused on the general issue of the perception of risk resulting from the use of agricultural technology and its relation to food choices, derives a demand function for an aggregated food product. The consumers' goal is to maximize their utility subject to a budget constraint. From the utility maximization problem, the indirect utility function *v* is:

$$v(p, r(Z), y) \quad = \quad \text{Max.} \left\{ EU = (1 - r(Z)) \cdot U^0(x,m) + r(Z) \cdot U^n(x,m) \right\}$$

$$\text{s.t.} \quad \mathrm{I} = px + mn \tag{4}$$

where *p* is the price of *x, n* is the price of a composite commodity bundle *m,* and I is monetary income. The indirect utility function has the properties of increasing in income and decreasing in price and risk. The optimization problem can be solved using the Lagrangian technique. The first-order condition obtained by differentiating the Lagrangian with respect to *x* can be solved in terms of price. By Roy's identity, the Marshallian demand function can also be derived from the derivative of the indirect utility function with respect to prices and income, respectively. By the properties of the demand function, the quantity consumed is decreasing in price and risk:

$$-\,\mathrm{x}(\mathrm{p}, \mathrm{r}(\mathrm{Z}), \mathrm{y}) = \frac{\frac{\partial \mathrm{v}}{\partial \mathrm{p}}}{\frac{\partial \mathrm{v}}{\partial \mathrm{y}}}. \tag{5}$$

Survey results

The data used in this study were collected through a survey implemented in December 2003. The questionnaire used in the survey was designed by University of Geogia and the survey implementation was fully controlled by the Rural Development Administration in the Republic of Korea. The objective of the survey was to generate information about the attitudes, perception and consumption behavior with regard to the technology used in raising food by farmers, techniques used in postharvest handling of raw agricultural products, procedures applied by international food traders, and processing technologies used by food manufacturers. The underlying purpose of the survey was to supply information about potential links between risk perceptions and technology in order to sensitize decisions makers in technology development programs to the role of consumers in the ultimate commercial success of any technology. Because the recent history of public opposition to agricultural and food technologies in North America and Europe suggests that the inability to present scientific evidence about clear advantages of a technology leads to costly delays or an outright cancellation of widespread applications. As a result, the investment in research is mostly lost, farmers or the food industry fail to improve the quality or volume produced, while the public is denied potential benefits. Past mistakes of technology introduction and the insufficient evaluation of all effects of a new technology increased public skepticism and raised suspicion. Therefore, an examination of the public attitudes and understanding helps technology program managers and reduces the misallocation of research funds.

The short description provided in the following sub-sections provides insights about the most interesting aspects of the survey. The description is not intended to be complete, but it illustrates the most relevant aspects of the survey to this study.

Risk and food consumption. Because the risk perception plays an important role in the acceptance of new and modified foods, respondents were probed for their attitudes about risk associated with food consumption. The list of risk included food modifications that could be viewed favorably (e.g., vitamin fortification) to the use of fumigation to kill insects.

Survey results showed that 29 percent of respondents viewed an increased vitamin content obtained through breeding as posing no risk, but 41 percent perceived eating such foods as posing some or a lot of risk. About 30 percent of respondents remained neutral on this issue. Results about the risk perception of eating foods with allowable pesticide residue were dramatic. Less than two percent of respondents felt there was no risk if one consumed such foods, while 84 percent chose to answer that there was at least 'some risk' in eating foods with allowable pesticide residue. This is a very strong indication that the public at large is highly sensitive to the pesticide use in any form and volume in food production.

The use of harmless chemicals to enhance the appearance was generally perceived unfavorably. Although almost 8 percent of respondents did not view such applications as risky, still nearly 65 percent indicated that eating foods treated with harmless chemicals implied 'some' or 'a lot of risk.' The proportions of respondents viewing the fumigation of produce to kill insects were relatively smaller. Almost 15 percent of consumers did not associate any risk with such a procedure, while almost 19 percent viewed it as representing 'a lot of risk' and another 36 percent thought 'some risk' was involved. Somewhat surprising was that 77 percent of respondents associated washing produce with chlorinated water was posing at least some risk and only 7 percent did not think any risk was involved. The use of sanitizing solutions was perceived even more harshly than the use of chlorinated water. None among the surveyed selected the option 'definitely no risk' in case of the question about the use of sanitizing solution.

However, almost 81 percent associated some risk with this technology. Although sanitizing solutions are not yet commonly used, research on their development has been conducted. Finally, respondents showed a high level of tolerance for the presence of soil particles in raw fruits and vegetables. Fewer than four percent saw soil particles as posing ‘a lot of risk’ and less than 16 percent associated ‘some risk’ with such presence. More than 51 percent of respondents felt soil particles in raw fruits and vegetables posed no risk.

Research support. Respondents expressed their support for six research areas by selecting an option ranging from ‘strongly opposed’ to ‘strongly support.’ Interestingly, not a single respondent was ‘strongly opposed’ to research in any of the areas. The largest support was expressed for fruit and vegetable research where 79 percent and 77 percent of respondents, respectively, supported research in these two areas. About 74 percent of respondents also supported research on dairy livestock. However, because of such overwhelming support it is more insightful, perhaps, to list the percent of respondents who opposed research. Specifically, the following shares of respondents opposed research: 3 percent in fruit, 3.3 percent in rice, 3.5 percent in grains, 3.9 percent in vegetables, 5.4 percent in dairy livestock, and 6.3 percent in livestock, respectively.

Beneficiaries of agricultural and food technology research. Overall respondents disagreed that farmers and consumer benefitted from research. The disagreement was expressed by 26 percent of respondents with regard to benefits occurring to consumers and more than 20 percent in case of benefits occurring to farmers. The largest portion of respondents agreed that the benefits were reaped by exporters (nearly 60 percent of respondents) and food manufacturing industry (over 67 percent of respondents).

Technology approval. Prior to industrial application of a technology countries require that a technology be subjected to an approval process. The process aims at protecting consumers from untested technologies, while assuring the buyers and users of new technology that it poses no threat to quality of the product and does not have unknown detrimental effects on the environment.

The Korean Food and Drug Administration (KFDA) is the government agency in charge of food processing technology approval. The KFDA approval of technologies applied on farms was viewed as unnecessary by nearly 91 percent of respondents. Only 1.3 percent of respondents felt such an approval was 'strongly necessary.' A slightly larger share (1.5 percent) of respondents felt that the approval of technology by the food manufacturing industry was necessary, but nearly 69 percent felt it was unnecessary. A little over 24 percent of all respondents felt the approval was 'strongly necessary.' The share of respondents insisting on approval of technology was the highest in case of an approval by the supermarket chains. Nearly one in five respondents felt such an approval was necessary, while only 40 percent did not see it as necessary. In contrast, less than 8 percent of respondents expected the approval of technology by farmer organization, and nearly 66 percent saw such an approval as unnecessary.

Descriptive Statistics and Variable Specification

All respondents were women responsible for meal planning in their households. Because women usually have responsibility for food preparation in Korea, no males were included in the survey. Another reason for the single gender study was the evidence from earlier studies that more reliable results were obtained from female than male respondents because of women greater concern about technology (Cardello, 2003). Empirical research also showed that females were more likely to be concerned about food consumption (for example, Miles *et al.*, 2004; Bernard *et al.*, 2005).

Dependent variables. The specification of dependent variables was based on responses to a question listing several possible modifications or food handling procedures and the perception of such procedures by respondents as sources of risk. All respondents were asked to describe their own risk perception by responding to the following specific question: "In your view how much risk is involved by eating foods that [modified to increase vitamin content]?" Besides the food modification leading to increased vitamin content, the six risk sources used in other equations were: foods contain allowable amount of pesticide residue; were treated with harmless chemicals; were fumigated to kill insects; were washed in chlorinated water; were sprayed with a sanitizing solution; and raw fruits or vegetables containing soil particles. Respondents indicated their concerns on a five-step scale. The scale offered the following choices: "Definitely no risk", "No risk", "Neither risky, nor riskless", "Some risk", and "A lot of risk."

Despite the possibility to select from a five-step scale, in all seven cases the vast majority of respondents were satisfied with fewer options and either ignored the lower or the upper end of the scale. Only few respondents selected 'definitely no risk' in case of six questions. Therefore, first two offered choices, i.e., 'definitely no risk' and 'no risk' were combined into a single 'no risk' category. In case of the seventh issue referring to 'fruits or vegetables containing soil particles,' the fourth and the fifth categories ('some risk' and 'a lot of risk') were combined. Very few respondents considered soil particles as posing 'a lot of risk.'

Index variables. Fear is a natural feeling experienced by people and plays a role with respect to risk perception. Fear of potential risks associated with technology applications in food production has been an obstacle in the public acceptance of some products. The most publicized example of public skepticism in the United States causing a delay in technology commercialization was the case of the rbST use in milk production. Knowing the potentially important role of fear, the survey instrument probed respondents about their perceptions of risk stemming from two sources: fears related directly to food consumption (the food fear index) and fears associated with naturally occurring events (the natural event fear index).

Respondents were asked to share their views on nine specific issue. The list of risky events included, among others, ‘food poisoning caused by microbes’ and ‘pesticide contamination of foods’ as related to food consumption, while ‘being struck by lighting’, a ‘car accident’, and a ‘typhoon’ were examples of the latter. The concerns were indicated on a ten-step scale where the extreme choices included ‘no fear at all’ (=1) and ‘fear a lot’ (=10). To obtain a measure of risk perception, respondents’ answers were summed to create the fear index. The application of the food fear index and the natural fear index in the same model would lead to multicollinearity. Therefore, only the food fear index was used in the model (called simply ‘the fear index’ later in this thesis). The possible value of the fear index ranged from 3 to 30. The actual range of values was from 3 to 30 (Table 1) and the mean value was 21.9340.

Consumer support for food agricultural technology research can influence the degree of risk perception. If respondents had strongly positive attitude toward a specific technology, they were likely unafraid of its application. Moon and Balasubramanian (2004) reported that U.K. consumers had a more unfavorable attitude toward biotechnology than the U.S. consumers. The attitude differences can explain the varied public perceptions toward biotechnology between two countries.

Table 1. Descriptive Statistics of Variables Used in the Estimation of the Empirical Models.

Issue	Variable name	Definition	Mean	Std.dev.	Minimum	Maximum
Risk perception and specific events						
Modification	Vitamin	4-Step scale[a]	1.2360	1.00	0.00	3.00
Pesticide residue	Resid	4-Step scale[a]	2.1920	0.73	0.00	3.00
Appearance enhancement	Chemical	4-Step scale[a]	1.8550	0.92	0.00	3.00
Fumigation	Kilsect	4-Step scale[a]	1.5860	0.96	0.00	3.00
Chlorinated water	Cwater	4-Step scale[a]	2.1130	0.91	0.00	3.00
Sanitizing solution	Sanitiz	4-Step scale[a]	2.2250	0.87	0.00	3.00
Soil pesticides	Soil	4-Step scale[b]	1.5120	0.98	0.00	3.00
Indices						
Fear index	Ffind[c]	—	21.9340	4.44	3.00	30.00
Research index	Rsind[d]	—	23.7920	3.82	12.00	30.00
Benefit index	Bfind[e]	—	14.0690	2.78	4.00	20.00
Production technology						
Conventional practices	Convent	5-Step scale[f]	1.7160	0.67	1.00	3.00
Reduced pesticide	Modified	5-Step scale[f]	2.5830	0.92	1.00	4.00
Organic production	Nosynthe	5-Step scale[f]	4.2200	0.77	2.00	5.00
Unconventional practices	Uncontek	5-Step scale[f]	3.8180	0.77	2.00	5.00

Table 1. (Continued)

Issue	Variable name	Definition	Mean	Std.dev.	Minimum	Maximum
Approval process						
Korean FDA	KFDA	5-Step scale[g]	4.3650	0.81	1.00	5.00
Food industry	Indust	5-Step scale[g]	3.8440	0.91	1.00	5.00
Retailer	Market	5-Step scale[g]	3.2860	0.98	1.00	5.00
Farmer organization	Farmer	5-Step scale[g]	3.7920	0.92	1.00	5.00
Socio-demographic						
Education		0=High school or less; 1=College/University or graduate school	0.3350	0.47	0.00	1.00
Age		0=30-39 years; 1=40-54 years.	0.6000	0.49	0.00	1.00
Number of family members			3.9480	0.77	2.00	9.00
Income[h]			4.0290	1.91	1.00	8.00
Other variables						
Attribute of organic produces	Expensive	5-Step scale[f]	4.3620	0.55	3.00	5.00
Attribute of organic produces	Healthy	5-Step scale[f]	4.4310	0.60	3.00	5.00
Organic produce preferences	Organic	5-Step scale[i]	4.0670	0.77	2.00	5.00
Farm production	Farm	1=No; 2=Yes; 3=Don't know	1.7813	0.41	1.00	3.00

Table 1. (Continued)

Issue	Variable name	Definition	Mean	Std.dev.	Minimum	Maximum
Limited pesticide	Pestlim	5-Step scale[f]	4.3540	0.75	1.00	5.00
Organic	Pestfree	5-Step scale[f]	4.2900	0.74	1.00	5.00
International competition	Compwm	5-Step scale[f]	4.2740	0.76	1.00	5.00
Trust	Trustc	5-Step scale[f]	4.2000	0.75	1.00	5.00
Freshness	Fresh	5-Step scale[i]	4.6800	0.51	2.00	5.00
Food additives	Radditiv	5-Step scale[f]	4.1290	0.92	1.00	5.00
Pesticide technology	Rpest	5-Step scale[f]	4.4880	0.68	1.00	5.00
Partially cooked	Partial	5-Step scale[i]	3.0760	0.97	1.00	5.00
Having vitamin	Hvitamin	5-Step scale[i]	3.9650	0.81	2.00	5.00
Anti-carcinogens	Antic	1=almost never; 2=seldom; 3=neither often nor seldom; 4=often; 5=very often	4.0190	0.91	1.00	5.00
Gardening	Growfood	1=Grow own vegetables	0.0680	0.25	0.00	1.00

[a] The applied scale: 0=no risk; 1=neither risky, nor riskless; 2=some risk; 3=a lot of risk.

[b] The applied scale: 0=definitely no risk; 1=no risk; 2=neither risky, nor riskless; 3=some risk.

[c] Respondent indicated the degree of fear from 1=no fear at all to 10-fear a lot, with respect to three events: food poisoning caused by microbes, hunger, and pesticide contamination of foods.

[d] Respondent indicated the support on a five-step scale: 1=strongly oppose, 2=oppose, 3=neither support nor oppose, 4=support, 5=strongly support. The support referred to research on rice, grains other than rice, fruits, vegetables, livestock, and dairy products.

[e] Respondents indicated the support on a five-step scale: 1=strongly disagree; 2=disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree. Benefits occurred to farmers, food manufacturers, exporters, and importers.

[f] The five-step scale: 1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree.

[g] The five-step scale: 1=strongly necessary, 2=necessary, 3=neither necessary nor unnecessary, 4=unnecessary, 5=strongly unnecessary.

[h] Original income level divided by 10,000 won. Income categories were: 1=less than 199, 2=200-249, 3=250-299, 4=300-349, 5=350-399, 6=400-449, 7=450-499, 8=500 or more.

[i] The five-step scale: 1=not important at all, 2=not important, 3= Neither important nor unimportant, 4=Important, 5=very important.

