Consumers' Perception of Food-System Vulnerability to an Agroterrorist Attack

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This paper uses results from a 2004 survey (N=1,010) on consumer attitudes toward agroterrorism and food-system security to investigate heterogeneous attributes affecting vulnerability including risk perceptions and fear. Using 15 separate multinomial PROBIT regressions we distinguish between vulnerability on a number of aspects of food-system security including food type and position in the food-supply chain. Vulnerability is not found to be common across food groups or respondents, and a variety of distinguishing characteristics can be used to investigate how individuals might perceive vulnerability.

Since the events of September 11, 2001 there has been heightened awareness of the potential for a terrorist attack of a biological or chemical nature on the U.S. food supply, including agriculture. Alongside the obvious terrorist objective to cause harm to humans, animals, and property, a secondary, and in some cases overriding, objective of terrorism is to cause economic harm. Economic harm can arise from disruption to one of the many links across the supply chain, but the most potent form of economic harm might very well be the psychological impact of fear, and how it affects consumption. How the public views terrorist threats is not well understood, yet such views are perhaps more important than the dearth of literature in this area might suggest. From the business point of view agribusiness firms and retailers, should know what their customers are thinking. Furthermore, any risk communication requires knowing what constitutes a perceived risk or perceived vulnerability should indeed an event happen. This paper provides results from a 2004 nationwide poll in the United States to seek a better understanding of what consumers believe and how they view the vulnerabilities of specific food types and points on the supply chain to a terrorist disruption of the U.S. food supply. Our study is the first to examine this issue. Its importance lies in better understanding "what" consumers think about terrorist risks across the food-supply chain and food groups, and also provides a glimpse of "who" holds particular beliefs. We find, for example, that perceived vulnerabilities are not uniformly distributed across consumers and that many factors in combination can lead consumers to rank one food type as being more vulnerable than another or one point in the food-distribution/processing channel as more vulnerable than another. By understanding that differences in perceptions exist, the characteristics that explain these differences can be used to better target food-safety messages. Furthermore, because some research has found a connection between vulnerability and fear (Killias and Clerici 2000) the results can also be used to gauge risk perceptions and possible affective response (Slovic 2002) should an agroterrorist event occur. Lastly, our research does not suggest a self-fulfilling prophecy between how consumers perceive vulnerability and any true vulnerability or any actual risk. Perception is not reality in this instance, and although one might well be tempted to link perceived vulnerability with actual vulnerability, we refrain from doing so and discourage readers from making any such attribution.

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Food-System Vulnerability

This section provides an overview of the potential vulnerabilities across the agricultural and food-supply chain. Before proceeding, it is important to distinguish among the various terminologies for fear, risk, and vulnerability, all of which are key ingredients to analyzing problems of risk. Fear is an emotional response of agitation and anxiety caused by the presence or imminence of danger; risk refers to the possibility of suffering harm or loss or some other measure of danger; vulnerability is the sus-

ceptibility of an individual, market, or economy to physical, emotional, or economic injury. Because of this susceptibility, vulnerability encompasses a sense of likelihood. This likelihood establishes the risk of harm, and it is the risk of harm based on objective measures of probability, or the perceived risk of harm based on subjective probabilities, that gives rise to the affective response of fear. Although such distinctions can be made between vulnerability, risk, and fear this does not ease the task of terrorist-risk assessment (as labeled by Garrick 2002) for the two required inputs—fear, which guides behavior, and vulnerability/risk, which guide fear—are inextricably linked. In fact, *Webster's Encyclopedic Unabridged Dictionary* definition for terror is "an intense fear that is somewhat prolonged and refers to imagined or future dangers" (cf. Becker and Rubinstein 2004), so an act of terrorism in this sense creates fear. Economics is generally not well suited for such an abstraction, yet it is quite evident that to create fear without purpose is a costly proposition for any terrorist. Turvey et al. (2003) use the concept of consumer hysteresis and discuss how fear can lead to a shift in demand and a fear-induced decrease in its elasticity. By recognizing this behavior a terrorist can create real negative welfare effects. Similarly, Becker and Rubinstein (2004) base their economics on a rational-choice model in which marginal utility remains constant over risky states while fear changes the marginal utility in each state. In other words, "fear depreciates utility from consumption," and by generating fear, even in low-probability events, the economic impacts may not be inconsequential. Furthermore, research by Killias and Clerici (2000) shows a very close link between vulnerability and fear (of crime).

In reality, the actual risks of an agroterrorist attack are quite minute. Globally, there have only been 21 recorded incidences of attacks on either the agricultural or food system since 1952 (Owens 2002; Cameron and Pate 2001). Still, the threat of terrorism on the food supply is real, and because of the huge economic, health, and social-welfare costs associated with food contamination, the food supply presents a tempting target for terrorists who want to destabilize the American economy (USFDA 2003; Turvey et al. 2003; Sandler and Enders 2002; Owens 2002; Foxell 2001; Cameron and Pate 2001; Wheelis 2000). Contamination of food may have enormous economic implications in the U.S., where one out of every eight Americans is employed in an occupation directly linked to food production (Chalk 2001). The costs to individual food companies and to entire agricultural sectors of failing to prevent food contamination can be enormous. These costs can include those associated with a physical recall of contaminated product. In 2000, the U.S. Department of Agriculture estimated that foodborne illnesses linked to five pathogens cost the economy $6.9 billion annually (Crutchfield and Roberts 2000). For example, Khan, Swerdlow, and Juranek (2001) report that the costs to a U.S. company of the 1998 recall of 30 million pounds of frankfurters and luncheon meats possibly contaminated by *Listeria* were between $50 and $70 million and ultimately caused the processing facility to be closed. The costs of failing to prevent food contamination can also mount as the result of damage to perceived reputation and quality, the costs of product liability litigation (Buzby, Frenzen, and Rasco 2001; Lenain, Bonturi, and Koen 2002), the loss of market value of company stock (Salin and Hooker 2001; Wang et al. 2002) and the loss of export markets (Nitsch and Schumacher 2002). Indeed, after the discovery of a single cow infected with Bovine Spongiform Encephalitis (BSE) in December of 2003 the beef industry saw a plunge in the value of older cattle, widespread layoffs, beef stranded on ships in foreign ports, and a 94-percent drop in beef exports, drastically reducing profits for many American beef processors (Scott 2004).

