Public Attitudes And Perceptions Of The Vulnerability Of The U.S Food Chain To Agroterrorism

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Abstract

This study uses results from marginal effects estimates across the foods and points of the food chain to rank the foods and food chain points in order of intensity of likelihood of a terrorist attack. The results show that young people, low incomers (<$35,000), those with medium to low knowledge about food chain and food safety, those skeptical about grocery abilities on food safety, and those with low education were likely to feel that certain foods are more likely to view likelihood of terrorist attacks possible.

The results underscores the importance of consumer concerns about terrorist threats at the farm level, processing, grocery stores, or food transport calling for measures to secure such foods or segments of the food chain by all concerned. Notwithstanding, education and out reach efforts are critical in informing the public about agroterrorim, and the predisposing factors. For policy makers, the recurring persistent consumer perception vulnerability of the certain foods and points in food chain, points to the public concern of these areas as insecure, thereby direct disproportionate efforts secure such foods and points of the food chain.

Introduction

Although the risk of a bioterrorist attack on the food system existed prior to the events of September 11, 2001 the term "food security" was not ordinarily linked in context to specific terrorist or violent acts. While these events, unto themselves did not alter the probability of an attack, the events put terrorism at the forefront of U.S. domestic and foreign policy and made many realize the potential fragility of the U.S. economy to terrorism. While the debate continues about the degree to which such attacks could successfully be orchestrated against the food system, the reality is that successful attacks could have tremendous human health, economic, and psychological consequences.

Terrorism directed towards the food system will pose a number of potential threats such as loss of human life, economic disruption, and negative impacts upon moral and consumer confidence. It will pose threats to both U.S. exports (18 % of U.S. agricultural production is exported) and imports (9 % of food consumed domestically) markets for food and agricultural products. In thinking about the vulnerability of the food system to terrorist attack, it is necessary to assess susceptibility of the food supply systematically. Events at one point in the food system would be inextricably linked to the ability of other points in the system to operate efficiently.

Public attitudes and perceptions towards agroterrorism is a critical component of prevention and response strategies by the government and food industries. However, how the public views terrorist threats is not well understood and understanding perceptions of risk can provide insights into certain vulnerabilities of specific food products/types.

The purpose of this paper is to determine how the public views food system security and how these views relate to confidence in government and/or the food industry

to detect and respond to an agroterrorist attack. From an economic point of view threats to the food chain create the risk of economic loss for the U.S. agricultural industry. Although the likelihood of a widespread attack on the system by domestic or foreign subversives is very low, and impacts on human or animal health and safety limited, the real economic crises will be in shaken consumer confidence, leading to the disruption of consumer demand, and an erosion of public trust and confidence in the food system.

The focus of this study is to seek a better understanding of what consumers believe, and how they perceive risks associated with terrorist disruption of the U.S food supply. In general the study attempts to identify the relationship between perceived vulnerabilities of various food groups, points of vulnerability in the food supply chain, and how these perceptions relate to socio-economic and value attributes. The specific objectives are to: (i) identify and estimate the importance of factors underlying public views on agroterrorism; (ii) attempt to profile foods, points in food chain in terms of vulnerabilities; and to (iii) explore the relation between socio-economic and value attributes and factors affecting public perceptions of food safety risks.

Survey Methodology

A survey instrument was developed Food Policy Institute, Rutgers University to collect information on consumer attitudes and risk perceptions toward Agro-Terrorism. 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 using from the 50 United 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. Although many of the numbers dialed were excluded, 60.1% of working residential numbers yielded completed interviews. A total of 1,010 interviews were completed (sampling error ±3.1%), and the

interviews took approximately 22.6 minutes to complete. The survey collected respondents' information on the effect of four different food contaminants (Anthrax, Botulism, Cyanide, and Salmonella). A section of the survey was devoted to gather information on the socio-economic and value characteristics of the respondents, including age, gender, ethnicity, education, income, family size, employment status, religious practice and social/political views. Also collected was respondents' knowledge information pertaining to the food chain continuum (starting from food production at the farm, manufacturing, processing, transportation too the food out lets-groceries), food safety and respondents 'confidence in the groceries and federal government to ensure safety of foods eaten in case of a contamination. Also respondents were asked to identify the food product within that category that they purchase most often. This product was used in conjunction with the contaminant agent to formulate the questions measuring affect.

For this analysis, respondent were asked to rate a particular type of food product or point of the chain as most vulnerable to terrorist attack. However, 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. Specifically, each respondent was asked to rate food/points of the food chain vulnerability to a terrorist attack (the food s ranged covered were fresh, processed and canned and the five points of the food chain continuum- Farms; processing plants; food warehouses; food transport; and grocery stores).