In the survey implemented in this study, respondents were asked to indicate their degree of support for six agricultural technology research fields: ‘Rice production’, ‘grains other than rice’, ‘fruit production’, ‘vegetable production’, ‘livestock raised for meat’, and ‘livestock producing milk and dairy products.’ The research support index was created by adding together respondents’ answers, similarly to the creation of the fear index. The degree of support was indicated on a five-step scale, where the extreme choices included ‘strongly oppose’ and ‘strongly support’ a particular research field. The possible value of the index ranged from 6 to 30. The actual range of values was 12 to 30 (Table 1) and the mean value was 23.7920.

Another important variable reflected that respondents thought about the benefits of the research in agricultural and food technology. Benefit seekers tended to learn about the technology they thought was beneficial. Health and economic benefits were reported as one of the most important factors behind public support for the technology (Hossain *et al.*, 2002a). Several previous studies indicated that consumers favored biotechnology if it increased benefits (Buhr *et al.*, 1993; Heiman *et al.*, 2000; Hine and Loureiro, 2002). The survey implemented in the current study asked respondents to indicate the benefits of research occurring to five groups: ‘farmers are better off’, ‘consumers are better off’, ‘food manufacturers are better off’, ‘food exporters are better off’, and ‘food importers are better off.’ Offered response categories indicated five levels of agreement with the presented statement about benefits, where the extreme choices included ‘strongly disagree’ and ‘strongly agree.’ To account for the overall value of benefits, a benefit index was constructed in a way similar to the creation of the fear and research support indices. The possible value of the index ranged from 5 to 50. The actual range of values was from 5 to 25 (Table 1) and the mean value was 17.2140. Observed mean values of each benefit variables ranged between third category, ‘neither agree nor disagree’ and fourth category, 'agree.' The lowest was 3.15 for 'consumer better off' and the highest was 3.66 for 'exporters better off.' Consumers generally agreed the research in agriculture and food technology contributed to the improvement of people's life. However, respondents thought that the biggest beneficiaries of research were food exporters.

Production technology variables. The preference for a production technology played a role in risk perception. A consumer showing a preference for conventional rather than organic foods may be less concerned about the pesticide residue. Therefore, in the survey instrument consumers were asked to indicate preferences about foods produced using four agricultural technologies. Responses were classified into one of five categories, where the extreme choices included 'strongly disagree' and 'strongly agree.'

Technology approval process. Trust in regulatory agencies was generally considered a key factor in risk analysis. Moreover, in the case of an unknown and brand new technology, trust had an important role in shaping public attitudes toward the technology (Moon and Balasubramanian., 2004). In addition, non-government organizations were sometimes influential in case of such technology effects as, for example, environmental damage, food safety, and consumer protection. Therefore, respondents to the survey implemented in this project were asked to indicate their opinion about the involvement of several entities in the approval of new food production technology. Specifically, respondents expected that it was necessary for a technology to be sanctioned by various links in the supply chain. Respondents shared their opinions about the degree of trust in the 'food manufacturing industry', 'supermarket chain', and 'farmer organization' or 'government' ability to assess the safety of a new technology. A five-step scale was used offering responses ranging from 'strongly unnecessary' to 'strongly necessary.'

Socio-demographic variables. Socio-demographic characteristics of a consumer are assumed to influence food choices reflecting risk perception about technology. The value of consumer characteristics in explaining the perception of risk is in their role of identifying the profiles of the consumer segment. Socio-economics and demographic characteristics are often easier to identify than the opinions and views consumer may have. Age and education have been found to influence the acceptance of biotechnology (Hossain *et al.*, 2002a). A study by Zepeda *et al.* (2003) found that race and gender had significant impacts on consumers' risk perception toward rbST-treated milk products.

The average household monthly income exceeded three million won per month in Korea. Monthly earnings are determined by the official pay scale in the case of government employees or employees of agencies and institutions funded from the central budget, for example research institutes, public schools and universities. However, in the private sector wages and salaries are subject to management decisions and reflect market conditions. Education is highly respected in Korea and almost all young Koreans obtain a high school degree. One third of the respondents had graduated from a university (Table 1), while almost all remaining respondents had a high school diploma. The average respondent was forty years old. The average age was, to some extent, influenced by the method applied to draw the initial sample, where the youngest age of the survey participant could not have fallen below 30 years. Personal interviews conducted in home settings during data collection may have contributed the average age value because younger women in Korea were more likely to work outside home, especially those who were university graduates. However, the average of 41.81 was not higher than that of consumers surveyed in the United States. The mean age reported by Hine and Loureiro (2002) was 44.38 years while Zepeda *et al.* (2003) listed the average respondent age of 44.8 years. The average surveyed household consisted of four persons, a substantially higher number than that in the United States. The relatively large household size may have an unexpected affect on risk perception in the context of food consumption. A large household suggested the presence of children making the meal preparer be sensitive to the issue of risk-food relation. The actual consumption behavior is determined by the budget constraint and may temper the risk perception because a meal preparer and shopper could have faced a trade off between an adequate volume of food and the degree of safety resulting from applied production technology. Respondents resided in even numbers across the five areas, which were selected a priori to represent various districts of the Seoul metropolitan area (Map 1).

<u>Other variables.</u> Variables described in previous sections were used in all seven equations. However, several variables were added to selected equations given the nature of the issue modeled by dependent variables and expanded the specification.

The variable ‘Expensive’ and ‘Healthy’ were to examine the effect of attitudes toward organically produced foods in comparison to conventionally produced foods. Respondents were asked to reveal their attitude by responding to the following question: “Organically produced foods in comparison to conventionally produced foods are [more expensive (Expensive); healthier (Healthy).]” These two variables were added to equations modeling effects of breeding, production practices, i.e., ‘modification for increasing vitamin’, ‘allowable amount of pesticide residue’, and ‘treated with harmless chemicals’, because organic foods are expected to be produced without any use of engineered plants or synthetic chemicals.

Map 1. Seoul City Area

Another variable related to the issue of organic foods was the variable ‘Organic’, which measured the preference for organic products. This variable was included into the equation related to the production stage, i.e., ‘modification for increasing vitamin content’, ‘allowable amount of pesticide residue’, and ‘treated with harmless chemicals.’

Respondents were asked whether they wanted to know what happened to the food on the farm. The variable ‘Farm’ was used as an explanatory variable in equations modeling farm relevant risk sources, i.e., ‘allowable pesticide residue’, ‘treated with harmless chemicals’, ‘washed in chlorinated water’, ‘sprayed with a sanitizing solution’, and ‘containing soil particles.’

The variable ‘Pestlim’ and ‘Pestfree’ examined the effects of attitudes toward the use of pesticides. Respondents were asked to share their opinions about “how important to you is it that food [have pesticide residue within allowable limits (Pestlim); be free from pesticide (Pestfree).]” These variable were viewed as relevant in the equation investigating the risk perception of eating foods contains allowable pesticide residue.

The variable ‘Compwm’ was added to a single equation to measure the effect of attitude toward the focus of a new agricultural technology. Respondents were asked to reveal their attitude toward the focus of new agricultural technologies by responding to the following question: “New agricultural and food technologies should focus on [making agriculture more competitive on world market?]” Among food technologies, fumigation contributes to ensure competitiveness in world market by reducing the chances of transporting live pests across national borders. Therefore, the variable was inserted only ‘fumigation’ model.

The variable ‘Trustc’ investigated the effect of attitude toward the focus of a new agricultural technology. Respondents asked to reveal their concerns about assuring the trust of consumers in safe food supply from domestic or foreign sources. ‘Fumigation’ was a technology applied to long distance shipment.

The variable ‘Fresh’ measured the effect of attitudes reflecting the importance of freshness protection in foods. Consumers showed strong preference for freshness according to many reports from the retail industry. In case of agriculture, freshness is important for fruits and vegetables. In postharvest handling of fresh produce in the field or packinghouses, standard procedures involve washing produce in the process of hydrocooling or simply to remove any foreign material and microbes. Water in hydrocooling has chlorine added to it in a prescribed dose. Therefore, the variable ‘Fresh’ was related to two issues ‘the use of chlorinated water’ and ‘the used of sanitizing solutions.’

To measure the risk perception associated with adding any substances in the process of breeding, raising or handling food, the variable ‘Radditiv’ was created. The variable ‘Radditiv’ described respondents’ views on new agricultural technologies reducing the presence of additives in food. It was included in five equations modeling the risk perception resulting from eating food ‘modified to increase vitamin content’, ‘treated with harmless chemicals’, ‘fumigated to kill insects’, ‘washed in chlorinated water’, and ‘sprayed with sanitizing solution.’ Some of the treatments could leave small amounts on the surface of foods or even penetrate, for example, the flesh of fruits.

The variable ‘Rpest’ described respondents’ views on new agricultural technologies reducing the amount of pesticide used in production. The variable was included in two equations modeling the risk perception resulting from eating foods containing ‘allowable amount of pesticide residue’ and ‘soil particles.’ Both equations were related by ‘pesticide’ issues.

The variable ‘Partial’ was added only to the equation about the use of a sanitizing solution. Respondents were expected to respond whether they were willing to buy a partially prepared food. Partially prepared foods require less preparation at home and shorten the meal preparation time, while generating less waste. However, partially prepared foods might have been contaminated by harmful bacteria such as Salmonella. A sanitizing solution reduces or effectively kills harmful kinds of germs.

A group of consumers considered the vitamin content as an important attribute of food. The variable ‘Hvitamin’ measured the effect of the attitude toward vitamin. The variable was added to the model of the risk perception stemming from the ‘modification increasing vitamin content.’ It seemed to be clear that this issue is relevant with foods modified to increase vitamin content.

The variable ‘Antic’ investigated the effects of consumer attitudes toward anti-carcinogens. Some materials can cause cancer. For example, chlorine is a known carcinogen. ‘Antic’ was added to two models: ‘modification increasing vitamin content’ and ‘the use of chlorinated water to wash fresh produce.’

The variable ‘Growfood’ investigated whether consumers intended to cultivate their own vegetable or not. Growing food is a hobby that can prevent consumption of possibly contaminated retail food products. Because the variable was limited to growing vegetables, it was excluded from the equation of fumigation.

Estimation Procedure

The perceived risk by consumer, y, was assumed as the function of subjective probability of an adverse outcome from consuming food. The degree of consumer risk perception is influenced by a vector of variables, i.e., socio-economic variables. It is, however, impossible to observe consumers' actual risk perception. Modeling with a latent variable is widely used in economic analysis (Moon *et al*., 2002; Huang *et al*., 1999). Even though consumers' risk perception is not observed directly, the categories that indicated respondent concerns are known. By estimating the probability of choosing a certain category, respondents' risk perceptions can be implicitly inferred.

The ordered logit or probit method was deemed the most suitable for the model estimation given the nature of the responses. The question format used in the survey instrument led to the specification of dependent variables indicating the degree of risk perception toward food consumption (Table 1). Respondents indicated their concerns on a five-step scale, where the description of agricultural technology used in food production ranged from representing 'definitely no risk' to implying 'a lot of risk.' First, the theoretical structure of the probit and logit model is discussed. Then, the preferred model for the empirical specification is determined through the comparison of the model predictive power.

Let y* denote a consumer response variable toward a risk perception issue raised in a question:

$$y^* = X'\beta + \varepsilon \tag{6}$$

The consumer's actual risk perception y is unobserved, as mentioned earlier, therefore, facing a question based on a scale, a respondent will choose the category closest to her actual feelings.

We observe the consumer choice y^* such that:

$$
\begin{aligned}
y^* &= 0, && \text{if } y < 0 \\
&= 1, && \text{if } 0 < y \le \mu_1 \\
&= 2, && \text{if } \mu_1 < y \le \mu_2 \\
&= 3, && \text{if } \mu_2 < y \le \mu_3 \\
&= 4, && \text{if } \mu_3 < y \le \mu_4
\end{aligned}
\qquad (7)
$$

where the μ's are unknown parameters to be estimated (like coefficients β). Because the error term is assumed to have a normal distribution, we normalize the mean and variance of ε to equal zero and one, respectively. The probability of observed choice falling into each category is:

$$
\begin{aligned}
&\Pr ob(y = 0 \mid X) = F(-X'\beta), \\
&\Pr ob(y = 1 \mid X) = F(\mu_1 - X'\beta) - F(-X'\beta), \\
&\Pr ob(y = 2 \mid X) = F(\mu_2 - X'\beta) - F(\mu_1 - X'\beta), \\
&\Pr ob(y = 3 \mid X) = F(\mu_3 - X'\beta) - F(\mu_2 - X'\beta), \\
&\Pr ob(y = 4 \mid X) = 1 - F(\mu_3 - X'\beta).
\end{aligned}
\qquad (8)
$$

For example, $\Pr ob(y = 0)$ represents the probability of the lowest step on the scale of perceived risk selected by a consumer and the selection value is 0, while $F(\cdot)$ stands for the cumulative probability of standard normal distribution:

$$P_i = F(X'\beta) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{X'\beta} e^{\frac{-z^2}{2}} dz, \quad \left(z \sim N(0,1)\right) \qquad (9)$$

In case of the logit model, P_i is assumed to have a logistic distribution like (10)

$$P_i = F(X'\beta) = \frac{e^{X'\beta}}{1 + e^{X'\beta}} \qquad (10)$$

The difference between the logit and the probit approach is the assumption about the distribution of the error term. Contrary to the logit model associated with the logistic distribution, the probit approach maintains the normal distribution of error terms, the most persuasive distribution among probability distributions. The normal distribution assumption is justified because of the adequate amount of data in the sample and by the application of the central limit theorem.

For both the logit and the probit models, the maximum likelihood method was used to estimate the coefficients β and μ. Consumer choice (7) can be simplified:

$Z_{ij} = 1$ if y_i falls into the j^{th} category;

$Z_{ij} = 0$ otherwise;

where i = 1, 2…n., j = 0,1…m., n = 1000, and m = 4. Then, the probability equation (8) can be re-defined:

$$\Pr ob\left(Z_{ij} = 1\right) = \Phi\left(\mu_j - \beta'\chi_i\right) - \Phi\left(\mu_{j-1} - \beta'\chi_i\right) \qquad (11)$$

From (11), the maximum likelihood function is given by:

$$L = \prod_{i=1}^{n}\prod_{j=1}^{m}\left[\Phi\left(\mu_j - \beta'\chi_i\right) - \Phi\left(\mu_{j-1} - \beta'\chi_i\right)\right]^{Z_{ij}} \qquad (12)$$

By differentiating (12) with regard to β one obtains the maximum likelihood estimators. In case of logit model, the ordered probability function is defined (Calfee *et al*.,2001):

$$\Pr ob\left(U(r_1) > U(r_2) > \cdots > U(r_j)\right) = \prod_{h=1}^{j-1}\frac{e^{\beta' X(r_h)}}{\sum_{m=h}^{j} e^{\beta' X(r_m)}} \qquad (13)$$

where $X(r_h)$ is the vector of attributes of the alternative ranked h in the ordering. The maximum likelihood function is given by:

$$L = \sum_{i=1}^{n} \ln \left(\prod_{h=1}^{j-1} \frac{e^{\beta' X(r_{ih})}}{\sum_{m=h}^{j} e^{\beta' X(r_{im})}} \right) \tag{14}$$

where $X(r_{ih})$ represent the attributes of alternative that respondent i assigned in ranking h.

However, the interpretation of the ordered response model requires caution. Each estimated coefficient does not represent the effect of an individual variable on the dependent variable (Greene, 2003). Rather, marginal effects of each variable need to be calculated to establish each effect. The marginal effect is calculated by the first derivatives of the probability of choosing a category among all categories.