Recognizing food-system vulnerabilities, industry and government have made large legislative, regulatory, and research investments designed to identify, reduce, and eliminate threats posed at key points in the supply chain (Sheffi 2001; Ollinger and Ballenger 2003). These include modifications to the Hazard Analysis Critical Control Points System (HACCP) (USDA-FSIS 1996; Nganje and Mazzacco 2000), improved quality-control measures throughout the food-supply chain (Antle 2000) and traceability of food through a proposal to mandate Country of Origin Labeling (CoOL), additional FDA regulations implementing the 2002 Bioterrorism Act, and the USDA's National Animal Identification System. Some have argued for increased shipment visibility through radio frequency identification device (RFID) tracking (Collins 2003) and greater collaboration along the food-supply chain, risk pooling, and increased reli-

ance on public/private partnerships in information sharing and security (Sheffi 2001). While consensus is lacking on the degree to which the food system is vulnerable to a deliberate attack aimed at destabilizing the economy and disrupting the flow of food (e.g. Cameron and Pate 2001; Foxell 2002), it is beyond debate that the opportunity exists (WHO 2002).

Risk Perceptions and Vulnerability

We focus on understanding the perceived vulnerabilities that give rise to consumers' fear. Vulnerability is related to the perceived likelihood of an event occurring. Our aim here is to treat vulnerability as a bundle of attributes and perceptions. In the next sections we describe results from a national telephone survey with questions specifically geared towards measuring how consumers perceive risk and vulnerability. We then describe these effects using an econometric consumer-choice model.

A survey instrument was developed to collect information on consumer attitudes and risk perceptions toward agroterrorism. Specifically, each respondent was asked to rate the vulnerability of food or points of the food chain to a terrorist attack. The foods covered included fresh, processed, and canned; the five segments of the food chain continuum are farms, processing plants, food warehouses, food transport, and grocery stores). Contamination of foodstuffs can occur at any point during the food-production process, from the importation of seeds to the unpacking of finished products at a supermarket. Along the way, even relatively unprocessed food passes through warehouses and packaging/labeling facilities and is transported several times on vehicles that are not always secure (Greco 2002). A section of the survey was devoted to gathering information on the socio-economic and value characteristics of the respondents, including age, gender, ethnicity, education, income, family size, employment status, religious practice, and political views. Also collected was respondents' knowledge of information pertaining to the food-chain continuum, (starting from food production at the farm, manufacturing, processing, transportation to the food outlets and groceries), food safety, and respondents' confidence in the groceries and federal government to ensure safety of foods eaten in case of a contamination.

Data from non-institutionalized American adults were gathered from October 2004 to November 2004, using telephone interviews. The interviews were completed using computer assisted-telephone interview technology (CATI). Adult respondents were selected from the 50 states using random-digit dialing, and proportionally selecting for gender. U.S. Census Bureau population estimates were used to verify the approximate distribution for proportionate national coverage. A total of 1,010 interviews were completed (sampling error ±3.1%), and the interviews took approximately 22.6 minutes to complete. Responses to some of the questions in the survey were not usable for the analysis, thus excluding some respondents from the sample during empirical analysis. As a result of excluding these respondents, a total of 762 completed surveys were used for empirical analysis.

We measure two classes of vulnerability based on type of food and segment in the supply chain. By vulnerability we mean the likelihood of exposure to harm. Although we use the term "current" in the questions, no time frame was placed on the risk, but it was assumed that the perceptions were related to the present or near future rather than some distant event. The first class of vulnerability dealt with the nature of the food item, while the second dealt with vulnerability across the food-distribution network and supply chain. The food items included as choices were meat, fruits and vegetables, fresh foods, dairy products, grains, beverages, processed foods, prepared foods, canned foods, and frozen foods.[1] Segments of the food chain and food-distribution channel considered included processing plants, food transport, food warehouses, grocery stores, and farm.[2] Both questions were rated on a 100-point scale. Using responses to these questions, the dependent variable was discretized into four categorical groups based on the quartiles of the

[1] The exact question asked for specific foods was "Now I would like to talk to you about the current vulnerability of some types of food to a terrorist contamination. Please tell me on a scale of 1 to 100, 0 being *Not at all likely* and 100 being *Absolutely likely*, how likely you think each of the following is to be a target for terrorist contamination."

[2] The exact question asked for point of the food chain was "I would like to talk to you about the current vulnerability of some specific parts of the food-supply chain in the U.S. Please tell me on a scale of 1 to 100, 0 being *Not at all likely* and 100 being A*bsolutely likely*, how likely you think each of the following is to be a target for terrorist contamination."

100-point scale. We then collapsed the third and fourth quartile into one category after testing for heterogeneity in the groups. The Mann-Whitney non-parametric test was applied; the test reveals that collapsing the third and fourth categories causes no loss of information in the dependent variable relating to the vulnerability of the food or a point in the food chain (Mann and Whitney 1947).