The exact questions asked 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. Incase of the food chain points. In case food chain points: 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 absolutely likely. How likely*

you think each of the following is to be a target for terrorist contamination." Using the responses to the respective question, the dependent variable Y (vulnerability of the food chain point/food) was defined as follows: $Y_i = 0$ if the response was "*not at all vulnerable*", Y = 1 if the response was "*somewhat vulnerable*", and Y = 2 if the response was "*most vulnerable.*"

Conceptual Framework and Empirical Model

The purpose of this study is to identify and estimate the influence of consumers' socio-economic and value attributes on their perceptions about agroterrorism particularly, vulnerabilities[1] of various foods and points of the food chain. It is assumed that a consumer's attitude towards agroterrorism is determined by his/her perceptions of risks associated with terrorism. Therefore a consumer's perception about vulnerabilities of the foods /points of the food chain will ultimately depend on how they rated vulnerability to attacks (i.e., not at all vulnerable vis- ã-vis highly vulnerable).

Let Z_i denote consumer i's perceived vulnerability of the food/point of the food chain. However, people with different personal attributes may hold different views about the associated vulnerabilities to various foods/points of the food chain i.e. rating certain segments of the food system or foods to be more or less vulnerable than others. Accordingly, Z_i is modeled as a function of the i^{th} consumers economic, demographic, and value attributes as follows:

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

where x_{ij} denotes the j^{th} attribute of the i^{th} respondent, $\boldsymbol{\beta} = (\beta_0, \beta_1, \ldots, \beta_k)$ is the parameter vector to be estimated and ν is the error disturbance term.

[1] Vulnerability is used as a measure of likelihood of terrorist attack.

Consumer i's perception about the vulnerability of the food/point of the food chain can be modeled in terms of the comparison between not at all vulnerable to to most vulnerable (Z_i) as follows. Consumer i will perceives the food/point of the food chain as *not vulnerable at all* (rated between 0 and 25) if Z_i is not positive, *somewhat vulnerable* (scale 26-54) the food/point of the food chain if Z_i is positive but below some threshold μ, and *highly vulnerable* if the food/point of the food chain was rated between 56-100 if Z_i is greater than μ. Formally, consumer i's order of vulnerability perception of the food/point of the food chain is denoted by Y_i where Y = 0 implies *not vulnerable at all*, Y = 1 implies *somewhat vulnerable*, Y = 2 implies *highly/most vulnerable*, can be expressed in probability terms as follows:

$$\begin{aligned} &Y_i = 0 \text{ if } Z_i \leq 0, \\ &Y_i = 1 \text{ if } 0 < Z_i \leq \mu, \text{ and} \\ &Y_i = 2 \text{ if } Z_i \geq \mu. \end{aligned} \tag{2}$$

Under the assumption that the error term in equation (1) follows the standard normal distribution, the above probabilistic model yields the well known ordered probit model.

In this setting, the probabilities that Y_i = 0, 1, and 2 are given by:

$$\begin{aligned} &P(Y_i = 0) = \Phi(-\beta' X_i) \\ &P(Y_i = 1) = \Phi(\mu - \beta' X_i) - \Phi(-\beta' X_i) \\ &P(Y_i = 2) = 1 - \Phi(\mu - \beta' X_i) \end{aligned} \tag{3}$$

where Φ is the cumulative function of the standard normal distribution. This model is chosen because the dependent variable is discrete in nature and has a natural ordering. The β-vector and the μ's can be jointly estimated using the maximum likelihood (ML) procedure which yields consistent and asymptotically efficient estimators. The marginal effects of the independent variables can be estimated using the estimated coefficients of the model (Greene, 2002). In this framework, the marginal effects of the independent

variables on P (Y_i| Y_i = 0, 1, 2) are given by:

$$\partial P(Y_i = 0)/\partial X_j = -\phi(-\boldsymbol{\beta}'\mathbf{X})\beta_j$$
$$\partial P(Y_i = 1)/\partial X_j = [\phi(-\boldsymbol{\beta}'\mathbf{X}) - \phi(\mu - \boldsymbol{\beta}'\mathbf{X})]\beta_j \quad (4)$$
$$\partial P(Y_i = 2)/\partial X_j = \phi(\mu - \boldsymbol{\beta}'\mathbf{X})\beta_j$$

where ϕ is the density function of the standard normal variable and X_j is continuous. When X_j is discrete, the marginal effects are obtained by evaluating the P(Y_i) at alternative values of X_j. When X_j is discrete, the marginal effects are obtained by evaluating the P (Y_i) at alternative values of X_j. For the binary predictor variables, the first derivative result does not apply. In order to evaluate the effect of a binary variable, one has to calculate the difference in probabilities when the equation is evaluated at both levels of the binary variable with the other explanatory variables held at their mean values. Hence, the marginal effect of a binary variable is given by:

$$prob(y = 1 \mid \bar{X}_*, d = 1) - prob(y = 1 \mid \bar{X}_*, d = 0) \quad (5)$$

where $\bar{X}_*$ equals the mean of all the other variables and *d* is the binary explanatory variable. For example, the probability that a male consumer will perceive fruits and vegetables to be most vulnerable to attack, is given by the difference between the two probabilities (i.e. Probability (male=1) –Probability (female=0).