The marginal effect means the probability of moving from one category of responses to another. If the marginal effect is negative, this implies a movement to other category from that category once the explanatory variable changes; if the marginal effect is positive, it implies the movement into that category from other categories (He *et al*., 1998). However the magnitude of the marginal effects is not absolute but relative value. Because the marginal effects of all categories summed to zero, if the marginal effect of one category increased, the marginal effect of another category should decrease.

The choice of the logit over probit model is another stage of the empirical investigation. The main difference between the two models is the assumption of the nature of probability density function. Kmenta (1997) suggested a selection criterion. The logistic and cumulative normal distributions have the S-shape between 0 and 1. Both are similar in the mid-range but the logistic function has heavier tails than the probit function. Heavier tails imply that the logit model has an advantage in the representation of observed data frequencies concentrated in the tail.

Figures 1 through 7 showed frequency distributions of preliminary results of ordered logit and ordered probit predictions. For example, Figure 1 refers to the dependent variable representing the risk perception of consuming foods modified to increase the vitamin content and shows that the distribution of actual data was shifted to the right. Both logit and probit models generated almost the same prediction results. Contrary to the distribution of responses to other questions considered in this study, which were shifted to right, the distribution representing risk perception of consuming raw fruits and vegetables that contain soil particles was shifted to the left. In the second and the fourth categories, the predicted values obtained from the logit model were closer to the actual distribution than that of the probit model. However, as noted by Kmenta the ordered probit model showed a slightly better predictive power in the third category than the ordered logit model.

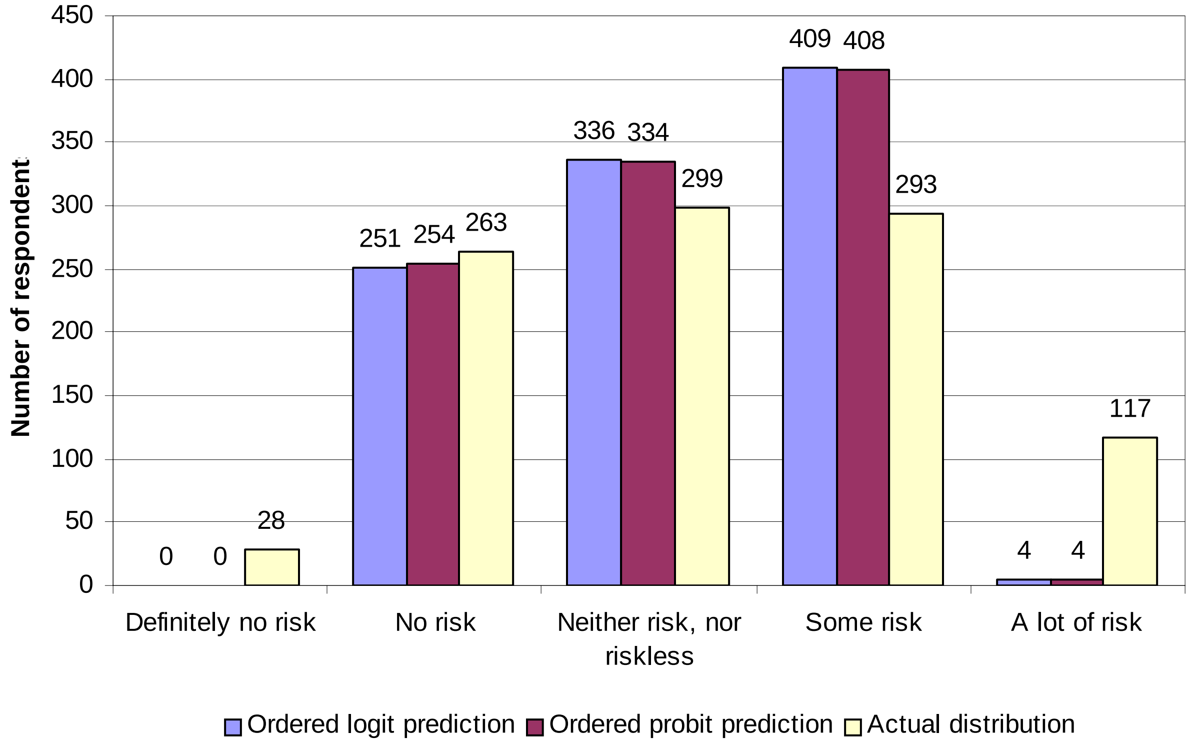

Figure 1. Distribution of Actual Frequencies, and Preliminary Results of Ordered Logit and Probit Prediction in Response to the Question "In your view, how much risk is involved by eating foods that have been modified through breeding to increase vitamin content?"

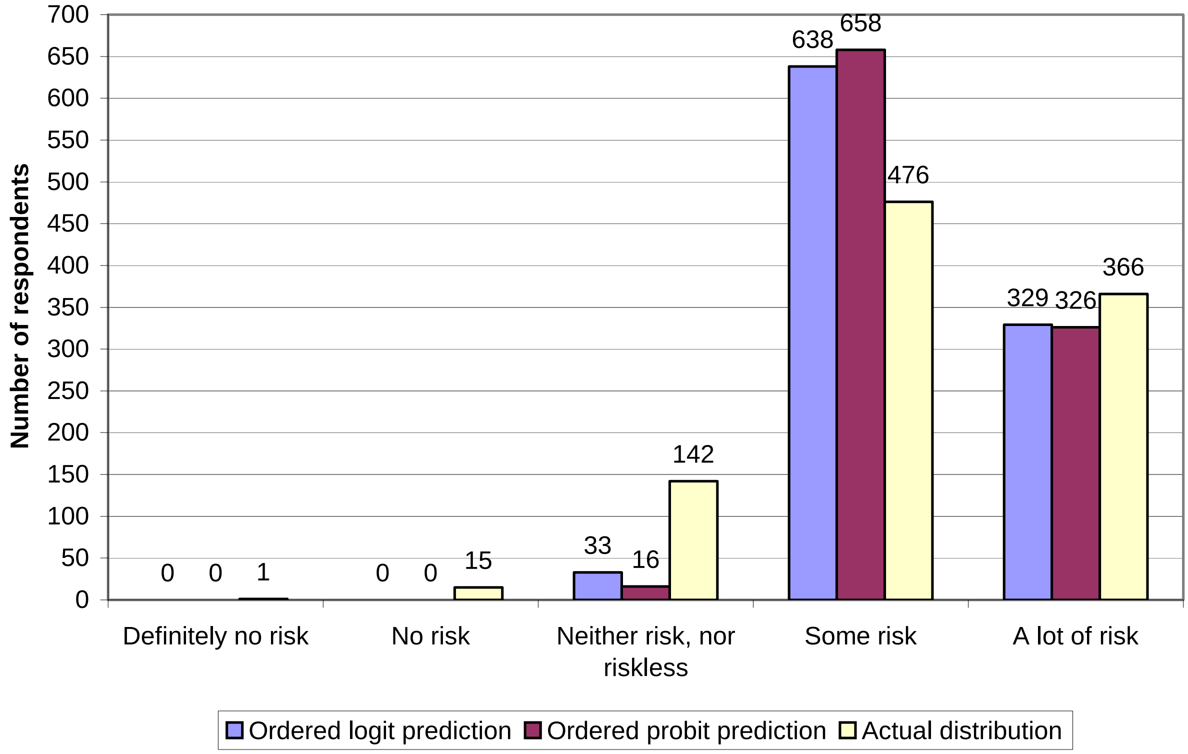

Figure 2. Distribution of Actual Frequencies, and Preliminary Results of Ordered Logit and Probit Prediction in Response to the Question"In your view, how much risk is involved by eating foods that contain allowable amount of pesticide residue?"

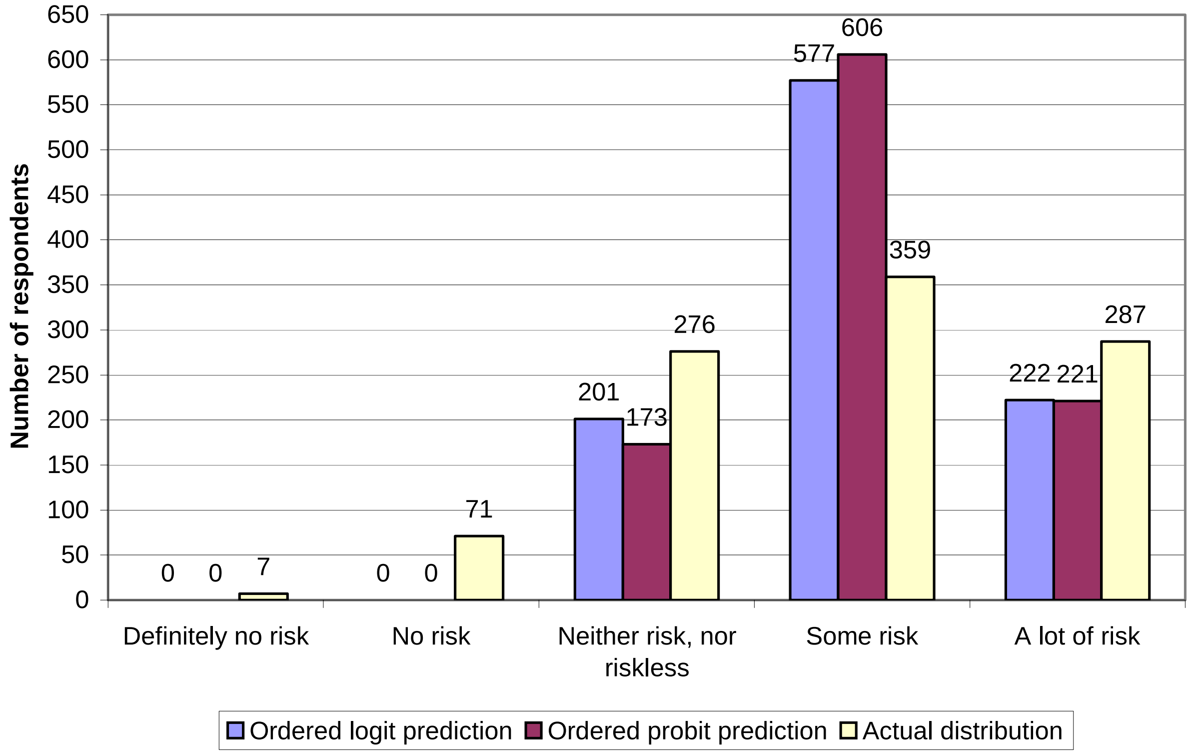

Figure 3. Distribution of Actual Frequencies, and Preliminary Results of Ordered Logit and Probit Prediction in Response to the Question "In your view, how much risk is involved by eating foods that have been treated with harmless chemicals to improve appearance?"

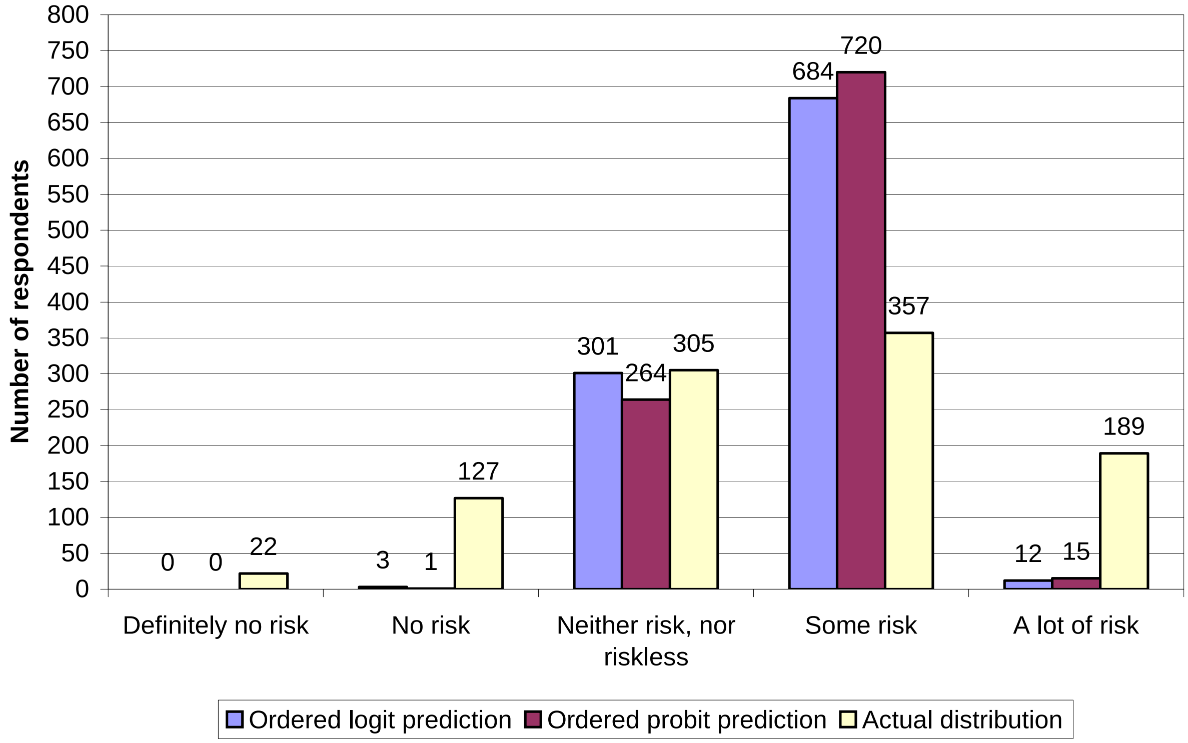

Figure 4. Distribution of Actual Frequencies, and Preliminary Results of Ordered Logit and Probit Prediction in Response to the Question "In your view, how much risk is involved by eating foods that have been fumigated to kill insects?"