The resulting three discretized values were applied to an ordered multinomial PROBIT model using the approach described in Greene (2002). The dependent variables were defined as follows: Y_i = 0 if the response was "not at all vulnerable" (i.e., rated between 0 and 25), Y = 1 if the response was "somewhat vulnerable" (rated between 26 and 55), and Y = 2 if the response was "most vulnerable" (rated between 56 and 100). These breaks were validated using the Mann-Whitney test. A total of 15 separate regressions were run, one for each of ten different *food types* and five different *segments along the supply chain*. The rationale behind separate models is that, from a theoretical point of view, consumer perceptions need not be homogenous. Consumers from different backgrounds (demographic, economic, etc.) may perceive the various risks differently. Let Z_i be an index of consumer i's perceived vulnerability of the food/point of the food chain. People with different economic and demographic attributes such as income or education and other attributes such as religiosity or political affiliation may rate certain segments of the food system or foods to be more or less vulnerable than may others. Using responses to these questions, the dependent variable Y of an ordered multinomial PROBIT model $Y = f(Z) - g(x_1, x_2...)$ where $f(\ )$ is a nonlinear function of an estimated index Z, which in turn is a function of the independent variables x_{ij}. The attributes used in the analyses are defined in detail below. Accordingly, Z_i is modeled as a function of the i^{th} consumer's economic, demographic, and value attributes as follows:

$$Z_i = \beta' \mathbf{X} + \nu_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_k x_{ik} + \nu_i, \quad i = 1, 2, \ldots, n \quad , \tag{1}$$

where x_{ij} denotes the jth attribute of the ith respondent, $\beta = (\beta_0, \beta_1, \ldots, \beta_k)$ is the parameter vector to be estimated and ν is the error disturbance term (see Greene 2002 for details).

The model explanatory variables capture the potential influence of economic, demographic, and value attributes of the respondents on perceived vulnerability. The variables listed in Table 1 can be described in broad categories of sex, age, education, income, politics and religiosity, knowledge of the food system, trust, and regionalism. Sex is used to distinguish whether males or females have differing views on vulnerability. For example, the idea of the "security mom" might indicate that females are more sensitive to vulnerability than are males.[3] The age variables represent possible differences in attitudes toward degrees of vulnerability due to life experiences. We use education as a knowledge metric; individuals with more education may be more aware and knowledgeable of issues of food safety and vulnerability across the food chain. Income is used as a metric of wealth. Income can reflect many attributes, including education, but could also indicate a broader knowledge base and awareness of current events, leading to differences in opinions and attitudes about risk. Religiosity was included as a metric to determine whether faith influences beliefs and attitudes. This may lead to different beliefs about the risks from those of lesser faith. Political sensitivities are important in terms of beliefs about threats. For example, a clear divide is evident between republicans and democrats regarding the Iraq war. This divisiveness may translate into attitudes about vulnerability. The knowledge-base items about food safety and the food chain might indicate different degrees of perceived vulnerability. For example, identifying trust through a confidence indicator in the ability of government and groceries to protect the food supply against intentional contamination might reflect different degrees of vulnerability. If there is substantial trust, then vulnerability and risk may be perceived to be low. Finally, regional differences may arise for a number of reasons. For example the concentration of centers of commerce and trade, versus concentrations of agriculture and agribusiness, may represent different value systems. Risk perceptions may also be influenced on an east-west basis because the eastern states, due to the events of 9/11, might be viewed as being more vulnerable. Also, there may be disparity by regions because of

[3] This study does not distinguish between mothers and females; we use the term in its common nomenclature.

Table 1. Descriptive Statistics.

Variable	Description of variable	Mean	Std. dev
MALE	1 = respondent is male; 0 = female	0.46	0.50
YOUNG	1= age less than 25 years; 0 = otherwise	0.10	0.29
MIDAGE	1 = age is between 25 and 54 years; 0 = otherwise	0.62	0.49
MATAGE	1 = age 55 and 64 years; 0 = otherwise	0.15	0.35
SENAGE*	1 = age 65 or higher; 0 = otherwise	0.14	0.34
BELOWHSC	1 = Below High school education; 0 = otherwise	0.34	0.48
TWO_4YRC	1 = some two year college education to four-year college education; 0 otherwise	0.52	0.50
GRAD*	1 = graduate education; 0 = otherwise	0.14	0.35
LOW_MIDINC(INCLT35)	1 = (annual) income below $35,000; 0 = otherwise	0.33	0.47
MID_INC(INC35-50)	1 = (annual) income between $35,000 and $50,000; 0 = otherwise	0.17	0.37
MID_HIINC(INC50-75)	1 = (annual) income between $50,000 and $75,000; 0 = otherwise	0.22	0.42
HIGHINC(INCAB75)*	1 = (annual) income greater than $75,000; 0 = otherwise	0.29	0.45
RELIG	1 = attends church (or other house of worship) at least once a week, several times a month or once a month; 0 = otherwise	0.60	0.49
WHITE	1 = respondent is white (Caucasian); 0 otherwise Can different perceptions of risk be attributed to ethnicity.	0.83	0.38
LIBERAL	1 = identifies himself/herself as liberal; 0 = otherwise	0.18	0.38
CONSERV	1 = identifies himself/herself as conservative; 0 = otherwise	0.31	0.46
CENTRIST*	1 = identifies him/herself in between; 0 = otherwise	0.51	0.50
HI_KNFCN*	1 = has great deal of knowledge about the food supply chain; 0 otherwise	0.08	0.27
MED_ KNFCN	1 = has average knowledge about the food supply chain; 0 otherwise	0.61	0.49
LOW_ KNFCN	1 = has low knowledge about the food supply chain; 0 otherwise	0.31	0.46
HI_KNFSFT*	1 = has great deal of knowledge about the food safety; 0 otherwise	0.07	0.26

Table 1. Descriptive Statistics. (Continued)

Variable	Description of variable	Mean	Std. dev
MED_ KNFSFT	1 = has average knowledge about the food safety; 0 otherwise	0.59	0.49
LOW_ KNFSFT	1 = has low knowledge about the food safety; 0 otherwise	0.34	0.47
FSAF_GRC	1 = holds view that food in the grocery store is safe; 0 = otherwise	0.56	0.50
DBSAF_GRC	1 = holds view that food in the grocery store is unsafe due to deliberate tampering; 0 = otherwise	0.82	0.38
ACFSAF_GRC	1 = holds view that food in the grocery store is unsafe due to accidental errors; 0 = otherwise	0.63	0.48
SKEP_GROCAB	1 = holds skeptic view about Grocery ability to ensure food safety; 0 = otherwise	0.15	0.35
SKEP_GOVAB	1 = holds skeptic view about Government ability to ensure food safety; 0 = otherwise	0.21	0.41
MIDWEST	1 = respondent resides in Midwest; 0 = otherwise	0.25	0.43
SOUTH	1 = respondent resides in southern U.S.; 0 = otherwise	0.36	0.48
NOR_EAST*	1 = respondent resides in Northeastern U.S.; 0 = otherwise	0.18	0.39
WEST	1 = respondent resides in western states.; 0 = otherwise	0.20	0.40

* Implies that the variable was dropped during estimation to avoid dummy variable trap.

political power—for example the "red states" versus "blue states" for those regions predominantly republican versus democratic.