The model explanatory variables included the economic, demographic, and value attributes of the respondents. The specific definitions of the independent variables and the rationale for their inclusion in the empirical model are provided below.

Gender: The dummy variable *MALE* is assigned a value of 1 if the respondent is male, and 0 otherwise (i.e., female). The sample of respondents falling into male was 46

percent and the rest was 54 percent. No *a priori* assumption is made regarding the effect of gender variation on the dependent variable.

Age: It is assumed that perceptions towards agroterrorism varies across consumers of different ages, four separate age groups are identified as follows: (1) below 25 years (*YOUNG*); (2) between 25 and 54 years (*MIDAGE*); (3) between 55 and 64 years (*MATAGE*); and (4) 65 years or more (*SENAGE*). About 10 percent of the respondents belong to group 1, 62 percent belong to group 2, 14 percent belong to group 3, and the remaining 14 percent belong to group 4. Although there is no *a priori* expectation as to how public perceives agroterrorism, this is expected that it would vary among different age groups.

Income: To explore how different income groups perceive risks associated with agroterrorism, four different (annual) income levels are identified as follows: (1) below $35,000 (*LOWINC*); (2) between $35,000 and $50,000 (*MIDINC1*); (3) between $50,000 and $75,000 (*MIDINC2*); and (4) $75,000 or more (*HIGHINC*). About 33 percent of the respondents have income less than $35,000, 17 percent between $35,000 and $50,000, 22 percent between $50,000 and $75,000, and the remaining 29 percent have income of $75,000 or more. No *a priori* assumption is made about the effect of income on an individual respondent's risk perception associated with agroterrorism.

Race: Respondents are classified into to two groups on the basis of their race or ethnicity. Accordingly, a dummy independent variable *WHITE* is defined by assigning a value of 1 if the respondent is white (Caucasian) and 0 otherwise (i.e., all other racial or ethnic background). About 83 percent of the respondents are white and the remaining 17 percent belong to other races. The effect of this variable on the dependent variable in an

empirically open question.

Political Ideology: After the September 11, 2001 terrorist attacks against the U.S. it is assumed that Americans of different political leanings will view likelihood terrorist acts differently. Since liberals and conservatives often disagree on policies to fight terrorism, respondents' political ideology is included in the empirical model to test this hypothesis. Respondents are classified into three groups on the basis of their self-reported ideology as follows: (1) liberal (*LIBERAL*); (2) conservative (*CONSER*); and (3) in between liberals and conservatives (*CENTRIST*). About 18 percent of the respondents identified themselves as conservative, 31 percent as liberal, and the remaining 51 percent as centrist. There is no *a priori* expectation about the effect of this variable on the dependent variable.

Education: It is hypothesized that the more educated respondent will view likelihood of terrorist attacks differently from the less educated. To examine this issue, respondents are classified into the following three categories: (1) high school diploma or less (*BELOWHSC*); (2) some college (two year) including 4-year college degree (TWO_4YEARCOL), (3) graduate degree (*GRAD*). About 34 percent of the respondents have high school diploma or less, 52 percent have attained the two-year college or had 4 year of college degree, and the remaining 14 percent have a graduate degree.

Religion: People of different religions or religiosity are hypothesized to think differently about risks associated with terrorism. To explore the influence of a person's religiosity on his/her attitude/perception towards terrorism respondents' religiosity is included in the model as an independent variable, which is measured by their attendance at church or other similar house of worship. A dummy independent variable *RELIG* (attends a church

or other house of worship once a week, several times a month or once a month) is defined by assigning a value of 1 if the respondent is worshipped regularly and 0 otherwise. Approximately 60 percent of the respondents are regular worshipers, wile 40 percent occasional worshipers and never attended a church or other house of worship. *A priori* it is expected that more religious individuals are more likely to agree that terrorist events can be orchestrated against the U.S.

Knowledge of About the Food Supply Chain: Knowledge about food production at the farm though processing, manufacturing, processing, and its transportation to food outlets i.e. grocery stores is assumed to be critical in shaping perceptions as to what points of the supply chain is vulnerable. To explore this, the empirical model includes respondents' knowledge of the food chain as an explanatory variable. In order to obtain measure of respondents' knowledge of the food chain respondents were asked to state how much they know about the food chain. Their responses to this question placed was used to define three knowledge categories. (1) Those high knowledge bout the food chain (*HI_KNFCH*); (2) those with medium (average) food chain knowledge *MED_KNFCH*: and 3) and those with low knowledge, *LOW_KNFCN*. About 8 percent of the respondents were highly knowledgeable, 61 percent were average in knowledge aspects related to food supply chain, with 31 percent saying they knew little or nothing at all about the food chain.