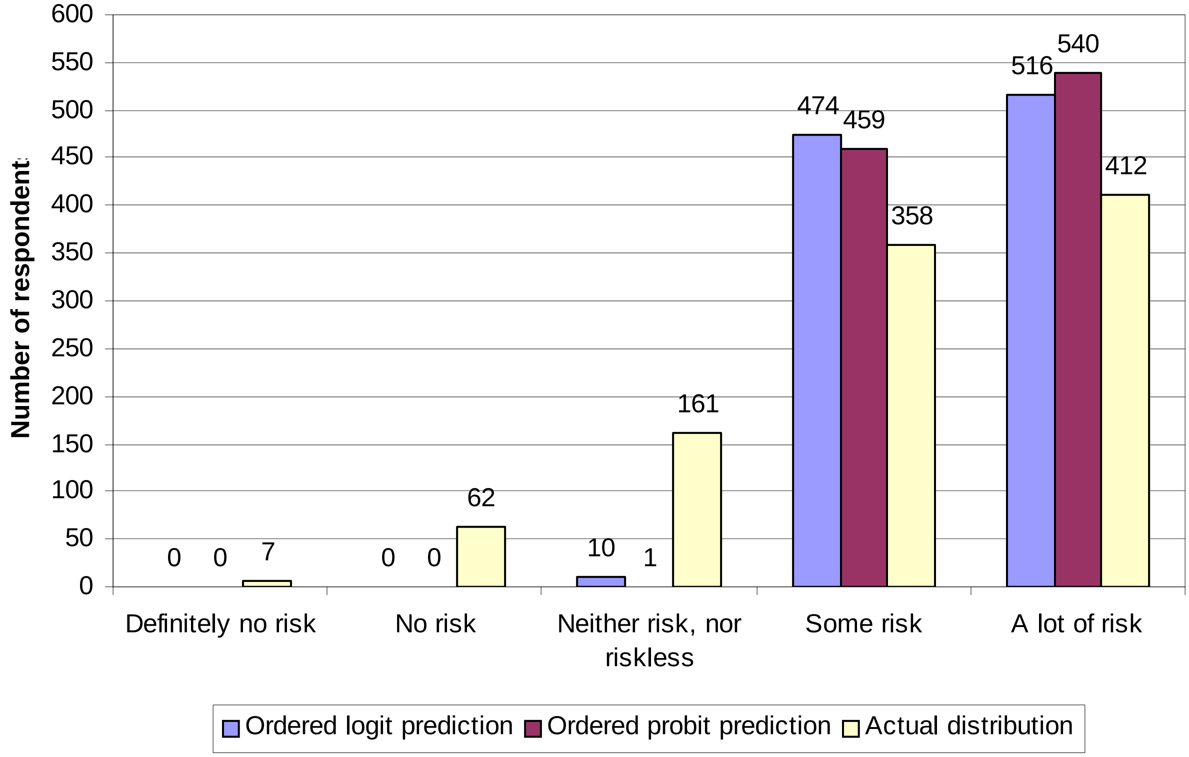

Figure 5. Distribution of Actual Frequencies, and Preliminary Results of Ordered Logit and Probit Prediction in Response to the Question "In your view, how much risk is involved by eating foods that have been washed in chlorinated water?"

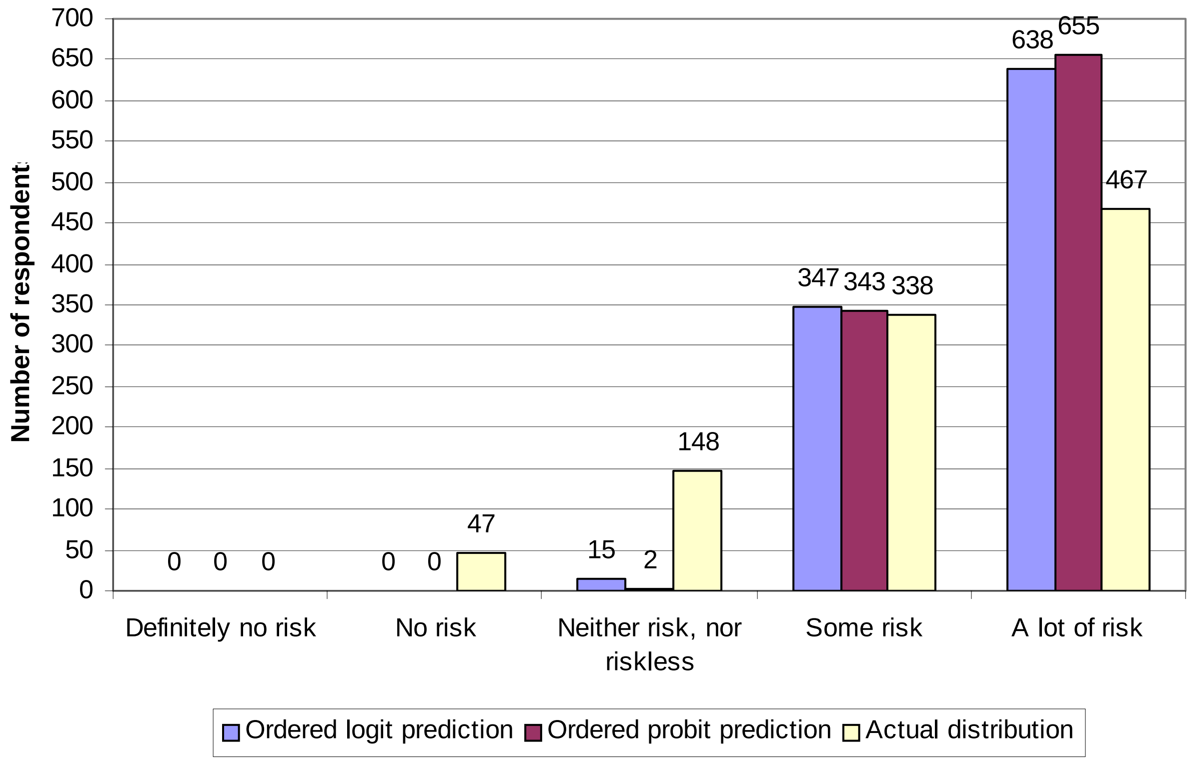

Figure 6. Distribution of Actual Frequencies, and Preliminary Results of Ordered Logit and Probit Prediction in Response to the Question"In your view, how much risk is involved by eating foods that have been sprayed with sanitizing solution?"

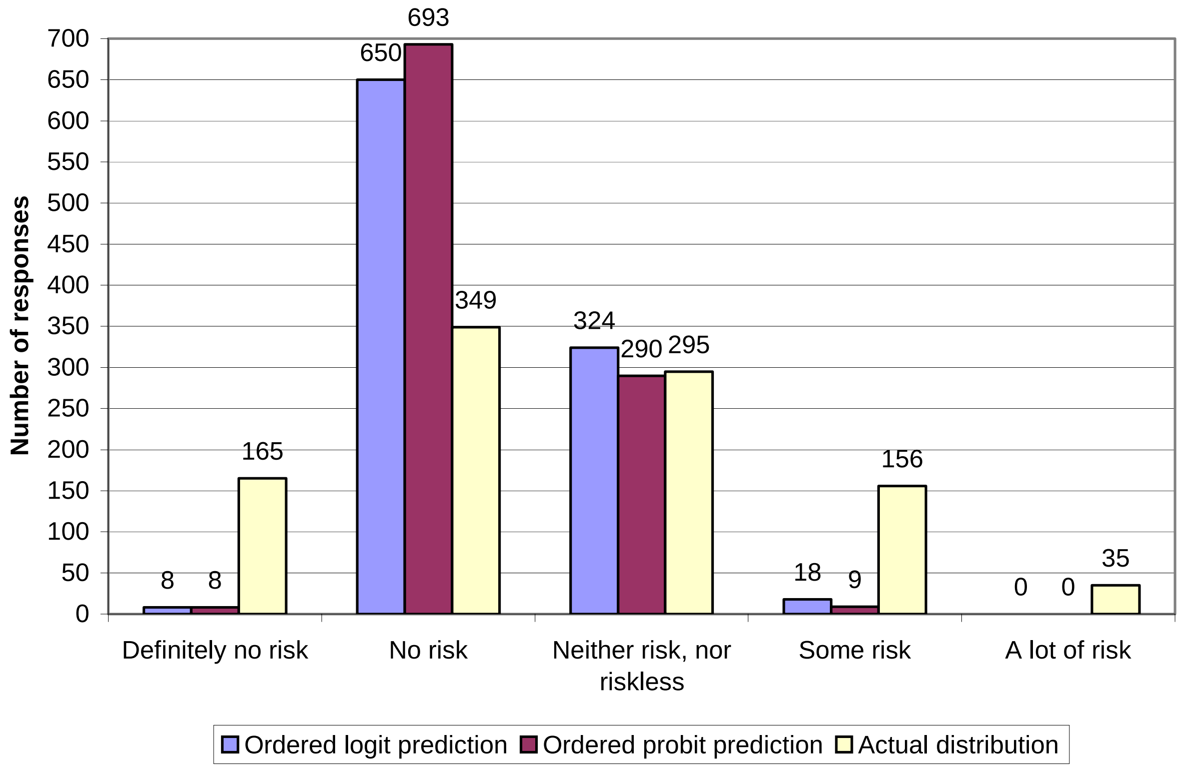

Figure 7. Distribution of Actual Frequencies, and Preliminary Results of Ordered Logit, and Probit Predictions in Response to the Question "In your view, how much risk is involved by eating raw fruits or vegetables that contain soil particles?"

CHAPTER 4

ESTIMATION RESULTS OF EMPIRICAL MODELS

This chapter presents the estimation results and interpretation of the empirical models. The first section of the chapter addresses the possible statistical problems and solutions. The representativeness of the sample is examined and the problems caused by the violation of statistical assumption were discussed. The second section presents the estimation results of consumer risk perceptions about seven risk sources associated with food consumption.

Comparison of the Sample and the Population Demographic and Socio-economic Characteristics

A comparison of demographic and socio-economic characteristics of the survey respondents and the whole population of Korea provided important insights. By design, the survey respondents were restricted to females sorted by age groups. Females are traditionally responsible for food shopping and preparation in Korea, therefore, surveying females was essential to obtain responses from the household decision makers. A slightly larger portion of survey respondents received a university degree than the number of university graduates in total population. Although the share of respondents in the highest income category is about the same as in the total population, consumers from households with the lowest income are under-represented. The share of respondents in the third income category (Table 2) was twice as large as the corresponding share in the total population. However, income level discrepancies between the sample and population profiles are common in consumer studies. Results from the current study apply mostly to households with the above average incomes. Furthermore, household income differences result from the actual survey location and geographical income

Table 2. The Comparison of Demographic and Socio-economic Characteristics of the Population of the Republic of Korea and the Survey Respondents.

Characteristics	Category	Korea	Sample respondents
		- - - - - - - - - - percent	- - - - - - - - - - -
Females	-	49.8	100.0
Age	30-39 years	47.1	40.0
	40-49 years	39.5	40.0
	50-54 years	13.4	20.0
Education	High school graduate or less	71.5	66.5
	College/University graduate or postgraduate	28.5	33.5
Household Income[a]	<195 won	34.3	6.4
	195-305 won	28.5	37.4
	306-395 won	15.0	33.9
	>395 won	22.2	22.3
Household size	1-3 members	55.5	20.4
	4 members	31.1	64.9
	>5 members	19.2	14.7

[a] Scaled by dividing by 10,000 won.

Source: 2000 Population and Housing Census Report, 2003 Annual Report on the Household Income and Expenditure Survey, National Statistical Office, Republic of Korea.

distribution. The Seoul metropolitan area receives 48.1% of the whole gross domestic product of Korea (Korea National Statistical Office, 2004a). The average household income of the Seoul metropolitan area is higher the national average (Korea National Statistical Office, 2004b). Regarding the household size, especially the smallest size category, there is a difference between shares reported in the survey and the total population. In the smallest household size category the difference is in part explained by the omission of one-person households in the survey, which focused on families. The survey design may have also contributed to the large share of household reporting four members. However, given the focus on food selection and concerns about the use of agricultural and food manufacturing technology, the distribution of households across size categories provides important insights into consumer behavior.

Heteroskedasticity

In the classical linear regression, the variance of error term is assumed to be constant for all observed values. Heteroskedasticity is commonly found in cross-sectional data. If the homoskedasticity assumption was violated, the regression estimators would not be efficient (Kmenta, 1997). Once incorrect information is incorporated in the model, the hypothesis test result and confidence intervals are suspect.

The effect of income on monthly saving amount is likely to be heteroskedastic because individuals with high-incomes have more discretionary income than the low-income respondents. The cross-tabulation of specific risk perceptions and the income level reported by respondents shows the variation across income brackets (Table 3). However, a strongly pronounced relationship between risk perceptions and the income level was not observed in the survey data. The cross-tabulation of specific risk perceptions and the educational attainment level showed a lack of clear pattern, in a way similar to that reported for household income (Table 4). Even

Table 3. Cross-tabulation of Specific Risk Perceptions and the Income Level Reported by Respondents.

Perceived risk	Income level[a]	Definitely no risk	No risk	Neither risk nor riskless	Some risk	A lot of risk
		- - - - - - - - - - number of respondents - - - - - - - - -				
Food with modified vitamin content	Less than 199	1	17	21	17	8
	200-249	1	52	52	52	16
	250-299	3	48	62	58	30
	300-349	5	58	58	69	26
	350-399	2	34	41	31	15
	400-449	8	28	27	27	10
	450-499	3	10	15	15	4
	More than 500	5	16	23	24	8
Allowable pesticide residue level in foods	Less than 199	0	4	11	28	21
	200-249	1	5	26	73	68
	250-299	0	0	22	106	73
	300-349	0	2	30	112	72
	350-399	0	3	22	56	42
	400-449	0	1	13	50	36
	450-499	0	0	3	25	19
	More than 500	0	0	15	26	35
Food treated with chemicals to improve appearance	Less than 199	1	4	18	17	24
	200-249	1	11	45	58	58
	250-299	0	10	50	82	59
	300-349	1	14	65	79	57
	350-399	0	9	36	51	27
	400-449	2	12	29	36	21
	450-499	2	2	14	12	17
	More than 500	0	9	19	24	24

Table 3. (Continued)

Perceived risk	Income level[a]	Definitely no risk	No risk	Neither risk nor riskless	Some risk	A lot of risk
		- - - - - - - - - - number of respondents - - - - - - - - -				
Fumigation of fruits and vegetables to kill insects	Less than 199	2	8	22	21	11
	200-249	4	26	52	57	34
	250-299	0	19	65	87	30
	300-349	3	27	64	85	37
	350-399	2	20	33	46	22
	400-449	4	13	30	33	20
	450-499	1	7	11	13	15
	More than 500	6	7	28	15	20
Eating foods washed with chlorinated water	Less than 199	0	6	11	11	36
	200-249	1	12	27	59	74
	250-299	0	7	32	94	68
	300-349	0	16	27	85	88
	350-399	9	3	21	39	53
	400-449	1	3	7	10	26
	450-499	2	3	13	24	34
	More than 500	0	0	13	26	35
Food sprayed with sanitizing solution	Less than 199	0	3	8	16	37
	200-249	0	8	22	51	92
	250-299	0	7	30	87	77
	300-349	0	8	35	75	98
	350-399	0	5	20	41	57
	400-449	0	8	16	31	45
	450-499	0	3	7	16	21
	More than 500	0	5	10	21	40

Table 3. (Continued)

Perceived risk	Income level[a]	Definitely no risk	No risk	Neither risk nor riskless	Some risk	A lot of risk
		- - - - - - - - - - number of respondents				- - - - - - - - -
Raw fruits and vegetables containing soil particles	Less than 199	12	25	19	8	0
	200-249	36	70	43	22	2
	250-299	28	60	67	34	12
	300-349	28	74	64	43	7
	350-399	17	43	37	23	3
	400-449	27	29	25	13	6
	450-499	6	15	18	6	2
	More than 500	11	33	22	7	3

[a] Scaled by dividing original levels by 10,000 won.

Table 4. Cross-tabulation of Specific Risk Perceptions and the Educational Attainment Reported by Respondents.

Perceived risk	Educational attainment	Definitely no risk	No risk	Neither risk nor riskless	Some risk	A lot of risk
		- - - - - - - - - - number of respondents - - - - - - - -				
Food with modified vitamin content	High school graduate or less	14	176	186	206	83
	University graduate or post grad.	14	87	113	87	34
Allowable pesticide residue level in foods	High school graduate or less	1	10	91	321	242
	University graduate or post grad.	0	5	51	155	124
Food treated with chemicals to improve appearance	High school graduate or less	6	49	188	238	184
	University graduate or post grad.	1	22	88	121	103
Fumigation of fruits and vegetables to kill insects	High school graduate or less	17	79	204	243	122
	University graduate or post grad.	5	48	101	114	67

Table 4. (Continued)

Perceived risk	Educational attainment	Definitely no risk	No risk	Neither risk nor riskless	Some risk	A lot of risk
		- - - - - - - - - - number of respondents - - - - - - - -				
Eating foods washed with chlorinated water	High school graduate or less	7	38	108	258	254
	University graduate or post grad.	0	24	53	100	158
Food sprayed with sanitizing solution	High school graduate or less	0	34	102	238	291
	University graduate or post grad.	0	13	46	100	176
Raw fruits and vegetables containing soil particles	High school graduate or less	102	226	189	123	25
	University graduate or post grad.	63	123	106	33	10

though the responses of high school graduate group was scattered more widely than that of university graduates, a relationship between risk perceptions and the educational attainment level was not clearly established.