Table 1 presents the specific definitions of the independent variables used in the empirical model. Using the variable definitions, the following empirical model is specified to model perceived vulnerability of a food or point of the food chain (Z_i) and consumer economic, demographic, and value attributes:

$$(Z_i) = \beta_0 + \beta_1 MALE + \beta_2 MED\_KNFC + \beta_3 LOW\_KNFC + \beta_4 MED+KNFS + \beta_5 LOW\_KNFS + \beta_6 FSAF\_GRC + \beta_7 DBSAF\_GRC + \beta_8 FACC\_GRC + \beta_9 CFDGRCA + \beta_{10} CFDGOVA + \beta_{11} YOUNG + \beta_{12} MIDAGE + \beta_{13} MATAGE + \beta_{14} BELOWHS + \beta_{15} TWO\_4YRC + \beta_{16} RELIG + \beta_{17} LIBERAL + \beta_{18} CONSERV + \beta_{19} WHITE + \beta_{20} INCLT35 + \beta_{21} INCLT35+50 + \beta_{22} INCLT50\_75 + \beta_{23} MIDWEST + \beta_{24} SOUTH + \beta_{25} WEST + \varepsilon. \quad (2)$$

An ordered multinomial PROBIT model was estimated for each of the ten foods and five points in the food chain using maximum-likelihood (ML) estimation. The model summary statistics, β-coefficients (along with their t-ratios), and the marginal effects, evaluated at the means, were obtained by using the software package LIMDEP (Econometric Software 2002).

Empirical Results

The descriptive statistics show that we can rank perception into three categories: most vulnerable, medium vulnerability, and least vulnerable. In the case of food products, it was found that meat, fruits and vegetables, and fresh food products were (perceived to be) the most vulnerable. The foods that consumers believed less likely to be attacked were prepared foods, canned foods, and frozen foods. About 35 percent of the respondents felt that the meat products were most vulnerable to attack, with 31 percent and 30 percent feeling that fresh foods and fruits and vegetables will be terrorist targets. Processing plants, food transport, and grocery stores were perceived to be the most vulnerable points in the food-supply chain. Processing plants ranked highest, with 33 percent of the respondents feeling that this segment of the supply chain was most vulnerable to attack; least vulnerable were the food warehouses, which only 12 percent of the respondents felt were vulnerable to attack.

In terms of the econometric analysis, we focus on reporting the marginal effects (evaluated at the means) of the most vulnerable food/point of the food chain to be attacked (i.e., the marginal effects of the probability of being "most vulnerable" to a terrorist attack [Y = 2] and for the statistically significant variables only). To analyze the results, we first establish model performance via measures of goodness of fit. In this respect, results suggest that the response categories coded 0, 1, and 2 are indeed ordered as justified previously by the Mann-Whitney test. Additionally, the chi-square statistic test for the overall significance of the independent variables is used to reject the null in all the 15 models, suggesting that the regressors chosen were relevant in explaining the likelihood of a terrorist attack. Secondly, individual coefficients were subjected to the t-test for significance. However, coefficients from ordered multinomial PROBIT models are difficult to interpret, and one has to be cautious in using them to make inferences (Greene 2002). We therefore use the calculated marginal effects to make inferences on how changes in regressors affect the perceived probabilities of particular events.

Explaining Perceptions of Vulnerability

The independent variables—race, religion, and views about the ability of the federal government to ensure food safety after a contamination—were insignificant predictors across all the models and therefore are not reported. The parameter estimates and the associated t-ratios of the models are reported in Tables 2–5. Tables 2 and 3 provide ordered multinomial PROBIT estimates for the seven food and beverage categories, while Table 4 presents results for points along the food chain. The first set of columns in Tables 2–5 present the ordered multinomial PROBIT parameter estimates, while the second set of columns present the marginal effects. The marginal effects of an independent variable for given change are calculated at their sample means while holding other independent variables constant.

The results show that education, income, and age had the most influence in the consumer's perception on vulnerability. Using the marginal effects

estimates, foods and points of the food chain were ranked in terms of intensity of consumer perceptions about vulnerability. For example, using age to rank vulnerability, young people felt that meats, fresh foods, and fresh fruits and vegetables were most vulnerable, while processing plants, food transport, and groceries were ranked as the most likely targets of a terrorist attack. These observations are summarized below.

Gender: Compared to females, males were four to ten percent less likely to consider occurrence of terrorist acts on meats, fresh foods, and fruits and vegetables and on processing plants, food transport and grocery stores.

Age: Compared to those over 65 years, young people (<25 years) were 13 to 27 percent more likely to consider the meats, fruits and vegetables, and fresh foods as more vulnerable along with the processing plants, food transport, and grocery stores. Four categorical variables were defined for age to measure relative groupings of young, middle-aged, and aged. While actual age data was collected for respondents, some respondents preferred to provide age according to categories.

Income: Low-income respondents (those earning less than $35,000) considered meat and grocery stores to be equally as vulnerable as did those in the high-income category (over $75,000). Low-income respondents placed fruits and vegetables, fresh foods, and food transport in the second tier; those in this income group were about ten more likely to consider fruits and vegetables and fresh foods vulnerable and about six percent more likely to consider food transport vulnerable. Income was collected as a categorical rather than a continuous variable.

Education: Those with a high school education or less were four to 12 percent more likely to consider the meats, fruits, and vegetables, processing plants, and food transport to be more vulnerable to terrorist attacks than were those with graduate degrees.