Knowledge of Food Safety: Respondents were also asked to rate themselves on how much they knew about the food safety within the American Food supply chain. Respondents were classified into three categories based on their answers to this question. (1) Those high knowledge bout the food safety (*HI_KNFSAFT*); (2) those with medium

(average) knowledge *MED_KNFSAFT*: and 3) and those with low knowledge on food safety, *LOW_KNFSAFT*. About 7 percent of the respondents were highly knowledgeable on food safety matters, 59 percent were average in knowledge aspects related to food safety, while 34 percent said they knew little or nothing all about the food safety.

Grocery Safety: Consumer perception on the safety of the grocery stores was considered an important measure of the public confidence in the food supply chain particularly the grocery stores. A dummy variable defined as *FSAF_GRC* to take a value of 1 if the respondent viewed the grocery store where he/she shops as very safe to extremely safe, and 0 otherwise. About 56 percent of the respondents felt that their grocery stores were safe while 44 percent felt otherwise (somewhat safe or not at all safe).

Confidence in Grocery Stores to Ensure Food Safety: Consumer confidence in grocery stores is included in the empirical model by defining a dummy independent variable *SKEP_GROCAB* that takes a value of 1 if the respondent somewhat or strongly disagrees that the grocery store has the ability to ensure that the food is safe to be eaten and 0 otherwise. About 15 percent of the respondents were skeptical about grocery ability to ensure food safety.

Confidence in Federal Government To Ensure Food Safety: Respondents were asked, "*in case a terrorist contaminating specific foods with a chemical or biological agent, how confident are you that the federal government has the ability to ensure that food is safe to eat*." The federal government as a protector of the greater public interest plays an important role in ensuring food safety. Thus in case of a such an event occurring we test for consumer confidence in the federal government in the empirical model by including a

dummy independent variable *SKEP_GOVAB* that takes a value of 1 if the respondent *SKEP_GOVAB* that takes a value of 1 if the respondent somewhat or strongly disagrees that the federal government has the ability to ensure that the food is safe to be eaten and 0 otherwise. About 21 percent of the respondents were skeptical about grocery ability to ensure food safety.

Deliberate Food Tampering: a dummy independent variable defined as *DBSAF_GRC* was assigned a value of 1 if respondents viewed food in a grocery store to be somewhat to never deliberately contaminated, and 0 otherwise. About 82 percent of the respondents fall into category 1 .

Accidental Food Tampering: a dummy independent variable defined as *FACC_GRC* was assigned a value of 1 if respondents viewed food in a grocery store to be somewhat to never accidentally contaminated, and 0 otherwise. About 63 percent of the respondents fall into category 1.

Region: In order to explore potential regional differences in perception on agroterrorism, respondents were classified into four groups by defining the following four regional dummy variables: (1) *NOR_EAST*; (2) *SOUTH*; (3) *MIDWEST*; and (4) *WEST*. No *a priori* assumptions were made about regional differences in vulnerability perceptions on foods or points of the food chain.

Using the above variable definitions, the following empirical model is specified to model vulnerability of a food or point of the food chain ($VULN_i$) and consumer economic, demographic and value attributes:

$$\begin{aligned} VULN_i = {} & \beta_0 + \beta_1 MALE + \beta_2 MED\_KNFC + \beta_3 LOW\_KNFC + \beta_4 MED\_KNFS + \\ & + \beta_5 LOW\_KNFS + \beta_6 FSAF\_GRC + \beta_7 DBSAF\_GRC + \beta_8 FACC\_GRC + \\ & \beta_9 SKEP\_GROCAB + \beta_{10} SKEP\_GOVAB + \beta_{11} YOUNG + \beta_{12} MIDAGE + \beta_{13} MATAGE \\ & + \beta_{14} BELOWHS + \beta_{15} TWO\_4YRC + \beta_{16} RELIG + \beta_{17} LIBERAL + \beta_{18} CONSERV \\ & + \beta_{19} WHITE + \beta_{20} INCLT35 + \beta_{21} INCLT35\_50 + \beta_{22} INCLT50\_75 \\ & + \beta_{23} MIDWEST + \beta_{24} SOUTH + \beta_{25} WEST + \varepsilon \end{aligned} \quad (6)$$

where the variables are as defined earlier.

A probit model is 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 were obtained by using the software package LIMDEP (Limdep Version 8.0 User's Manual, 2002).

Empirical Results

The descriptive statistics show that we can rank vulnerability perception into three categories; most vulnerable; medium and least vulnerable. In the case of foods, meat, fruits and vegetables, and fresh food products were the most vulnerable. On those foods less likely to be attacked were prepared foods, canned and frozen foods. About 35 percent of the respondents felt that the meat products would be attacked, with 31 and 30 percent feeling that fresh foods and fruits and vegetables will be terrorist targets. Processing plants, food transport and grocery stores were the most vulnerable food chain points. In case the food supply chain, processing plants topped with 33 percent of the respondents feeling that it will be attacked, and least were the food warehouses where only 12 percent of the respondents felt that it will be attacked (Figures 1 and 2).