The use of cross-tabulation is an application of an intuitive method. To test for the presence of heteroskedasticity precisely, residuals were estimated using the ordered logit approach. Then, the OLS estimation verified the relationship between the square of residuals and explanatory variables in the model. In case of confirmed linear relationship, the variable was suspected to contribute to heteroskedasticity problem.

After correcting for the presence of heteroskedasticity with White's consistent estimator covariance matrix, the result was tested by the application of the likelihood ratio test. The null hypothesis was that the variances of all observations were the same. The rationale behind the use of the likelihood ratio test was that "if the null hypothesis is true, the value of the maximized likelihood function obtained under the assumption of homoskedasticity should not differ significantly from that obtained under assumption of possible heteroskedasticity." (Kmenta, 1997).

The test static for the likelihood ratio test was:

$$\text{LR} = -2\left(\ln \hat{L}_R - \ln \hat{L}_U\right) \tag{15}$$

where, $\hat{L}_R$ and $\hat{L}_U$ represent the log-likelihood functions evaluated at the restricted and unrestricted estimates, respectively.

The possible heteroskedasticity problem was checked and corrected for all seven models. The estimation software was LIMDEP 7.0.

Multicollinearity

The classical linear regression model assumes normality and absence of correlation among explanatory variables (Kmenta, 1997). In the logistic regression, this assumption is also required. Multicollinearity in an ordered logit model implies the existence of strong correlation among the explanatory variables and hurts the explanatory power of parameters. Even though the overall test of the explanatory power of the model suggest good fit, coefficient of individual explanatory variables are statistically insignificant.

Let a regression model with two explanatory variables be:

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \qquad (16)$$

The variance of the estimated β_1 is:

$$\mathrm{Var}(\hat{\beta}_1) = \frac{\sigma^2}{\sum X_1 (1 - r_{12}^2)} \qquad (17)$$

where r_{12} is the correlation coefficient between X_1 and X_2. If the value of r_{12} approaches the value of one, the value of the variance will increase. In a multi-variable model, the factor $\frac{1}{1 - r_{12}^2}$ is generalized to $\frac{1}{1 - R^2}$ and is called the variation inflation factor (VIF). Consequently, a high degree of multicollinearity inflates the VIF value and yields imprecise parameters.

The possible existence of muticollinearity was checked for all seven models. The multicollinearity diagnosis was performed by the linear regression analysis. The dependent variable of each risk perception model was used as the dependent variable in the linear regression. The largest value among computed VIF values did not exceed 4. Usually the value of VIF exceeding 20 indicates the presence of multicollinearity. The test was performed using STATA as the estimation software.

The Test for Endogeneity

The economic theory typically guides the selection of variables that are included in the empirical model. Explanatory variables in a model are assumed to have a causal effect on the dependent variable implying the direction of the effect. However, in many economic relationships the causality is difficult to establish. Such difficulties arise from the inaccuracy due to the time period of measuring the effect, i.e., the length of the observation period. In case of the cross-sectional data used in this study, the selection of variables appearing on the right-hand-side of the equation is guided by the utility theory. The utility theory provides only general guidelines, while the proposed empirical problem examines the effect of risk on consumer perceptions. Variables included in the vector contain measures of respondent views of the importance of technology attributes or a degree of agreement with the presence of a specific attribute. Because the dependent variable is risk perception, therefore, it is possible that some responses used to specify explanatory variables were not formed independently.

Among explanatory variables, the fear index was questioned with regard to causal effect on the dependent variable. The fear index measured consumers' fear from eating contaminated foods. If the object of fear was not restricted to contaminated food, establishing causality would be less problematic. Because fear is a broad concept, it is plausible to expect that fear as a person's natural feeling can influence perceptions associated with a potential risk. The Hausman test was used to examine causality between dependent variables and the fear index.

Suppose that there are the following structural models:

$$Y = a_0 + a_1X_1 + a_2X_2 + e_1 \qquad (18)$$

$$X_1 = b_0 + b_1Y + e_2 \qquad (19)$$

where, Y represents the consumer perceived risk from eating foods that are a source of potential risks and X_1 represents the fear index.

First, X_1 was assumed to be an exogenous variable and estimated using (18). The parameters and variances from this estimation were $\hat{\delta}$ and $Var(\hat{\delta})$, respectively. Then (19) was estimated, where X_1, the fear index was the dependent variable. The obtained expected values of X_1 were used as an instrumental variable (IV) in (18). Finally, following the estimation of (18) with IV, the obtained parameters and variances were named $\hat{\delta}^*$ and $Var(\hat{\delta}^*)$.

The null hypothesis of the Hausman test is "X_1 is exogenous, both δ and δ* are consistent, and δ* is asymptotically efficient." The test statistic is:

$$w = (\hat{\delta}^* - \hat{\delta})' \{Est.Var(\hat{\delta}) - Est.Var(\hat{\delta}^*)\}^{-1} (\hat{\delta}^* - \hat{\delta}) \qquad (20)$$

For all seven equations, the test values of a statistic computed by LIMDEP 7.0 were not sufficiently large to reject null hypothesis. The fear index, therefore, can be used as an explanatory variable.

Consumer Risk Perceptions Regarding Seven Risk Sources Associated with Food Consumption

<u>Modification increasing vitamin content.</u> The fear index positively and significantly influenced the risk perception of modification that led to increased vitamin content (Table 5). The stronger the feelings of fear due to the consumption of contaminated foods, the higher perceived risk associated with eating foods modified to increase their vitamin content. The result is consistent with expectations. A person who is highly risk averse and fearful of potential risk associated with food consumption is concerned with any form of food modification, even if such a modification involves increasing the content of vitamins. Vitamins are generally viewed as a desirable element in foods and millions of consumers world-wide digest vitamin supplements in belief that their health benefits from a larger rather than smaller quantity of vitamins.

Table 5. Ordered Logit Estimation Results of the Risk Perception Associated with Eating Foods Modified to Increase Vitamin Content.

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Constant	-.1941	-.09								
Indices										
Ffind	.0731	2.18[b]	-.0073	-2.64[a]	-.0015	-.2.31[b]	.0054	1.54	.0034	.70
Rsind	-.0534	-1.44	.0059	1.78[c]	.0012	1.68[c]	-.0043	-1.09	-.0027	-.70
Bfind	-.2071	-2.95[a]	.0197	4.33[a]	.0041	3.18[a]	-.0146	-1.43	-.0092	-.71
Production Technology										
Convent	.2852	1.21	-.0151	-.75	-.0031	-.74	.0112	.80	.0070	.44
Modified	-.5780	-2.76[a]	.0463	3.29[a]	.0095	2.70[a]	-.0343	-1.40	-.0215	-.70
Nosynthe	.3906	1.90[c]	-.0430	-2.36[b]	-.0088	-2.11[b]	.0318	1.40	.0200	.65
Uncontek	.2460	1.26	-.0207	-1.17	-.0042	-1.14	.0153	.98	.0096	.58

Table 5. (Continued)

Variable name	Coefficient	t-value	Marginal effect							
			C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Approval Process										
KFDA	-.7051	-2.66[a]	.0628	3.45[a]	.0129	2.77[a]	-.0465	-1.37	-.0292	-.71
Indust	.2841	1.46	-.0261	-1.51	-.0054	-1.44	.0194	1.12	.0122	.63
Market	.4635	2.46[b]	-.0458	-3.15[a]	-.0094	-2.58[a]	.0339	1.43	.0213	.68
Farmer	-.1913	-1.17	.0189	1.18	.0039	1.14	-.0140	-.94	-.0088	-.61
Socio-demographic										
Income	-.0044	-.06	.0014	.21	.0003	.21	-.0010	-.21	-.0006	-.20
Edu[d]	-.5813	-1.75[c]	.0463	4.18a	.0081	2.03[b]	-.0339	-.33	-.0206	-.20
Age[d]	-.3717	-1.32	.0320	2.83a	.0070	1.78[c]	-.0238	-.21	-.0152	-.15
Members	.1550	.89	-.0143	-.94	-.0029	-.92	.0106	.94	.0067	.50
Other variables										
Expensive	.6940	2.32[b]	-.0635	-2.76[a]	-.0130	-2.37[b]	.0470	1.66[c]	.0295	.63
Healthy	-.5920	-2.25[b]	.0605	2.79[a]	.0124	2.41[b]	-.0448	-1.29	-.0281	-.71

Table 5. (Continued)

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Organic	.4816	2.20[b]	-.0467	-2.73[a]	-.0096	-2.37[b]	.0346	1.48	.0217	.66
Radditiv	.2602	1.62	-.0255	-1.91[c]	-.0052	-1.75[c]	.0189	1.31	.0118	.63
Hvitamin	.5619	2.42[b]	-.0453	-2.74[a]	-.0093	-2.32[b]	.0335	1.43	.0211	.67
Antic	-.3424	-1.97[b]	.0313	2.22[b]	.0064	2.02[b]	-.0232	-1.25	-.0145	-.69
Growfood[d]	.5415	1.10	-.0527	-3.61[a]	-.0158	-8.44[a]	.0399	.26	.0285	.45
μ1	2.9299	4.15[a]								
μ2	6.8756	4.08[a]								
Log-likelihood function	-1270.855									

Note: For variable specification and full name description see Table 1.

[a] Significant at α=.01.

[b] Significant at α=.05.

[c] Significant at α=.10.

[d] Marginal effects for binary variables are Pr[y|x=1]-Pr[y|x=0].

As commented in the estimation procedure section, the effect of the fear index was measured by the marginal effects, not a coefficient. The effects of “no risk” and “neither risky, nor riskless” were statistically significant among four marginal effect values. The marginal effect of the fear index change on the probability of choosing the “no risk” category was -.0073. This implies that a change in the food fear index value by ten decreased the probability of choosing category “no risk” by 7.3 percent. Because the marginal effect on the probability of choosing upper categories, i.e., “a lot of risk” was not statistically significant, the extent of the effect the fear index might had on the risk perception is not clear.

The benefit index negatively and significantly influenced the risk perception. The marginal effect of the benefit index change on the probability of choosing category “no risk” was .0197. The probability that a respondent would not view the modification increasing vitamin content as a source of risk increased by .0197 in response to a change in the benefit index. The stronger respondent agreement with the benefits from agricultural research, the lower was the perceived risk from a modification leading to an increase in the vitamin content.

With regard to food production technology variables, respondents who preferred food produced with practices limiting pesticide use were less likely to perceive eating foods with modified vitamin content as risky. The marginal effect on the probability of choosing category “no risk” was .0463. The probability that a respondent would not view the modification increasing vitamin content as a source of risk increased by .0463 in response to a change in the variable ‘Modified.’

However, respondents who preferred food produced using unconventional practices, i.e., without synthetic pesticides, showed high degree of risk perception of consuming foods with the modified vitamin content. The marginal effect of the explanatory variable on the probability of choosing category “no risk” was -.0430.

Effects of variables describing the necessity of the approval process regarding the use of a new technology on risk perception associated with the modification increasing the vitamin content were mixed. The stronger was the view of the necessary approval of the modified food by the Korean Food and Drug Administration (KFDA), the less risk perceived associated with eating foods with their modified vitamin content. This result was expected because respondents showed a high degree of trust in the KFDA reflected in the high average score of 4.365 (Table 1). It appears that foods produced with the KFDA approved technologies were considered safe and many respondents expected any new technology to be subject to the approval process. Some respondents seemed to distrust even the process of modifying the vitamin content, typically a fortification rather than a reduction in vitamin content, they could be satisfied only if a government agency was a part of the process. The marginal effect of the approval by the KFDA on the perceived risk resulting from eating food with the modified vitamin content was .0628. The effect implies that the probability of respondents choose “no risk” increases by 6.28 percent once the KFDA approval was issued.

However, the technology approval by a supermarket chain could be expected to lead to an opposite outcome. The necessity of a retailer’s approval strengthened the perception of risk in the case of food vitamin content modification. Although a supermarket chain may be interested in such foods, it seems that consumers recognized that, possibly due to retailer profit motives, such actions should be viewed with suspicion. The value of the marginal effect on the probability of choosing category “no risk” was -.0458.

Among socio-economic variables the respondent's education level had a statistically significant effect on the perception of risk resulting from consuming foods with modified vitamin content. The effect on the probability of choosing category "no risk" was -.0463. The well-educated were less likely than less educated to perceive the modification as a risk. Consumers with a higher degree of education al attainment had comparatively more opportunities to learn about modification through breeding than the less-educated. Hossain *et al.* (2002a) reported that a high educational attainment was an important explanatory variable with regard to the approval of biotechnology use.

Several variables measured the effect of attitudes toward organically produced foods in comparison to conventionally produced foods on the risk perception of foods with the modified vitamin content. The variable 'Expensive' had a significant and positive effect on risk perception. Respondents, who agreed that organic products were more expensive than conventional products were more likely to express a high degree of concern about the food modification increasing the vitamin content than respondents who disagreed with such a statement. However, the variable 'Healthy' had a significant and negative effect on risk perception. Respondents agreeing that organic products were healthier than conventional products were less likely to view vitamin content modification risky than those who disagreed. Respondents who viewed organic produce as healthy were interested in the health aspect of conventional foods as well and if such foods would have a modified vitamin content, such modification was perceived as a desirable attribute.

The variable 'Hvitamin' had a positive and significant effect on risk perception. Respondents who attached importance to the vitamin content in food showed a high degree of concerns about the modification increasing the vitamin content. The marginal effect on the probability of choosing category "no risk" was -.0453. The more vitamins consumers desire, the riskier was the consumption of foods with modified vitamin content in their perceptions. In this case, consumers might have preferred vitamins, but only those that occurred naturally, and not those that were added to foods.

Respondents who considered the amount of anti-carcinogens in food important associated less risk than respondents who did not attach great importance to the presence of anti-carcinogens. Vitamin D is to be an anti-oxidant and anti-carcinogen and the obtained result was a rational reflection of consumer awareness.

<u>Allowable amount of pesticide residue in consumed food.</u> The fear index positively but barely significantly influenced the risk perception of eating foods with allowable amount of pesticide residue (Table 6). The marginal effect of the fear index on the probability of choosing category “no risk” was -.0003. The probability that a respondent would not view allowable amount of pesticide residue in consumed food as a source of risk would decrease by .0003 in response to a change in the fear index. Respondent who feared eating contaminated foods also had a high level of risk perception associated with the consumption of foods with allowable amount of pesticide residue. The segment of highly sensitive consumers could opt toward buying organically produced foods.

Regarding food production technology variables, respondents who preferred food produced using conventional production practices were less likely to perceive eating foods with allowable pesticide residue risky than those who showed less preference for conventional production methods. The marginal effect of the explanatory variable on the probability of choosing category “no risk” was .0037. The probability that a respondent would not consider allowable amount of pesticide residue in consumed food as a source of risk would increase

Table 6. Ordered Logit Estimation Results of the Risk Perception Associated with Eating Foods Containing Allowable Level of Pesticide Residue.