Political Leanings: Political leaning was identified by asking respondents if they were liberal, centrist, or conservative. We refrained from asking any questions about actual party affiliation because one could be conservative and vote Democratic or liberal and vote Republican. Conservatives were five to seven percent less likely to consider meats, fresh foods, and fruits and vegetables to be the more likely targets of attack compared to the centrists.

Knowledge about the Food-Supply Chain and Food Safety: Those with medium knowledge about the food-supply chain were 12 percent more likely to consider fresh foods to be the most likely target of a terrorist attack compared to those with excellent knowledge. Those with low knowledge of food safety were five to 11 percent more likely to view processing plants, food transport, and grocery stores as the most vulnerable to a terrorist attack compared with those with excellent knowledge.

Grocery Store Safety: Those who considered grocery stores to be extremely safe compared to those who did not were six percent more likely to consider fruits and vegetables to be a most likely target of terrorism, and were five to 11 percent more likely to consider processing plants, food transport, and grocery stores to be most vulnerable to attacks.

Deliberate Food Tampering and Accidental Food Tampering: Those who felt that food in the grocery stores was unsafe due to deliberate tampering or accidental errors were five to 17 percent more likely to consider meats, fresh food, and fruits and vegetables to be more likely targets of a terrorist attack. Similarly, they were six to nine percent more likely to feel the same about processing plants, food transport, and grocery stores.

Confidence in Grocery Stores and the Federal Government to Ensure Food Safety: Those who were skeptical about grocery stores having an ability to ensure food safety in the case of contamination were four to 16 percent more likely to believe that meats, fruits and vegetables, and fresh foods were the most likely targets of terrorist attacks. They were also about seven percent more likely than those with confidence in grocery stores to think that food transport was most likely to be attacked. Having confidence in the federal government to ensure food safety in the case of contamination was not found to be significant.

Region: People from the West were six to ten percent less likely to consider meats, fruits and vegetables, and fresh foods to be the most likely targets of terrorist attacks than were those from the Northeast.

Table 2. Estimated Model Coefficients, t-ratios, and Marginal Effects for Meat, Fruit and Vegetables, and Fresh Foods.

				Marginal effects		
	Meat	Fruit & veg.	Fresh foods	Meat	Fruit & vegetables	Fresh foods
Constant	1.3178	1.4218	1.5907			
	(3.93)	(4.24)	(4.76)	-	-	-
MALE	0.2634*	0.2268*	0.1301			
	(2.90)	(2.50)	(1.45)	-0.10	-0.08	-0.04
YOUNG	-0.6975*	-0.5704*	-0.4473*			
	(-3.61)	(-3.01)	(-2.36)	0.27	0.21	0.17
MIDAGE	-0.3320*	-0.3691*	-0.2596**			
	(-2.47)	(-2.72)	(-1.94)	0.12	0.12	0.09
MATAGE	-0.2099	-0.2693	-0.1383			
	(-1.28)	(-1.63)	(-0.84)	0.08	0.10	0.05
BELOWHS	-0.3100	-0.1673	-0.2375			
	(-2.09)	(-1.12)	(-1.60)	0.12	0.06	0.08
TWO_4YR	-0.1887	-0.2382**	-0.1938			
	(-1.42)	(-1.76)	(-1.44)	0.07	0.08	0.07
LOW_MIDINC(INCLT35)	-0.3764*	-0.3014*	-0.1936			
	(-3.08)	(-2.48)	(-1.60)	0.14	0.10	0.07
MIDINC(INCOM35-50)	-0.0659	-0.1634	-0.2002			
	(-0.48)	(-1.19)	(-1.47)	-	0.06	0.07
MID_HIINC(INCOM50-75)	0.0388	-0.1274	-0.0729			
	(0.32)	(-1.02)	(-0.59)	-	0.04	-
RELIG	-0.1202	-0.0437	-0.0638			
	(-1.30)	(-0.47)	(-0.69)	0.04	0.01	-
WHITE	0.1609	-0.0582	-0.1268			
	(1.32)	(-0.49)	(-1.05)	-0.06	0.02	0.04
LIBERAL	0.1180	0.1891	-0.0070			
	(0.97)	(1.57)	(-0.06)	-0.04	-0.06	-
CONSERV	0.1639	0.2130*	0.1448			
	(1.61)	(2.10)	(1.44)	-0.06	-0.07	-0.05
MED_KNFCN	-0.2757	-0.2015	-0.3476			
	(-1.47)	(-1.09)	(-1.87)*	0.10	0.07	0.12
LOW_KNFCN	-0.0428	-0.0596	-0.1537			
	(-0.21)	(-0.29)	(-0.75)	-	0.02	0.05
MED_KNFST	-0.0224	-0.0278	0.0525			
	(-0.12)	(-0.15)	(0.28)	-	0.01	-
LOW_KNFST	-0.1254	0.0047	0.0378			
	(-0.60)	(0.02)	(0.19)	0.05	0.00	-

Table 2. Estimated Model Coefficients, t-ratios, and Marginal Effects for Meat, Fruit and Vegetables, and Fresh Foods. (Continued)

				Marginal effects		
	Meat	Fruit & veg.	Fresh foods	Meat	Fruit & vegetables	Fresh foods
FSAF_GRC	-0.0230	-0.1887*	-0.1085			
	(-0.24)	(-1.97)	(-1.14)	-	0.06	0.04
DBSAF_GRC	-0.4367*	-0.3841*	-0.3198*			
	(-3.46)	(-3.12)	(-2.60)	0.17	0.14	0.12
ACFSAF_GRC	-0.2669*	-0.1598	-0.2698*			
	(-2.69)	(-1.63)	(-2.76)	0.10	0.05	0.09
Skep_GROCAB	-0.4040*	-0.1731	-0.1292			
	(-2.98)	(-1.27)	(-0.97)	0.14	0.06	0.04
Skep_GOVAB	0.0801	0.1178	-0.1672			
	(0.69)	(1.01)	(-1.44)	-	-0.04	0.06
MIDWEST	0.2809*	0.1823	0.2235**			
	(2.10)	(1.38)	(1.69)	-0.10	-0.06	-0.07
SOUTH	0.1600	0.0614	0.1797			
	(1.27)	(0.50)	(1.45)	-0.06	-0.02	-0.06
WEST	0.2767*	0.1945	0.2145			
	(2.00)	(1.41)	(1.57)	-0.10	-0.06	-0.07

* denotes coefficient is significant at 0.05 level.
** denotes coefficient is significant at 0.10 level.