In terms of the econometric analysis, we focus on reporting the marginal effects of the most likely 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, first we establish model performance via measures of goodness of fit. In this respect, the statistically significant coefficient for the threshold parameter μ, suggests that the response categories coded 0,1,2 are indeed ordered. 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 probit models are difficult to interpret and one has to be cautious in using them to make inferences (Green 2000). We, therefore, use the calculated marginal effects to make inferences on how changes in regressors affect the probabilities of particular events.

Explaining Vulnerability of Foods/food chain points Perceptions

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 were not reported.

The parameter estimates and the associated t-ratios of the models are reported in Tables 2-3. The first three columns of Table 2-4 present results pertaining to foods and the points of the food chain vulnerabilities. The three columns of Tables 2-4 present the respective estimated marginal effects of the foods and the points of the food chain. Table 5 presents results on the remaining foods and points of the food chain. The marginal

effects of an independent variable for given change are calculated at their sample means while holding the other independent constant.

The results show that that education, income and age consumer characteristics 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 (Figure 3). For example, using age to rank vulnerability, young people felt that meats, fresh foods and fresh fruits and vegetables were most vulnerable, with processing plants; food transport and groceries were ranked as most likely targets of a terrorist attack given the age factor. Below there is a detailed description of the results.

Gender: Compared to females, males were 4 to 10 percent less likely to consider occurrence of terrorist acts on meats, fresh foods and fruits and vegetables and processing plants, food transport and grocery stores points of the food chain.

Age: Young people (< 25 years) compared those (>65 years) were 13 to 27 percent more likely to consider the meats, fruits and vegetables and fresh foods as more vulnerable as well as the processing plants, food transport and grocery stores.

Income: Low incomers (those earning less than 35,000 dollars) considered meat and grocery stores to be equally vulnerable than those in the high income categories earning over $75,000 dollars. This people placed fruits and vegetables in the second tier with, with fresh foods and food transport, where those who belonged to this income group were about 10 and 6 percent more likely to consider the respective foods and points of the food chain vulnerable.

Education: Those who had attained high school education and less were 4 to 12 percent

more likely to consider the meats fruits and vegetables processing plants and food transport to more vulnerable to terrorist attacks than those with graduate level of education.

Political Ideology: Conservatives were 5 to7 percent less likely to consider the attacks on meats, fresh foods fruits and vegetables to be the more likely targets of attack compared to the centrists.

Knowledge of About the Food Supply Chain and Food Safety: Those with medium knowledge about food supply chain compared to those with excellent knowledge were 12 percent more likely to consider fresh foods to be most likely target of a terrorist attack. On the other hand, those with low knowledge on food safety compared with those with excellent knowledge were 5 to 11 percent more likely to view processing plants, food transport and grocery stores under the most vulnerable to a terrorist attack.

Grocery Stores Safety: Those who considered grocery stores to be extremely safe compared those who did not were 6 percent more likely to consider fruits and vegetables to be a most likely target of terrorism and were 5 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 deliberate tampering or accidental errors were 5 to 17 percent more likely to consider meats, fresh food and fruits and vegetables more likely to be targets of a terrorist attack. Similarly, they were 6 to 9 percent to fell the same for processing plants, food transport and grocery stores.

Confidence in Grocery Stores To Ensure Food is Safe: Those who were skeptical about grocery stores having an ability to ensure food safety in case of a contamination

were 4 to 16 percent more likely to believe that meats, fruits and vegetables and fresh foods were most likely targets of terrorist attacks. And about 7 percent more likely than those with confidence in grocery stores to think that food transport was most likely to be attacked. While confidence in federal government to endure food safety in case of contamination was not significant.

Region: People from the west compared to those from the northeast region were 6 to 10 percent les likely to consider the meats, fruits and vegetables and fresh foods to be most likely targets of terrorist attacks.

Concluding Remarks

The results across foods and food chain show that both social economic attributes have a role to play in predicting 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 intensity of likelihood of a terrorist attack. The results show that young people, low incomers (<$35,000), those with medium to low knowledge about food chain and food safety, those skeptical about grocery abilities, and those with low education likely to feel that certain foods are more likely to view likelihood of terrorist attacks possible.

In view of these results, education and out reach efforts are critical in informing the public about agroterrorim, and the predisposing factors. For policy makers, the recurring persistent consumer perception vulnerability of the certain foods and points in food chain, points to the public concern of these areas as insecure, thereby direct disproportionate efforts secure such foods and points of the food chain. The industry should also be aware of consumer's concerns be it at farm level, processing, grocery

stores, or food transport to put in place measures to secure such foods or segments of the food chain.

This analysis has contributed toward a better understanding of public perceptions about agroterrorism and how prone the food system is towards agroterrorism. While contributing to the academic regulation literature in agroterrorism, the study may be useful for various institutions associated with food production and marketing in identifying consumer concerns and in formulating appropriate private and public policies to contain, prevent and respond to agroterrorism.