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Constant	-.7757	-1.54								
Indices										
Ffind	.0107	1.61	-.0003	-2.09[b]	-.0030	-.2.10[b]	-.0037	-.46	.0070	1.52
Rsind	.0089	1.27	-.0003	-1.38	-.0024	-1.38	-.0029	-.45	.0056	.97
Bfind	-.0093	-1.04	.0002	.97	.0023	.98	.0027	.48	-.0052	-.92
Production Technology										
Convent	-.1185	-1.96[c]	.0037	3.27[a]	.0362	3.33[a]	.0435	.51	-.0834	-1.59
Modified	.0187	.72	-.0009	-1.19	-.0088	-1.19	-.0106	-.44	.0203	.90
Nosynthe	-.0057	-.17	-.0001	-.13	-.0012	-.13	-.0015	-.13	.0029	.13
Uncontek	-.0172	-.53	.0007	.70	.0065	.70	.0078	.42	-.0149	.58

Table 6. (Continued)

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Approval Process										
KFDA	-.0537	-1.41	.0012	1.23	.0121	1.24	.0145	.48	-.0279	-1.03
Indust	.0523	1.44	-.0015	-1.52	-.0141	-1.53	-.0170	-.46	.0326	1.03
Market	.1002	2.10[b]	-.0030	-3.59[a]	-.0293	-3.68[a]	-.0353	-.48	.0677	1.38
Farmer	-.0713	-1.79[c]	.0022	2.51[b]	.0216	2.54[b]	.0261	.48	-.0500	-1.29
Socio-demographic										
Income	-.0136	-1.05	.0003	.84	.0030	.84	.0036	.41	-.0068	-.71
Edu[d]	.0027	.56	.0002	.23	.0023	.23	.0027	.02	-.0052	-.02
Age[d]	.0592	1.13	-.0017	-1.32	-.0167	-1.37	-.0194	-.24	.0379	.18
Members	.0074	.28	-.0005	-.59	-.0048	-.59	-.0058	-.33	.0111	.50
Other variables										
Expensive	.1557	1.93[c]	-.0046	-3.52[a]	-.0446	-3.61[a]	-.0537	-.46	.1029	1.24
Healthy	.0005	.01	.0004	.32	.0036	.32	.0043	.29	-.0082	-.32

Table 6. (Continued)

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Organic	.0325	.80	-.0011	-1.06	-.0105	-1.06	-.0126	-.43	.0241	.82
Farm	.0003	1.43	-.0000	-1.16	-.0000	-1.58	-.0001	-.47	.0002	1.11
Pestlim	.1991	2.25[b]	-.0061	-4.99[a]	-.0586	-5.24[a]	-.0706	-.48	.1353	1.41
Pestfree	.1320	1.98[b]	-.0040	-3.25[a]	-.0384	-3.31[a]	-.0463	-.48	.0887	1.35
Rpest	.0111	.33	-.0002	-.17	-.0017	-.17	-.0021	-.15	.0040	.17
Growfood[d]	-.0339	-.39	.0020	-2.40[b]	.0187	2.24[b]	.0190	.12	-0397	-.16
$\mu 1$	.9619	2.40[b]								
$\mu 2$	1.8518	2.45[b]								
Log-likelihood function	-950.190									

Note: For variable specification and full name description see Table 1.

[a] Significant at α=.01.

[b] Significant at α=.05.

[c] Significant at α=.10.

[d] Marginal effects for binary variables are Pr[y|x=1]-Pr[y|x=0].

by .0037 in response to a change in the variable ‘Convent.’ Conventional agricultural practices involve applications of large volume of synthetic fertilizers and pesticides.

Effects of variables describing the necessity of the approval process regarding the use of a new technology were mixed. The more necessary was an approval by the supermarket chains in respondents’ opinion, the stronger was the perception of risks. However, the farmer organization’s approval mitigated the perception of risk because the relationship between such an approval and the risk perception stemming from the presence of an allowable amount of pesticide residue.

The variable ‘Expensive’ had a significant and positive effect on risk perception. Respondents who agreed that organic products were more expensive than conventional products were more likely to be concerned about the food containing allowable amount of pesticide residue than respondents who disagreed with such a statement. There exist a group of consumers think the premium for organic products results from pesticide use reduction.

The variable ‘Pestlim’ had a positive and significant effect on the risk perception of eating foods with allowable amount of pesticide residue. Respondents who considered that pesticide residue within allowable limitation important were more concerned about the risk associated with foods containing allowable amount of pesticide residue than respondents who disagreed with such a statement. This relationship was expected and the result confirmed it. The variable ‘Pestfree’ showed a similar effect to the variable ‘Pestlim’ on the risk perception linked to the presence of the allowable pesticide residue. Respondents who agreed that foods should be completely free from pesticide showed a high degree of risk perception from foods containing allowable amount of pesticide residue. For these respondents any pesticide residue was perceived as a severe risk source.

Estimation of this model confirmed relatively fewer variables to have a significant effect on the dependent variable. There is a possibility that the word 'allowable' confused some respondents and their actual risk perceptions were not revealed. People have their subjective standards of what represents an allowable amount. Such individual standards can vary widely and might not have been captured in the survey.

Consumption of foods treated with harmless chemicals. The research support index positively and significantly influenced the risk perception associated with eating foods treated with harmless chemicals (Table 7). The marginal effect of the research support index on the probability of choosing category "no risk" was -.0021, implying that a ten percent change in the research support index decrease the probability of choosing category "no risk" by 2.1 percent. Respondent who are more supportive of research activities associated a higher risk of consuming foods treated with harmless chemicals than respondents less supportive of research. It appears that this segment of consumers would support research if it would lead to a decrease in the use of any synthetic chemicals in food production.

The benefit index negatively and significantly influenced the risk perception. Consumers who strongly agreed that the benefits occurred to the supply chain links, but not to retail consumers perceived the risk of harmless chemicals' use as low. The marginal effect of the benefit index on the probability of choosing category "no risk" was .0041, i.e., almost twice the size of the marginal effect of the research support index.

With regard to production technology variables, respondents who preferred food produced using modified practices with limited pesticides associated less risk with the treatment of food with harmless chemicals than those who showed no preference for modified practices. It seems that respondents paid attention and distinguished between harmless chemicals and other

Table 7. Ordered Logit Estimation Results of the Risk Perception Associated with Eating Foods Treated with Chemicals to Improve Appearance.

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Constant	-1.2856	-1.28								
Indices										
Ffind	.0147	1.04	-.0009	-1.04	-.0024	-1.04	.0003	.09	.0029	1.13
Rsind	.0343	1.99[b]	-.0021	-1.98[b]	-.0055	-1.99[b]	.0008	.09	.0068	.92
Bfind	-.0675	-2.89[a]	.0041	2.85[a]	.0109	2.89[a]	-.0015	-.09	-.0134	-1.12
Production Technology										
Convent	-.0238	-.23	.0014	.23	.0038	.23	-.0005	-.08	-.0047	-.25
Modified	-.1778	-2.45[b]	.0108	2.42[b]	.0287	2.45[b]	-.0041	-.09	-.0354	-1.07
Nosynthe	.3034	3.28[a]	-.0184	-3.24[a]	-.0489	-3.28[a]	.0070	-.09	.0604	1.03
Uncontek	-.0285	-.31	.0017	.31	.0046	.31	-.0007	-.08	-.0057	-.31

Table 7. (Continued)

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Approval Process										
KFDA	-.2124	-2.27[b]	.0129	2.25[b]	.0343	2.27[b]	-.0049	-.09	-.0423	-1.10
Indust	.2857	3.28[a]	-.0173	-3.23[a]	-.0461	-3.28[a]	.0065	.09	.0568	1.04
Market	.0633	.86	-.0038	-.86	-.0102	-.86	.0015	.09	.0126	.68
Farmer	-.0494	-.61	.0030	.61	.0080	.61	-.0011	-.09	-.0098	-.53
Socio-demographic										
Income	-.1206	-3.49[a]	.0073	3.42[a]	.0195	3.49[a]	-.0028	-.09	-.0240	-1.04
Edu[d]	.1861	1.36	-.0110	-2.07[b]	-.0299	-2.34[b]	.0033	.05	.0375	.21
Age[d]	.1178	.94	-.0072	-1.41	-.0190	-1.54	.0029	.05	.0233	.13
Members	.0991	1.82[c]	-.0085	-1.81[c]	-.0227	-1.82[c]	.0032	.09	.0280	.85
Other variables										
Expensive	.2347	2.03[b]	-.0142	-2.02[b]	-.0379	-2.03[b]	.0054	.09	.0467	.85
Healthy	-.1296	-1.20	.0073	1.20	.0209	1.20	-.0030	-.09	-.0258	-.93

Table 7. (Continued)

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Organic	.3584	4.37[a]	-.0217	-4.27[a]	-.0578	-4.38[a]	.0082	.09	.0713	1.03
Farm	.0008	1.80[c]	-.0000	-1.81[c]	-.0001	-1.80[c]	.0000	.09	.0002	.98
Trustc	.0534	.59	-.0032	-.59	-.0086	-.59	.0012	.09	.0106	.50
Radditiv	.2792	3.77[a]	-.0169	-3.68[a]	-.0450	-3.77[a]	.0063	.09	.0555	1.05
Rfertil	-.1408	-1.61	.0085	1.60	.0227	1.61	-.0032	-.09	-.0280	-1.01
Growfood[d]	.1409	.61	-.0081	-1.64	-.2249	-1.81[c]	.0018	.04	.0288	.16
μ1	1.9718	28.32[a]								
μ2	3.6445	44.72[a]								
Log-likelihood function	-1218.326									

Note: For variable specification and full name description see Table 1.

[a] Significant at α=.01.

[b] Significant at α=.05.

[c] Significant at α=.10.

[d] Marginal effects for binary variables are Pr[y|x=1]-Pr[y|x=0].

agri-chemicals. The marginal effect of .0108 suggested that if a respondent strongly preferred foods from a modified process, she was more likely to fall into the category of respondents who not perceived that eating foods treated with harmless chemicals was risky. However, respondents in favor of foods produced using unconventional practices (i.e., without synthetic pesticides) showed a higher degree of risk perception than those who were less in favor of unconventional production practices. The marginal effect on the probability of choosing category "no risk" was -.0184. The probability that a respondent would not view the consumption of foods treated with harmless chemicals as a source of risk would decrease by 1.8 (about two percent) in response to a change in the variable 'Nosynthe.'

Effects of variables describing the necessity of the approval process regarding the use of a new technology on risk perception were mixed. The KFDA approval variable showed negative and significant effect on the risk perception implying that the more necessary was the approval in the respondent's opinion, the lower perceived risk from consuming food treated with harmless chemicals. The marginal effect of the approval by the KFDA on the perceived risk from eating food treated with harmless chemical was .0129. However, the technology approval by the food manufacturing industry could be expected to have an opposite effect. The necessity of the food manufacturing industry's approval strengthened the perception of risk. The calculated effect on the probability of choosing category "no risk" was -.0173. Consumers seem to distrust commercial organizations that are directly involved in the technology development and implementation sensing the pecuniary motives. Economic incentives could compromise the scientific scrutiny and a premature dismissal of information different than results supporting the lack of harmful effects of a technology.

Among socio-economic variables the household income and the number of household members were statistically significant. Respondents in higher income brackets were less likely to perceive risk of harmless chemical applications than respondents in lower income brackets. Consumers with high incomes had comparatively more choices, including a choice of organic foods, than people with low incomes. The marginal effect on the probability of choosing category “a lot of risk” was -.0240. The number of household members had a positive effect implying that, most likely, families with children were more concerned about foods treated with harmless chemicals than families without children. The marginal effect on the probability of choosing category “a lot of risk” was .0279.

The variable ‘Expensive’ had a significant and positive effect on risk perception. Respondents who agreed that organic products were more expensive than conventional products were more likely to be concerned about the food treated with chemicals than respondents who disagreed with such a statement. This relationship suggests that in consumer minds the premium for organic products results from the withdrawal of applications of even harmless chemicals and indicates a high degree of consistency of opinions shaped by respondents. The marginal effect on the probability of choosing category “no risk” was -.0142.

The variable ‘Organic’ measured the effect of preference for organically produced foods. The result showed that positive and significant effect on the risk perception suggesting that respondents who preferred organic products perceived a higher risk resulting from the use of harmless chemicals than respondents who did not prefer organic foods. In a way similar to results in earlier equations, the group of respondents showing preference for organic foods consistently viewed any use of any chemicals as a source of risk. The marginal effect of ‘Organic’ on the probability of choosing category “no risk” was -.0217.

The variable 'Radditiv,' describing respondents' views on new agricultural technologies reducing the presence of additives in food, had a positive and significant effect on the perceived risk from eating food treated with harmless chemical. Respondents who agreed that reducing the presence of additives from foods tended to perceive a high degree of risk from the treatment of chemicals than those who thought the focus of new technology on additive reduction was less important. Although this variable referred to a different class of substances than 'chemical' or 'harmless chemicals,' its effect was similar to the effect of preferences for organic foods supporting the existence of a group, which related such substances to an increased risk of food treated with harmless chemicals. The marginal effect on the probability of choosing category "no risk" was -.0169.

Even though the variable 'Farm' showed significantly positive effect on the risk perception, the role of the variable was very small. The marginal effect on the probability of choosing category risk was actually not different from zero.

<u>The use of fumigation to kill insects</u>. The fear index positively and significantly influenced the risk perception of eating foods fumigated to kill insects (Table 8). The higher was the value of the index, the higher was the perceived risk associated with the consumption of foods fumigated to kill insects. Fumigation was often required in case of imported fresh produce to reduce the possibility of unintended introduction of insect pests which may harm a similar domestic crop. Several subtropical crops were fumigated using methyl bromide even in shipments between Hawaii and continental United States, but the use of methyl bromide was terminated due to possible harmful effects. Although Korean consumers may not be aware of banning the use of the substance in the United States, fumigation may evoke negative feelings as an unfamiliar procedure. The marginal effect of the fear index on the probability of choosing

Table 8. Ordered Logit Estimation Results of the Risk Perception Associated with Eating Foods Fumigated to Kill Insects.