Table 3. Estimated Model Coefficients, t-ratios, and Marginal Effects for Dairy, Grain, Beverages, and Processed Food.

	Coefficients				Marginal effects			
	Dairy	Grain	Bever-ages	Processed food	Dairy	Grain	Bever-ages	Processed food
Constant	1.4938* (4.42)	1.2413* (3.71)	1.5837* (4.67)	1.2004* (3.54)	-	-	-	-
MALE	0.1783* (1.96)	0.0927 (1.03)	0.1569 (1.72)	0.1163 (1.26)	-0.06	-	-0.04	-
YOUNG	-0.3161 (-1.67)	-0.0893 (-0.48)	-0.2010 (-1.06)	-0.2209 (-1.16)	0.11	0.03	0.06	0.06
MIDAGE	-0.2163 (-1.58)	-0.1664 (-1.24)	-0.0534 -0.40	-0.0186 -0.14	0.07	0.05	0.02	-
MATAGE	-0.2241 (-1.34)	-0.0322 (-0.19)	-0.0035 (-0.02)	0.0442 (0.26)	0.07	-	0.00	-
BELOWHS	-0.1872 (-1.24)	-0.3609* (-2.40)	-0.1997 (-1.33)	-0.2809** (-1.81)	0.06	0.11	0.06	0.08
TWO_4YR	-0.3046 (-2.23)	-0.3171 (-2.32)	-0.0998 (-0.73)	-0.3400 (-2.41)	0.10	0.10	0.03	0.09
LOW_ MIDINC(INCLT35)	-0.2051 (-1.68)	-0.1034 (-0.85)	-0.2592* (-2.11)	-0.2879 (-2.32)	0.07	0.03	0.08	0.08
	-0.0369 (-0.27)	-0.1686 (-1.23)	-0.1219 (-0.88)	-0.0144 (-0.10)	-	0.05	0.04	-
MID_ HIINC(INCOM50-75)	0.1153 (0.92)	-0.0529 (-0.42)	0.0574 (0.45)	0.1390 (1.08)	-0.04	-	-0.02	-0.04
RELIG	-0.0517 (-0.55)	-0.0870 (-0.94)	0.0047 (0.05)	0.0580 (0.61)	-	-	0.00	-
WHITE	0.1284 (1.05)	0.0630 (0.52)	0.0741 (0.61)	0.2728* (2.25)	-0.04		-0.02	-0.08
LIBERAL	0.0489 (0.40)	0.0404 (0.33)	0.0567 (0.47)	-0.1157 (-0.94)	-	-	-0.02	0.03
CONSERV	0.0746 (0.73)	0.1669 (1.65)	-0.1278 (-1.25)	-0.0545 (-0.53)	-	-0.05	0.04	-
MED_KNFCN	-0.2952 (-1.55)	-0.2127 (-1.13)	-0.2484 (-1.29)	-0.0341 (-0.18)	0.09	0.06	0.07	-
LOW_KNFCN	-0.0806 (-0.38)	-0.0245 (-0.12)	0.0639 (0.30)	0.2092 (0.99)	-	-	-0.02	-0.05
MED_KNFST	0.0689 (0.36)	0.3384** (1.76)	0.1042 (0.53)	0.0114 (0.06)	-	-0.10	-0.03	-
LOW_KNFST	0.0909 (0.44)	0.2503 (1.22)	-0.0075 (-0.04)	-0.1586 (-0.76)	-	-0.07	0.00	0.04

Table 3. Estimated Model Coefficients, t-ratios, and Marginal Effects for Dairy, Grain, Beverages, and Processed Food. (Continued)

	Coefficients				Marginal effects			
	Dairy	Grain	Bever-ages	Processed food	Dairy	Grain	Bever-ages	Processed food
FSAF_GRC	-0.1505 (-1.56)	-0.2755* (-2.88)	-0.2242* (-2.32)	-0.1440 (-1.47)	0.05	0.08	0.06	0.04
DBSAF_GRC	-0.2294** (-1.87)	-0.2467* (-2.03)	-0.3740* (-3.06)	-0.3895* (-3.16)	0.08	0.08	0.12	0.12
ACFSAF_GRC	-0.4424* (-4.49)	-0.3180* (-3.23)	-0.0866 (-0.88)	-0.1834** (-1.84)	0.14	0.10	0.03	0.05
Skep_GROCAB	-0.2809* (-2.02)	-0.2134 (-1.57)	-0.3505* (-2.49)	-0.0984 (-0.71)	0.08	0.06	0.09	0.03
Skep_GOVAB	0.0757 (0.64)	0.0793 (0.68)	-0.0544 (-0.46)	-0.0946 (-0.80)	-	-	0.02	0.03
MIDWEST	0.1376 (1.02)	0.2253 (1.70)	0.1286 (0.95)	0.2675* (1.97)	-0.04	-0.07	-0.04	-0.07
SOUTH	-0.0033 (-0.03)	0.1200 (0.97)	-0.0623 (-0.50)	0.0191 (0.15)	-	-0.04	0.02	-
WEST	0.1341 (0.96)	0.1590 (1.16)	-0.0419 (-0.30)	0.2939 (2.09)	-0.04	-0.05	0.01	-0.07

* denotes coefficient is significant at 0.05 level.
** denotes coefficient is significant at 0.10 level.

Table 4. Food Chain Points: Estimated Model Coefficients, t-ratios, and Marginal Effects for Processing Plants, Food Transportation, and Grocery Stores.