References

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Table 1: Descriptive Statistics

Variable	Description of Variable	Mean	Std. Dev
MALE	1 = respondent is male; 0 = otherwise	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; 0 = otherwise	0.34	0.48
TWO_4YRC	1 = some or full four-year college education; 0 otherwise	0.52	0.50
GRAD	1 = graduate education; 0 = otherwise	0.14	0.35
LOW_MIDINC	1 = (annual) income below $35,000; 0 = otherwise	0.33	0.47
MID_INC	1 = (annual) income between $35,000 and $50,000; 0 = otherwise	0.17	0.37
MID_HIINC	1 = (annual) income between $50,000 and $75,000; 0 = otherwise	0.22	0.42
HIGHINC*	1 = (annual) income greater than $75,000; 0 = otherwise	0.29	0.45
WORSHIP_REG	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	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
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 to be somewhat to never deliberately contaminated; 0 = otherwise	0.82	0.38
ACFSAF_GRC	1 = holds view that food in the grocery store to be somewhat to never accidentally contaminated; 0 = otherwise	0.63	0.48

Table 1. Cont.

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

Notes: Asterisk implies that the variable was dropped during estimation to avoid dummy variable trap.

Table 2. Foods: Estimated Model Coefficients, t-ratios & Marginal Effects						
				Marginal effects		
	MEAT	FRT &VEG	FRESH	MEAT	FRT &VEG	FRESH
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
MED_KNFC	-0.2757	-0.2015	-0.3476			
	(-1.47)	(-1.09)	(-1.87)*	0.10	0.07	0.12
LOW_KNFC	-0.0428	-0.0596	-0.1537			
	(-0.21)	(-0.29)	(-0.75)	-	0.02	0.05
MED_KNF	-0.0224	-0.0278	0.0525			
	(-0.12)	(-0.15)	(0.28)	-	0.01	-
LOW_KNF	-0.1254	0.0047	0.0378			
	(-0.60)	(0.02)	(0.19)	0.05	0.00	-
FSAF_GR	-0.0230	-0.1887*	-0.1085			
	(-0.24)	(-1.97)	(-1.14)	-	0.06	0.04
DBSAF_G	-0.4367*	-0.3841*	-0.3198*			
	(-3.46)	(-3.12)	(-2.60)	0.17	0.14	0.12
FACC_GR	-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
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
RELIG	-0.1202	-0.0437	-0.0638			
	(-1.30)	(-0.47)	(-0.69)	0.04	0.01	-
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
WHITE	0.1609	-0.0582	-0.1268			
	(1.32)	(-0.49)	(-1.05)	-0.06	0.02	0.04
INCLT35	-0.3764*	-0.3014*	-0.1936			
	(-3.08)	(-2.48)	(-1.60)	0.14	0.10	0.07
INCOM35	-0.0659	-0.1634	-0.2002			
	(-0.48)	(-1.19)	(-1.47)	-	0.06	0.07
INCOM50	0.0388	-0.1274	-0.0729			
	(0.32)	(-1.02)	(-0.59)	-	0.04	-
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
μ	0.9694*	0.8703*	0.8863*			
	(18.03)	(17.26)	(17.63)	-	-	-

Note: Single asterisk denotes that the coefficient is significant at .05 level while double asterisk denotes that coefficient is significant at .10 level