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Constant	1.9181	2.30[b]								
Indices										
Ffind	.0437	3.18[a]	-.0052	-3.14[a]	-.0057	-3.16[a]	.0044	.59	.0064	.96
Rsind	.0021	.13	-.0003	-.13	-.0003	-.13	.0002	.13	.0003	.12
Bfind	-.0310	-1.38	.0037	1.38	.0040	1.38	-.0031	-.49	-.0045	-.91
Production Technology										
Convent	.0006	.01	-.0001	-.01[a]	-.0001	-.01	.0001	.01	.0001	.01
Modified	-.2553	-3.62[a]	.0302	3.56[a]	.0330	3.60[a]	-.0259	-.56	-.0373	-.95
Nosynthe	.1253	1.38	-.0148	-1.38	-.0162	-1.38	.0127	.57	.0183	.73
Uncontek	.0378	.43	-.0045	-.43	-.0049	-.43	.0038	.38	.0055	.37

Table 8. (Continued)

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Approval Process										
KFDA	-.3561	-3.79[a]	.0421	3.75[a]	.0460	3.75[a]	-.0361	-.55	-.0520	-.99
Indust	.3377	3.87[a]	-.0399	-3.83[a]	-.0437	-3.83[a]	.0343	.57	.0493	.93
Market	.0699	.98	-.0083	-.98	-.0090	-.98	.0071	.50	.0102	.68
Farmer	-.0203	-.25	.0024	.25	.0026	.25	-.0021	-.23	-.0030	-.24
Socio-demographic										
Income	-.0047	-.14	.0006	.14	.0006	.14	-.0005	-.14	-.0007	-.14
Edu[d]	-.0005	-.00	-.0001	-.01	-.0001	-.01	.0001	.00	.0001	.00
Age[d]	.1481	1.19	-.0177	-1.88[c]	-.0190	-2.21[b]	.0153	.13	.0214	.21
Members	-.1596	-2.08[b]	.0189	2.07[b]	.0263	2.08[b]	-.0162	-.51	-.0233	-1.00
Other variables										
Compwm	-.2850	-2.79[a]	.0337	2.77[c]	.0368	2.77[a]	-.0289	-.56	.0416	-.93
Trustc	.1759	1.70	-.0208	-1.69[c]	-.0227	-1.68[c]	.0178	.56	.0257	.80

Table 8. (Continued)

Variable name	Coefficient	t-value	Marginal effect							
			C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Radditiv	.1742	2.51[b]	-.0206	-2.50[b]	-.0225	-2.50[b]	.0177	.57	.0254	.88
Rpest	-.0541	-.58	.0064	.58	.0070	.58	-.0055	-.36	-.0079	-.58
$\mu 1$	1.6390	25.48[a]								
$\mu 2$	3.3750	39.67[a]								
Log-likelihood function	-1287.194									

Note: For variable specification and full name description see Table 1.

[a] Significant at α=.01.

[b] Significant at α=.05.

[c] Significant at α=.10.

[d] Marginal effects for binary variables are Pr[y|x=1]-Pr[y|x=0].

category “no risk” was -.0052, implying that a ten percent change in the fear index decrease the probability of no risk perception by 5.2 percent.

Regarding food production technology variables respondents who agreed that food produced using modified practices limiting pesticide use associated less risk from fumigation than respondents who were less supportive of modified practices. The marginal effect of the variable ‘Modified’ on the probability of choosing category “no risk” was .0303.

The new technology approval by the KFDA on the fumigation as a perceived source of risk, results indicated that risk perceptions were lower if a respondent viewed the KFDA approval necessary. The marginal effect of the approval by the KFDA on the probability of choosing category “no risk” was .0422.

Respondents viewed the approval of the food manufacturing industry differently than the KFDA endorsement. The more insistence on the part of a respondent that any new technology be approved by the food manufacturing industry, the higher the degree of perceived risk associated with fumigating produce to kill insects. This relationship supports the notion that consumers distrust the approval process sanctioned by the industry rather than a third party. Even the appearance of a conflict of interest might invoke negative opinions among consumers. The marginal effect of the variable ‘Indust’ on the probability of choosing category “no risk” was -.0402.

Among socio-economic variables, the number of family members showed significant and negative effect implying that larger families (presumably with children) were less concerned about fumigation to kill insects. The result was somewhat unexpected and the effect differed in direction from that measuring the risk perception from eating foods treated with harmless chemicals. It appears that respondents did not consider fumigation to kill insects to pose a meaningful risk even if they had children. The marginal effect on the probability of choosing category “no risk” was .0171.

The variable ‘Compwm’ was only inserted to this equation to measure the effect of attitude toward the focus of new agricultural technology. Respondents who considered the competitiveness in world market important were less likely to associate risk with fumigation. Attitudes in favor of enhancing the competitive position of agriculture seemed to favor technological solutions and these attitudes were reflected in the low risk perception from the use of fumigation, which was applied in the international produce trade. The marginal effect on the probability of choosing category “no risk” was .0346.

The variable ‘Radditiv’ showed a significant and positive effect on the risk perception. Respondents who agreed that the reduction of additives in foods was important tended to perceive a higher degree of risk from the fumigation than respondents who were less anxious about the presence of additives. The marginal effect on the probability of choosing category “no risk” was -.0203.

<u>The use of chlorinated water to wash fresh produce.</u> The fear index positively and significantly influenced the risk perception of eating foods washed in chlorinated water (Table 9). The marginal effects of the fear index on the probability of choosing category “no risk” and “a lot of risk were -.0018 and .0078, respectively. Both values were statistically significant. This result was consistent with the generally confirmed result in other equations that respondents displaying a strong anxiety about eating contaminated food perceived almost any method of treating food in an unnatural way or with artificial substances as potentially harmful. The use of chlorinated water is part of the Good Production Practices and HACCP protocol used by farmers, packinghouses and food processors in the United States because it was judged inexpensive and

Table 9. Ordered Logit Estimation Results of the Risk Perception Associated with Eating Foods Washed in Chlorinated Water.

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Constant	.1672	.17								
Indices										
Ffind	.0317	2.08[a]	-.0018	-2.22[b]	-.0036	-2.24[b]	-.0024	-.38	.0078	2.69[a]
Rsind	.0511	2.74[a]	-.0027	-2.90[a]	-.0056	-2.92[a]	-.0037	-.38	.0120	1.78[c]
Bfind	-.0857	-3.16[a]	.0044	3.31[a]	.0090	3.35[a]	.0059	.40	-.0193	-2.34[b]
Production Technology										
Convent	-.2482	-2.07[b]	.0138	2.38[b]	.0279	2.40[b]	.0185	.42	-.0602	-2.21[b]
Modified	-.3437	-3.99[a]	.0197	4.58[a]	.0398	4.76[a]	.0263	.40	-.0858	-2.38[b]
Nosynthe	.1768	1.82[c]	-.0092	-1.75[c]	-.0185	-1.75[c]	-.0123	-.38	.0399	1.38
Uncontek	-.0939	-.97	.0056	1.07	.0112	1.07	.0074	.39	-.0243	-1.05

Table 9. (Continued)

Variable name	Coefficient	t-value	Marginal effect							
			C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Approval Process										
KFDA	-.0498	-.49	.0035	.66	.0072	.66	.0047	.37	-.0155	-.67
Indust	.1437	1.44	-.0080	-1.59	-.0161	-1.59	-.0107	-.39	.0348	1.37
Market	.0501	.56	-.0039	-.95	-.0079	-.95	-.0052	-.36	.0170	.88
Farmer	.0084	.09	.0001	.03	.0002	.03	.0001	.02	-.0005	-.03
Socio-demographic										
Income	-.0536	-1.48	.0027	1.34	.0054	1.34	.0036	.38	-.0116	-1.20
Edu[d]	.0270	.19	-.0037	-.79	-.0076	-.80	-.0052	-.08	.0165	.07
Age[d]	-.1087	-.77	.0073	2.04[b]	.0148	1.97[b]	.0101	.11	-.0323	-.13
Members	.1337	1.60	-.0076	-1.68[c]	-.0153	-1.69[c]	-.0101	-.36	.0330	1.27
Other variables										
Farm	-.2078	-1.27	.0115	1.38	.0232	1.38	.0154	.40	-.0501	-1.34
Fresh	.3316	2.37[b]	-.0188	-2.74[a]	-.0380	-2.76[a]	-.0251	-.37	.0257	.12

Table 9. (Continued)

Variable name	Coefficient	t-value	Marginal effect							
			C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Radditiv	.1121	1.51	-.0056	-1.45	-.0113	-1.46	-.0075	-.37	.0245	1.20
Antic	.1465	1.93[c]	-.0068	-1.74[c]	-.0138	-1.75[c]	-.0091	-.38	.2972	1.40
Growfood[d]	.1491	.54	-.0086	-1.70[c]	-.0179	-1.76[c]	-.0138	-.24	.0402	.18
μ1	1.5831	6.53[a]								
μ2	3.3988	7.50[a]								
Log-likelihood function	-1214.263									

Note: For variable specification and full name description see Table 1.

[a] Significant at α=.01.

[b] Significant at α=.05.

[c] Significant at α=.10.

[d] Marginal effects for binary variables are Pr[y|x=1]-Pr[y|x=0].

effective way to reduce or eliminate microbial contamination. However, some consumers find even this method unacceptable.

The research support index positively and significantly influenced the risk perception associated with eating foods washed in chlorinated water. Respondents who supported research activities were more likely than those less supportive to perceive as risky the consumption of foods washed in chlorinated water. The marginal effects on the probability of choosing category “no risk” and “a lot of risk” were -.0036 and .0120, respectively.

The benefit index negatively and significantly influenced the risk perception of the use of chlorinated water. The benefit index measured the consumer agreement with several statements referring to the occurrence of such benefits to various links in the supply channel except consumers. No a priori expectations regarding the direction of this variable influence was formed and the empirically determined course appears counterintuitive, especially when compared to the respondent skepticism of the food manufacturing technology approval effect. The marginal effects on the probability of choosing category “no risk” and “a lot of risk” were .0044 and -.0193, respectively.

Food production technology variables included several different approaches including the use of ‘conventional practices’ and ‘unconventional methods based on the latest technical developments.’ Respondents who preferred food produced using conventional production practices or modified practices with limited pesticide application did not to perceive as high the risk from eating foods washed in chlorinated water. The marginal effects of a change in each explanatory variable on the probability of choosing category “no risk” were .0138 and .0197, respectively. However, respondents favoring food production using unconventional practices, i.e., without synthetic pesticides, were more likely to associate a high degree of risk with the consumption of foods washed with chlorinated water than those less supportive of unconventional approach to production. The marginal effect on the probability of choosing category “no risk” was -.0092.

The number of household members was statistically marginally insignificant variable among socio-economic characteristics. The positive relationship implies that, possibly, families with children were more concerned about risk from eating foods washed with chlorinated water. The sensitivity to such treatments changes with age and children could potentially be affected by smaller amounts than adults.

The variable ‘Fresh’ was entered into the model to measure the effect of attitudes reflecting the importance of freshness as an attribute of food. The variable had a positive and significant effect on the risk perception stemming from the use of chlorinated water. Chlorinated water is used primarily in washing fresh produce prior to grading, sorting and packing, but also in hydrocooling. Hydrocooling is a necessary stage in postharvest handling of the temperate zone produce to preserve freshness and eating quality. However, according to respondents in this survey, the more important was that the new technology focus on freshness protection, the less desired was the consumption of foods washed with chlorinated water due to increased risk perception.

Furthermore, respondents who considered the amount of anti-carcinogens in food important associated more risk from eating foods washed with chlorinated water than respondents who did not attach great importance to the presence of anti-carcinogens. Chlorine is a known carcinogen and the obtained result was a rational reflection of consumer awareness. The content of chlorine in chlorinated water is very small and, generally, subject to repeated testing in the washing process, but this procedure may be viewed as insufficient.

<u>Spraying foods with a sanitizing solution.</u> The fear index positively and significantly influenced the risk perception of eating foods sprayed with sanitized solution (Table 10). This result was consistent with attitudes displayed by consumers who were particularly sensitive to the use of any unnatural substances. Although a sanitizing solution was not defined for respondents in the questionnaire, the solution is typically based on the ionized water, which has antimicrobial properties. The marginal effect of the food fear index on the probability of choosing category “a lot of risk” was .0097.

The research support index showed a positive and significant effect on the risk perception. This relationship implies that respondents favoring agricultural research were more likely to perceive the use of sanitizing solutions as potentially risky. It appears that research leading to new technologies may be supported, but a specific technology may be perceived a source of risk despite its scientifically established benefits and the use of all natural substances. The marginal effect of the research support index change on the probability of choosing category “a lot of risk” was .0106.

The benefit index negatively and significantly influenced the risk perception. The stronger the agreement on the part of respondents that benefits occurred to supply links other than consumers, the lower the perception of risk stemming from the use of the sanitizing solutions. The marginal effect on the probability of choosing category “a lot of risk” was -.0174.

With regard to food production technology variables, respondents who preferred food produced using conventional or modified (i.e., limited pesticide use) production practices associated less risk with the use of a sanitizing solution. The marginal effects of the change in each explanatory variable were -.0854 and -.0706, respectively.

Table 10. Ordered Logit Estimation Results of the Risk Perception Associated with Eating Foods Sprayed with Sanitizing Solution.

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Constant	.2666	.27								
Indices										
Ffind	.0389	2.64[a]	-.0014	-2.62[a]	-.0041	-2.64[a]	-.0042	-.77	.0097	7.38[a]
Rsind	.0428	2.38[b]	-.0015	-2.37[b]	-.0045	-2.38[a]	-.0047	-.76	.0106	2.15[b]
Bfind	-.0699	-2.81[a]	.0025	2.77[a]	.0073	2.80[a]	.0076	.86	-.0174	-2.82[a]
Production Technology										
Convent	-.3431	-3.20[a]	.0122	3.15[a]	.0358	3.19[a]	.0373	.89	-.0854	-3.31[a]
Modified	-.2837	-3.67[a]	.0101	3.60[a]	.0296	3.66[a]	.0308	.84	-.0706	-3.38[a]
Nosynthe	.1296	1.37	-.0046	-1.36	-.0135	-1.37	-.0141	-.68	.0323	1.31
Uncontek	.0657	.69	-.0023	-.69	-.0069	-.69	-.0071	-.50	.0163	.68

Table 10. (Continued)

Variable name	Coefficient	t-value	Marginal effect							
			C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Approval Process										
KFDA	-.0025	-.03	.0001	.03	.0003	.03	.0003	.03	-.0006	-.03
Indust	-.0060	-.06	.0002	.06	.0006	.06	.0007	.06	-.0015	-.06
Market	-.0164	-.21	0006	.21	.0017	.21	.0018	.21	-.0041	-.21
Farmer	.1325	1.59	-.0047	-1.58	-.0138	-1.59	-.0144	-.75	.0330	1.55
Socio-demographic										
Income	-.0823	-2.21[b]	.0029	2.19[b]	.0086	2.21[b]	.0090	.78	-.0205	-2.10[b]
Edu[d]	.2366	1.61	-.0082	-2.06[b]	-.0241	-2.14[b]	-.0266	-.28	.0589	.24
Age[d]	.1890	1.41	-.0069	-1.73[c]	-.0199	-1.80[b]	-.0201	-.23	.0469	.20
Members	.0284	.35	-.0010	-.35	-.0030	-.35	-.0031	-.29	.0071	.34
Other variables										
Farm	-.2036	-1.31	.0073	1.31	.0213	1.31	.0221	.78	-.0506	-1.34
Fresh	.5298	4.19[a]	-.0189	-4.12[a]	-.0553	-4.20[a]	-.0576	-.76	.1318	3.02[a]

Table 10. (Continued)

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Radditiv	.1491	2.06[b]	-.0053	-2.04[b]	-.0156	-2.05[b]	-.0162	-.75	.0371	1.91[c]
Partial	-.1677	-2.48[b]	.0060	2.46[b]	.0175	2.48[b]	.0182	.84	-.0417	-2.47[b]
Growfood[d]	.2945	1.18	-.0094	-2.41[b]	-.0285	-2.51[b]	-.0356	-.34	.0735	.30
μ1	1.6613	21.27[a]								
μ2	3.3965	37.96[a]								
Log-likelihood function	-1154.193									

Note: For variable specification and full name description see Table 1.

[a] Significant at α=.01.

[b] Significant at α=.05.

[c] Significant at α=.10.

[d] Marginal effects for binary variables are Pr[y|x=1]-Pr[y|x=0].