	Coefficients			Marginal effects		
	Processing plants	Food transportation	Grocery stores	Processing plants	Food transportation	Grocery stores
Constant	1.3559* (4.13)	1.0252* (3.12)	1.3819* (4.15)	-	-	-
MALE	0.1298 (1.45)	0.2061* (2.29)	0.2426* (2.71)	-0.05	-0.07	-0.08
YOUNG	-0.3532** (-1.89)	-0.4029* (-2.13)	-0.4018* (-2.14)	0.13	0.15	0.14
MIDAGE	-0.2526* (-1.92)	-0.3085* (-2.30)	-0.1978 (-1.48)	0.09	0.11	0.06
MATAGE	-0.2321 (-1.43)	-0.1430 (-0.87)	-0.1806 (-1.10)	0.09	0.05	0.06
BELOWHS	-0.1242 (-0.86)	-0.1836 (-1.25)	-0.0471 (-0.32)	0.04	0.07	-
TWO_4YR	-0.1029 (-0.79)	-0.1826 (-1.38)	-0.1282 (-0.96)	0.04	0.06	0.04
LOW_ MIDINC(INCLT35)	-0.2349** (-1.95)	-0.1539 (-1.27)	-0.3824* (-3.16)	0.09	0.06	0.13
MIDINC(INCOM35-50)	0.0129 (0.10)	0.0820 (0.60)	-0.1982 (-1.46)	-	-	0.07
MID_HIINC(INCOM50-75)	0.0976 (0.80)	0.0134 (0.11)	-0.0521 (-0.43)	-	-	-
RELIG	-0.0205 (-0.22)	-0.0434 (-0.47)	0.0581 (0.63)	-	-	-
WHITE	0.0274 (0.23)	0.1021 (0.85)	0.0422 (0.35)	-	-0.04	-
LIBERAL	0.0449 (0.37)	0.0368 (0.31)	0.0380 (0.32)	-	-	-
CONSERV	0.0385 (0.38)	0.0955 (0.95)	0.0562 (0.56)	-	-0.03	-
MED_KNFCN	-0.0387 (-0.21)	0.1168 (0.63)	-0.2042 (-1.07)	-	-0.04	0.07
LOW_KNFCN	0.0978 (0.48)	0.1080 (0.53)	-0.1714 (-0.82)	-0.03	-0.04	0.06
MED_KNFST	-0.1073 (-0.56)	-0.0660 (-0.35)	0.1036 (0.53)	0.04	-	-0.03

LOW_KNFST	-0.1464 (-0.71)	-0.1083 (-0.53)	0.1217 (0.59)	0.05	0.04	-0.04
FSAF_GRC	-0.3126* (-3.32)	-0.2481* (-2.61)	-0.1634** (-1.73)	0.11	0.09	0.05
DBSAF_GRC	-0.2463* (-2.00)	-0.2783* (-2.26)	-0.3502* (-2.86)	0.09	0.10	0.12
ACFSAF_GRC	-0.2423* (-2.49)	-0.1772** (-1.82)	-0.2793* (-2.87)	0.09	0.06	0.09
Skep_GROCAB	-0.2244 (-1.69)	-0.2087 (-1.57)	-0.1893 (-1.41)	0.08	0.07	0.06
Skep_GOVAB	-0.0923 (-0.82)	0.0078 (0.07)	-0.1637 (-1.43)	0.03	-	0.05
MIDWEST	0.1076 (0.82)	0.1067 (0.81)	0.0797 (0.60)	-0.04	-0.04	-
SOUTH	-0.0159 (-0.13)	0.0457 (0.37)	0.0694 (0.56)	-	-	-
WEST	0.0721 (0.53)	0.1703 1.24	0.1683 1.23	-	-0.06	-0.05

* denotes coefficient is significant at 0.05 level.
** denotes coefficient is significant at 0.10 level.

Table 5. Foods and Food Chain Points: Estimated Model Coefficients, t-ratios, and Marginal Effects.

	Coefficients					Marginal effects				
	Foods			Food chain points		Foods			Food chain points	
	Prep. foods	Canned foods	Frozen Foods	Farm	Food whs.	Prep. foods	Canned foods	Frozen foods	Farm	Food whs.
Constant	0.8307* (2.47)	1.4637* (4.19)	1.4169* (4.07)	1.2988* (3.80)	2.1267* (5.66)	-	-	-	-	-
MALE	0.1185 (1.27)	0.2047* (2.15)	0.2367* (2.50)	0.0879 (0.95)	0.0875 (0.89)	-	-0.04	-0.04	-	-
YOUNG	-0.0760 (-0.39)	-0.2630 (-1.32)	-0.0211 (-0.11)	-0.5529* (-2.85)	-.3127 (-1.53)	-	0.06	0.00	0.19	
MIDAGE	0.0397 (0.29)	-0.3560* (-2.47)	0.1520 (1.10)	-0.3915* (-2.79)	-.2509 (-1.68)	-	0.07	-0.03	0.11	
MATAGE	-0.0357 (-0.21)	-0.1134 (-0.64)	0.0585 (0.34)	-0.2566 (-1.50)	-.1057 (-0.57)	-	0.02	-	0.08	
BELOWHS	-0.1127 (-0.73)	0.1098 (0.70)	-.2882** (-1.79)	-0.1668 (-1.09)	-.4862* (-2.76)	0.03	-	0.06	0.05	
TWO_4YR	-0.2125 (-1.52)	-0.0797 (-0.56)	-0.3274* (-2.22)	-0.1123 (-0.81)	-.4029* (-2.47)	0.05		0.06	0.03	
LOW_ MIDINC(INCLT35)	-0.1224 (-0.98)	-0.3688* (-2.91)	-0.3250* (-2.55)	-0.2988* (-2.40)	-.3110* (-2.34)	0.03	0.08	0.07	0.09	
MIDINC(INCOM35-50)	-0.0216 (-0.15)	-0.1739 (-1.20)	-0.1411 (-0.98)	0.0633 (0.44)	-.1418 (-0.93)	-	0.04	0.03	-	
MID_ HIINC(INCOM50-75)	0.2212 (1.71)	0.1474 (1.10)	0.0936 (0.70)	0.0735 (0.58)	0.0288 (0.20)	-0.05	-	-	-	
RELIG	0.0651 (0.68)	-0.0139 (-0.14)	0.0138 (0.14)	-0.0234 (-0.25)	-.1062 (-1.05)	-	-	-	-	
WHITE	0.3701* (3.01)	0.2096 (1.69)	0.2612* (2.12)	0.2576* (2.11)	0.2485* (1.97)	-0.10	-0.05	-0.05	-0.08	
LIBERAL	0.2195** (1.75)	0.2074 (1.61)	0.1207 (0.94)	-0.0393 (-0.32)	0.0209 (0.16)	-0.05	-0.04	-	-	