Table 3. Foods: Estimated Model Coefficients, t-ratios & Marginal Effects

	Coefficients				Marginal Effects			
	DAIRY	GRAIN	BEVS.	PROC.FDS.	DAIRY	GRAIN	BEVS.	PROC.FDS.
Constant	1.4938*	1.2413*	1.5837*	1.2004*		-	-	
	(4.42)	(3.71)	(4.67)	(3.54)	-			-
	0.1783*	0.0927	0.1569	0.1163				
MALE	(1.96)	(1.03)	(1.72)	(1.26)	-0.06	-	-0.04	-
	-0.2952	-0.2127	-0.2484	-0.0341				
MED_KNFC	(-1.55)	(-1.13)	(-1.29)	(-0.18)	0.09	0.06	0.07	-
	-0.0806	-0.0245	0.0639	0.2092				
LOW_KNFC	(-0.38)	(-0.12)	(0.30)	(0.99)	-	-	-0.02	-0.05
	0.0689	0.3384**	0.1042	0.0114				
MED_KNF	(0.36)	(1.76)	(0.53)	(0.06)	-	-0.10	-0.03	-
	0.0909	0.2503	-0.0075	-0.1586				
LOW_KNF	(0.44)	(1.22)	(-0.04)	(-0.76)	-	-0.07	0.00	0.04
	-0.1505	-0.2755*	-0.2242*	-0.1440				
FSAF_GR	(-1.56)	(-2.88)	(-2.32)	(-1.47)	0.05	0.08	0.06	0.04
	-0.2294**	-0.2467*	-0.3740*	-0.3895*				
DBSAF_G	(-1.87)	(-2.03)	(-3.06)	(-3.16)	0.08	0.08	0.12	0.12
	-0.4424*	-0.3180*	-0.0866	-0.1834**				
FACC_GR	(-4.49)	(-3.23)	(-0.88)	(-1.84)	0.14	0.10	0.03	0.05
	-0.2809*	-0.2134	-0.3505*	-0.0984				
CFDGRCA	(-2.02)	(-1.57)	(-2.49)	(-0.71)	0.08	0.06	0.09	0.03
	0.0757	0.0793	-0.0544	-0.0946				
CFDGOVA	(0.64)	(0.68)	(-0.46)	(-0.80)	-	-	0.02	0.03
	-0.3161	-0.0893	-0.2010	-0.2209				
YOUNG	(-1.67)	(-0.48)	(-1.06)	(-1.16)	0.11	0.03	0.06	0.06
	-0.2163	-0.1664	-0.0534	-0.0186				
MIDAGE	(-1.58)	(-1.24)	-0.40	-0.14	0.07	0.05	0.02	-
	-0.2241	-0.0322	-0.0035	0.0442				
MATAGE	(-1.34)	(-0.19)	(-0.02)	(0.26)	0.07	-	0.00	-
	-0.1872	-0.3609*	-0.1997	-0.2809**				
BELOWHS	(-1.24)	(-2.40)	(-1.33)	(-1.81)	0.06	0.11	0.06	0.08
	-0.3046	-0.3171	-0.0998	-0.3400				
TWO_4YR	(-2.23)	(-2.32)	(-0.73)	(-2.41)	0.10	0.10	0.03	0.09
	-0.0517	-0.0870	0.0047	0.0580				
RELIG	(-0.55)	(-0.94)	(0.05)	(0.61)	-	-	0.00	-
	0.0489	0.0404	0.0567	-0.1157				
LIBERAL	(0.40)	(0.33)	(0.47)	(-0.94)	-	-	-0.02	0.03
	0.0746	0.1669	-0.1278	-0.0545				
CONSERV	(0.73)	(1.65)	(-1.25)	(-0.53)	-	-0.05	0.04	-
	0.1284	0.0630	0.0741	0.2728*				
WHITE	(1.05)	(0.52)	(0.61)	(2.25)	-0.04		-0.02	-0.08
	-0.2051	-0.1034	-0.2592*	-0.2879				
INCLT35	(-1.68)	(-0.85)	(-2.11)	(-2.32)	0.07	0.03	0.08	0.08
	-0.0369	-0.1686	-0.1219	-0.0144				
INCOM35	(-0.27)	(-1.23)	(-0.88)	(-0.10)	-	0.05	0.04	-
	0.1153	-0.0529	0.0574	0.1390				
INCOM50	(0.92)	(-0.42)	(0.45)	(1.08)	-0.04	-	-0.02	-0.04
	0.1376	0.2253	0.1286	0.2675*				
MIDWEST	(1.02)	(1.70)	(0.95)	(1.97)	-0.04	-0.07	-0.04	-0.07
	-0.0033	0.1200	-0.0623	0.0191				
SOUTH	(-0.03)	(0.97)	(-0.50)	(0.15)	-	-0.04	0.02	-
	0.1341	0.1590	-0.0419	0.2939				
WEST	(0.96)	(1.16)	(-0.30)	(2.09)	-0.04	-0.05	0.01	-0.07
μ	0.8574*	0.9541	0.8963	0.8951		-	-	
	(16.87)	(17.99)	(17.14)	(16.72)	-			-

Note: Single asterisk denotes that the coefficient is significant at .05 level while double asterisk denotes that coefficient is significant at .10 level

Table 4. Food Chain Points: Estimated Model Coefficients, t-ratios & Marginal Effects