The household income significantly and negatively influenced the risk perception in this case. Consumers from high income households had comparatively more choices than those with less income and it seems that if consumers were uncertain about attributes of a specific technology applied to food, they were more likely to avoid it if the budget constraint was less severe. The marginal effect on the probability of choosing category "a lot of risk" was -.0205.

Respondents who thought freshness was an important food attribute were likely to be more concerned about the use of a sanitizing solution than those less interested in freshness. The marginal effect on the probability of choosing category "a lot of risk" was .1318. The effect was quite high in magnitude compared to other calculated effects.

The variable 'Radditiv' positively and significantly influenced the risk perception. Respondents who agreed that the reduction of additives in foods was important tended to perceive a higher degree of risk from the use of a sanitizing solution than respondents who were less anxious about the presence of additives. The marginal effect on the probability of choosing category "a lot of risk" was .0371.

The variable 'Partial' negatively and significantly influenced the risk perception. Respondents who preferred partially prepared foods were likely to be less concerned about the use of a sanitizing solution than those less interested in partially prepared foods. The result is consistent with expectations. Even though it require less preparation at home and shorten the meal preparation time, partially prepared foods might have been contaminated by harmful bacteria such as Salmonella. A sanitizing solution reduces or effectively kills harmful kinds of germs.

<u>Raw fruits or vegetables containing soil particles.</u> The fear index positively and significantly influenced the risk perception of eating foods contain soil particles (Table 11). The marginal effect of the fear index change on the probability of choosing category “no risk” was -.0034.

Regarding food production technology variables, respondents who preferred food produced using conventional production practices were less likely to associate risk with eating raw fruits or vegetables containing soil particles. The direction of the effect was consistent with attitudes towards risk and its sources among respondents who favored conventional production practices.

Effects of variables describing the necessity of the approval prior to the use of a new technology on risk perception were mixed. The KFDA and a farmer organization approval showed negative and significant effect on the risk perception suggesting that as their approval was viewed as necessary, the presence of soil particles in raw produce was perceived as less risky. The marginal effects of the approval by the KFDA and a farmer organization on the probability of choosing category “no risk” were .0523 and .0317, respectively, indicating the strong role of the KFDA in the process. However, the necessity of the food manufacturing industry’s approval had the opposite effect; the stronger the necessary of the industry’s endorsement, the stronger the perception of risk due to soil particle presence. The marginal effect on the probability of choosing category “no risk” was -0337.

Among socio-demographic variables, the respondent’s age positively and significantly influenced the risk perception stemming from the consumption of raw produce containing soil particles. The elderly showed more concern about health and prevention even though the younger respondents discounted the risk of soil particles.

Table 11. Ordered Logit Estimation Results of the Risk Perception Associated with Eating Raw Fruits or Vegetables Containing Soil Particles.

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Constant	3.8200	4.77[a]								
Indices										
Ffind	.0260	1.90[c]	-.0034	-1.90[c]	-.0031	-1.89[c]	.0027	.76	.0038	1.00
Rsind	-.0138	-.84	.0018	.84	.0017	.84	-.0015	-.50	-.0020	-.73
Bfind	-.0023	-.11	.0003	.11	.0003	.11	-.0002	-.10	-.0003	-.11
Production Technology										
Convent	.2256	2.25[b]	-.0292	-2.23[b]	-.0272	-2.23[b]	.0238	.79	.0326	.81
Modified	.0206	.29	-.0027	-.29	-.0025	-.29	.0022	.28	.0030	.28
Nosynthe	-.1217	-1.39	.0157	1.38	.0147	1.38	-.0128	-.60	-.0176	-.91
Uncontek	.0834	.96	-.0108	-.96	-.0101	-.96	.0088	.63	.0120	.65

Table 11. (Continued)

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Approval Process										
KFDA	-.4049	-4.45[a]	.0523	4.38[a]	.0488	4.31[a]	-.0427	-.70	-.0584	-1.03
Indust	.2610	3.01[a]	-.0337	-3.00[a]	-.0314	-2.96[a]	.0275	.72	.0377	.94
Market	.0361	.50	-.0047	-.50	-.0044	-.50	.0038	.42	.0052	.44
Farmer	-.2456	-3.06[a]	.0317	3.03[a]	.0296	3.02[a]	-.0259	-.72	-.0354	-.95
Socio-demographic										
Income	.0333	1.01	-.0043	-1.01	-.0040	-1.01	.0035	.57	.0048	.74
Edu[d]	-.2128	-1.59	.0282	4.11[a]	.0248	2.89[a]	-.0230	-.49	-.0300	-.23
Age[d]	.2259	1.81[c]	-.0296	-2.76[a]	-.0267	-3.89[a]	.0242	.19	.0321	.37
Members	-.0794	-1.04	.0103	1.04	.0096	1.04	-.0084	-.52	-.0115	-.90
Other variables										
Farm	-.0005	-1.21	.0001	1.20	.0001	1.21	-.0001	-.64	-.0001	-.76
Rpest	.1879	-2.03[b]	.0243	2.03[b]	.0226	2.02[b]	-.0198	-.62	-.0271	-1.07

Table 11. (Continued)

			Marginal effect							
Variable name	Coefficient	t-value	C1=0	t-value	C2=1	t-value	C3=2	t-value	C4=3	t-value
Growfood[d]	-.3073	-1.22	.0435	6.61[a]	.0325	3.77[a]	-.0353	-.92	-.0406	-.31
μ1	1.7799	27.45[a]								
μ2	3.2666	38.94[a]								
Log-likelihood function	-1154.193									

Note: For variable specification and full name description see Table 1.

[a] Significant at α=.01.

[b] Significant at α=.05.

[c] Significant at α=.10.

[d] Marginal effects for binary variables are Pr[y|x=1]-Pr[y|x=0].

Overall, in comparisons to the other equations, fewer variables were statistically significant. A plausible explanation is that respondents did not consider soil particles as a risk source because soil particles have been commonly present and generations of Koreans grew accustomed to this fact.

CHAPTER 5

CONCLUSIONS AND IMPLICATIONS

Summary

Risk perception plays an important role in consumer behavior. The subjective perception of risk associated with food consumption influences the demand for food products. In recent years, the impact of risk perceptions extended downstream beyond the food market and directly affected the development and commercialization of agricultural and food processing technology. Because consumers value their well-being including health and the environment, many found technological advancements objectionable.

Differences in risk perception have their cultural dimensions. Although several previous studies have identified the relationships and attitudes, trust, and socio-economic characteristics, they focused on the American and European consumers. In increasingly liberalized global trade, risk perception studies should reflect the flows of trade and research on new technologies. This research focused on the perception of risk associated with food by consumers in the Republic of Korea. To examine consumer risk perceptions data used in this study were collected through a survey implemented in December 2003 by the Rural Development Authority using a questionnaire designed under the research project with the University of Georgia. To account for the cultural specificity of Korea, respondents were limited only to women, who are almost fully responsible for food shopping and preparation. A total of 1,000 women from the Seoul metropolitan area were selected and participated in the survey.

The perceptions of risk from seven sources were selected for the empirical analysis: foods modified to increase the vitamin content, foods containing allowable levels of pesticide residue, foods treated with harmless chemicals to improve appearance, foods fumigated to kill insects, foods washed in chlorinated water, foods sprayed with a sanitizing solution, and raw fruits or vegetables containing soil particles.

Explanatory variables were selected following earlier empirical studies on related topics because the economic theory provides few specific suggestions. In this study the explanatory variables reflected respondents' attitudes towards fears associated with food consumption, support for agricultural research, understanding of research benefits' distribution and opinions about the various production technologies, food attributes, and the trust in the technology approval process. A sub-set of variables include socio-economic and demographic features of respondents.

The ordered logit and probit approaches were considered as possible estimation techniques. Predicted values of the ordered logit approach were preferred to estimation results from the ordered probit model. The presence of heteroskedasticity was investigated using the likelihood ratio test, while the Hausman test was used to examine causality between dependent variables and the fear index variable.

Conclusions

Generally, there was a positive relationship between the fear index and the perception of food consumption associated with potential risk. Except for the question modeling risk perception from foods treated with harmless chemicals, all six models consistently generated positive relationship between the fear index on the risk perception. The higher the value of the fear index, the higher the perceived risk associated with the consumption of foods. Fear is a natural feeling, but it appears that respondents showing strong fear of food contamination or poisoning were strongly risk averse. Despite the information provided in the question, for example, that the pesticide residue was within the allowable limits, the value of the fear index and the risk perception moved in the same direction. This relationship was also true in case of the use of chlorinated water, a well-established practice consistent with guidelines for safe food handling. Even though it is not identical with the 'fear index' variable, earlier studies introduced a measure of 'outrage' as an explanatory variable (Zepeda *et al.*, 2003; Moon and Balasubramanian, 2004). Outrage was defined as an involuntary exposure; unfamiliar products; products with salient characteristics of deep moral significance; or the lack of benefit to consumers. The variable increased the risk perception according to results of previous research.

Effects of the research support index on risk perception were mixed. In case of foods treated with harmless chemicals, washed in chlorinated water, or sprayed with a sanitizing solution, the research support index positively influenced the risk perception, i.e., for example, respondents who were more supportive of research activities, were more likely to perceive risk associated with the consumption of foods treated with harmless chemicals. However, the research support index effect was negative with regard to risk perception from eating foods modified to increase the vitamin content. This result demonstrates that respondents recognized differences among various options presented to them in terms of the risk they posed. It was not surprising, but the statistical significance of the coefficient was reassuring.

The benefit index negatively influenced risk perceptions. Effects of this variable were statistically significant in case of the modification the vitamin content, treatment with harmless chemicals to improve appearance, washing in chlorinated water, and spraying with a sanitizing solution. The benefit index measured opinions about the occurrence of benefits to various levels in the supply chain and consumers. Not surprisingly, in the three out of four equations were this variable was statistically significant, the technology research benefitted primarily the supply chain players. The enhanced appearance or the use of agents reducing microbial contamination was either facilitating marketing or minimizing liability. Only in case of the modified vitamin content consumers benefitted by receiving an improved product, but suppliers could explore such an attribute to improve marketing. Earlier studies of American consumers reported similar results. An optimistic attitude toward agrobiotechnology decreased the risk perceptions associated with its commercial application (Hossain *et al.*, 2002a).

With regard to food production technology variables, respondents who preferred foods produced using unconventional practices, i.e., without synthetic pesticides, showed a high degree of risk perception in case of four food handling practices. Although the use of fumigation, chlorinated water or harmless chemicals can be viewed as consistent with the preference for production technologies reducing pesticide use, the similar attitude toward the modification of the vitamin content was unexpected. However, there appears to be a segment of respondents who would view this type of food enhancements as undesirable.

Respondents revealed different levels of trust for organizations potentially involved in the approval process of a new technology commercialization. Consumers showed a relatively higher degree of trust in the KFDA and farmer organizations than for supermarket chains or the manufacturing industry. Those who viewed the KFDA approval as necessary consistently perceived less risk associated with eating foods with modified vitamin content, treated with harmless chemicals to improve appearance, fumigated to kill insects, and raw fruits or vegetables containing soil particles. It appears that foods produced with the KFDA approved technologies were often considered safe and many respondents expected any new technology to be approved prior to commercialization. This result is consistent with previous studies. Moon and Balasubramanian (2004) reported that the level of trust in regulatory agencies negatively influenced the risk perception from agrobiotechnology. Hossain *et al.* (2002a) also pointed that the respondents who had trust in government tended to approve animal biotechnology suggesting that the trust in government decreased the perceived risk.

Even though socio-economic variables did not play a big role in this study, the findings were consistent with previous studies. In case of education, the educational attainment level negatively influenced the risk perception of consuming foods with increased vitamin content. The result is consistent with previous studies (Hossain *et al.*, 2002a; Hine and Loureiro, 2002).

Household income had a negative effect on the risk perception of eating foods 'treated with harmless chemicals', and 'sprayed with a sanitizing solution' . It is plausible that well-off consumers have access to alternative choices and are less concerned about risk from food consumption than consumers with a severe budget constraint. However, Chen and Chern (2002) reported that respondents in the high income bracket were more likely to buy gene-modified corn than respondents from the low income bracket.

Age had a positive effect on the risk perception of eating food containing soil particles. The elderly are more concerned for health and have comparatively more opportunities to learn about the recommended food consumption than the young.

The number of family members had statistically significant effect on three risk sources: the effects on risk perception stemming from the treatment with harmless chemicals and washing in chlorinated water were positive; however, the effect on the fumigation to kill insects was negative. The direction of the household size effect seems to reflect a great sensitivity of respondents to the use of any chemicals or procedures considered safe, although using a potential carcinogen (chlorine). The influence of fumigation is not clear, but perhaps, a vapor or smoke aimed at insects was viewed as less harmful than liquids.

Implications

The success of food policy and technology development is determined by consumer behavior. Consumer familiarity with all potential effects of technology determines the final acceptance of produced foods and the realization of returns from technology development. Policy makers' ignorance about consumer preferences hurts the efficiency of agricultural research programs. The results of this study can be used to mitigate perceived consumer risk and increase acceptance of new or modified technology.

Policymakers must pay attention to methods lessening consumer fears resulting from eating contaminated foods. Results of this study showed that the more respondents feared eating contaminated foods, the more risk they associated with new or modified food technology. The communication and a sustained effort in educating the public in the benefits of agricultural research will enhance the public acceptance of new technology. Because consumers trust government authority, the transparent and unbiased role of government agencies in the process of informing consumers about new technologies can decrease the risk perception associated with food consumption. Constant efforts to communicate among government, food industry, and consumers will improve the understanding of the agricultural technology.

Monitoring consumer preferences toward production practices is related to the public acceptance of a new technology. According to the survey and estimation results, there is an emerging consumer segment showing preference for reduced or eliminated use of chemicals. If consumer preferences have already shifted to foods produced using unconventional methods (without synthetic pesticides), agricultural products produced using other chemicals may not be welcomed in the market despite the government approval. Monitoring consumer preferences is also important for farmers and food manufacturers. In order to remain competitive, farmers and food manufacturers must take into account the changing preferences and apply acceptable production or processing technologies or face possible losses due to weak demand.

Knowledge of consumer perceptions and the variations across the consumer subgroups can greatly affect educational efforts. Results from this study provide limited guidance in terms of the socio-economic and demographic characteristics of audiences targeted by information campaign. Rather, expressed views and opinions, including fear perception, were factors that differentiated the response to a specific issue.

This study can be expanded in different ways. In the data collection process, all respondents were only women who lived in the Seoul metropolitan area. Because women are responsible for meal preparation in Korea, this restriction contributed the collection of reliable information about food concerns. However, limiting the pool of respondents to women led to the loss of some important differentiating variables, i.e., gender, occupation, or residential locations. The variation of consumers' risk perception between respondents in urban and rural area is expected larger than that among urban residents.

Most of variables used in the model reflected emotions such as fear, or dislike. For the practical use of the study, identifying subgroups whose risk perception was based on stable characteristics (e.g., income, education) could be more helpful for policy makers than use of variables describing only emotions.

Finally, the result of the study gives an opportunity for further demand analysis. The study is based on the assumption that the risk perception influences consumers' food demand and identified factors that influence consumers' risk perception. In the conceptual framework, a possibility of establishing demand function including a risk variable was noted. Due to the lack of pricing information, the study could not derive a demand function. Future research explaining the relationship between risk, price, and demand can provide important economic implications.

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