Table 5. Foods and Food Chain Points: Estimated Model Coefficients, t-ratios, and Marginal Effects. (Continued)

	Coefficients					Marginal effects				
	Foods			Food chain points		Foods			Food chain points	
	Prep. foods	Canned foods	Frozen Foods	Farm	Food whs.	Prep. foods	Canned foods	Frozen foods	Farm	Food whs.
CONSERV	0.0123 0.12	-0.1150 -1.09	-0.0683 -0.65	0.0507 0.49	0.0519 0.47	-	0.02	-	-	
MED_KNFCN	-0.2062 (-1.07)	-0.2293 (-1.13)	-0.2881 (-1.44)	-0.0399 (-0.21)	-0.1426 (-0.70)	0.05	0.05	0.05	-	0.02
LOW_KNFCN	0.2527 (1.19)	0.0177 (0.08)	-0.0483 (-0.22)	-0.0749 (-0.36)	0.0364 (0.16)	-0.06	-	-	-	-
MED_KNFST	0.2445 (1.25)	0.2459 (1.19)	0.1882 (0.94)	-0.0872 (-0.44)	0.1926 (0.94)	-0.06	-0.05	-0.04	-	-0.03
LOW_KNFST	0.0315 (0.15)	0.1399 (0.64)	-0.0267 (-0.13)	-0.0614 (-0.29)	0.0282 (0.13)	-	-	-	-	-
FSAF_GRC	-0.1652 (-1.68)	-0.2290* (-2.29)	-0.1575 (-1.58)	-0.2119* (-2.17)	-0.1340 (-1.29)	0.04	0.05	0.03	0.06	0.02
DBSAF_GRC	-0.3779* (-3.06)	-0.4203* (-3.36)	-0.3062* (-2.46)	-0.1966 (-1.61)	-0.5887* (-4.71)	0.10	0.10	0.06	0.06	0.13
ACFSAF_GRC	-0.4023* (-3.99)	-.1860** (-1.81)	-.1853** (-1.81)	-0.0622 (-0.62)	-0.1657 (-1.57)	0.10	0.04	0.04	-	0.03
Skep_GROCAB	0.0565 (0.41)	-0.1410 (-0.97)	-0.1122 (-0.78)	-0.2455** (-1.75)	-.2699** (-1.71)	-	0.03	0.02	0.07	0.04
Skep_GOVAB	-0.1373 (-1.14)	-0.0461 (-0.37)	0.0096 (0.08)	0.1468 (1.24)	-0.0386 (-0.30)	0.03	-	-	-0.04	-
MIDWEST	0.2355 (1.71)	0.3813* (2.70)	0.1860 (1.34)	0.1978 (1.47)	0.1732 (1.19)	-0.05	-0.07	-0.03	-0.06	-0.03
SOUTH	-0.0342 (-0.27)	0.0893 (0.70)	0.0508 (0.40)	0.1942 (1.54)	0.1041 (0.78)	-	-	-	-0.06	-
WEST	0.2234 (1.59)	0.1661 (1.16)	0.2766** (1.91)	0.0346 (0.25)	0.1130 (0.76)	-0.05	-0.03	-0.05	-	-

* denotes coefficient is significant at 0.05 level.
** denotes coefficient is significant at 0.10 level.

Conclusion

The results across various food types and links in the food chain indicate with reasonable statistical comfort that socio-economic attributes have a role to play in identifying perceived vulnerabilities, with age having a higher influential effect. Using the marginal effects estimates across the foods and points of the food chain, we ranked the foods and food chain in order of likelihood of a terrorist attack. The results show that young people, those with low incomes (<$35,000), those with less than medium knowledge about the food chain and food safety, those skeptical about grocery store safety abilities, and those with low education (high school and below) were likely to feel that meats, fresh foods, and fruits and vegetables are more vulnerable to terrorist attacks than are other food items. People fitting this profile similarly viewed processing plants, food transport, and grocery stores to be more vulnerable to terrorist attacks than are the farm-level production and food warehouses. In view of these findings, education and outreach efforts are critical to informing the public about agroterrorism and food-system security. This analysis contributes to a better understanding of public perceptions about agroterrorism and how prone consumers believe the food system is to agroterrorism. However, what consumers believe may constitute a vulnerability says little about how such perceptions interact with economic decisions and markets or how consumers will respond to an actual attack. Indeed, readers should not interpret the results of this study as a response to terrorist risk. Furthermore, it is unlikely that perceptions have any a priori impact on markets, but they may have significant consequences should an event actually happen. In other words, latent individual perceptions may well be amplified or exacerbated by an actual event, with the different groups responding in different ways. There is some evidence to support this. Becker and Rubinstein (2003), for example, find that high-frequency air travelers did not change their behavior after the 9/11 terrorist attacks relative to low-frequency travelers; that high-frequency visitors to coffee houses in Israel did not change consumption patterns following suicide attacks relative to low-frequency users; and, citing Adda (2000), note that the decrease in beef consumption following the discovery of Mad Cow Disease in France in 1996 was by low-frequency beef consumers, not high-frequency beef consumers. Academic research investigating agroterrorism and fear is in its infancy. Research needs to continue in identifying critical parameters of economic models, and testing them experimentally with consumers.

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