	Coefficients			Marginal effects		
	PRC.PLTS	FD.TRANS.	GROC.STRS.	PRC.PLTS	FD.TRANS.	GROC.STRS.
Constant	1.3559*	1.0252*	1.3819*			
	(4.13)	(3.12)	(4.15)	-	-	-
MALE	0.1298	0.2061*	0.2426*			
	(1.45)	(2.29)	(2.71)	-0.05	-0.07	-0.08
MED_KNFC	-0.0387	0.1168	-0.2042			
	(-0.21)	(0.63)	(-1.07)	-	-0.04	0.07
LOW_KNFC	0.0978	0.1080	-0.1714			
	(0.48)	(0.53)	(-0.82)	-0.03	-0.04	0.06
MED_KNF	-0.1073	-0.0660	0.1036			
	(-0.56)	(-0.35)	(0.53)	0.04	-	-0.03
LOW_KNF	-0.1464	-0.1083	0.1217			
	(-0.71)	(-0.53)	(0.59)	0.05	0.04	-0.04
FSAF_GR	-0.3126*	-0.2481*	-0.1634**			
	(-3.32)	(-2.61)	(-1.73)	0.11	0.09	0.05
DBSAF_G	-0.2463*	-0.2783*	-0.3502*			
	(-2.00)	(-2.26)	(-2.86)	0.09	0.10	0.12
FACC_GR	-0.2423*	-0.1772**	-0.2793*			
	(-2.49)	(-1.82)	(-2.87)	0.09	0.06	0.09
CFDGRCA	-0.2244	-0.2087	-0.1893			
	(-1.69)	(-1.57)	(-1.41)	0.08	0.07	0.06
CFDGOVA	-0.0923	0.0078	-0.1637			
	(-0.82)	(0.07)	(-1.43)	0.03	-	0.05
YOUNG	-0.3532**	-0.4029*	-0.4018*			
	(-1.89)	(-2.13)	(-2.14)	0.13	0.15	0.14
MIDAGE	-0.2526*	-0.3085*	-0.1978			
	(-1.92)	(-2.30)	(-1.48)	0.09	0.11	0.06
MATAGE	-0.2321	-0.1430	-0.1806			
	(-1.43)	(-0.87)	(-1.10)	0.09	0.05	0.06
BELOWHS	-0.1242	-0.1836	-0.0471			
	(-0.86)	(-1.25)	(-0.32)	0.04	0.07	-
TWO_4YRCOL.	-0.1029	-0.1826	-0.1282			
	(-0.79)	(-1.38)	(-0.96)	0.04	0.06	0.04
RELIG	-0.0205	-0.0434	0.0581			
	(-0.22)	(-0.47)	(0.63)	-	-	-
LIBERAL	0.0449	0.0368	0.0380			
	(0.37)	(0.31)	(0.32)	-	-	-
CONSERV	0.0385	0.0955	0.0562			
	(0.38)	(0.95)	(0.56)	-	-0.03	-
WHITE	0.0274	0.1021	0.0422			
	(0.23)	(0.85)	(0.35)	-	-0.04	-
INCLT35	-0.2349**	-0.1539	-0.3824*			
	(-1.95)	(-1.27)	(-3.16)	0.09	0.06	0.13
INCOM35	0.0129	0.0820	-0.1982			
	(0.10)	(0.60)	(-1.46)	-	-	0.07
INCOM50	0.0976	0.0134	-0.0521			
	(0.80)	(0.11)	(-0.43)	-	-	-
MIDWEST	0.1076	0.1067	0.0797			
	(0.82)	(0.81)	(0.60)	-0.04	-0.04	-
SOUTH	-0.0159	0.0457	0.0694			
	(-0.13)	(0.37)	(0.56)	-	-	-
WEST	0.0721	0.1703	0.1683			
	(0.53)	1.24	1.23	-	-0.06	-0.05
μ	1.0384*	0.8758*	1.0221*			
	(19.21)	(17.54)	(18.92)	-	-	-

Note: Single asterisk denotes that the coefficient is significant at .05 level while double asterisk denotes that coefficient is significant at .10 level

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

	Coefficients					Marginal Effects				
	Foods			Food Chain Points		Foods			Food Chain Points	
	PREP. Foods	CAN. Foods	FROZEN Foods	FARM	FOOD WHS.	PREP. Foods	CAN. Foods	FROZEN Foods	FARM	FOOD WHS.
Constant	0.8307*	1.4637*	1.4169*	1.2988*	2.1267*	-	-	-	-	
	(2.47)	(4.19)	(4.07)	(3.80)	(5.66)					-
MALE	0.1185	0.2047*	0.2367*	0.0879	0.0875					
	(1.27)	(2.15)	(2.50)	(0.95)	(0.89)	-	-0.04	-0.04	-	-
MED_KNFC	-0.2062	-0.2293	-0.2881	-0.0399	-0.1426					
	(-1.07)	(-1.13)	(-1.44)	(-0.21)	(-0.70)	0.05	0.05	0.05	-	0.02
LOW_KNFC	0.2527	0.0177	-0.0483	-0.0749	0.0364					
	(1.19)	(0.08)	(-0.22)	(-0.36)	(0.16)	-0.06	-	-	-	-
MED_KNF	0.2445	0.2459	0.1882	-0.0872	0.1926					
	(1.25)	(1.19)	(0.94)	(-0.44)	(0.94)	-0.06	-0.05	-0.04	-	-0.03
LOW_KNF	0.0315	0.1399	-0.0267	-0.0614	0.0282					
	(0.15)	(0.64)	(-0.13)	(-0.29)	(0.13)	-	-	-	-	-
FSAF_GR	-0.1652	-0.2290*	-0.1575	-0.2119*	-0.1340					
	(-1.68)	(-2.29)	(-1.58)	(-2.17)	(-1.29)	0.04	0.05	0.03	0.06	0.02
DBSAF_G	-0.3779*	-0.4203*	-0.3062*	-0.1966	-0.5887*					
	(-3.06)	(-3.36)	(-2.46)	(-1.61)	(-4.71)	0.10	0.10	0.06	0.06	0.13
FACC_GR	-0.4023*	-0.1860**	-0.1853**	-0.0622	-0.1657					
	(-3.99)	(-1.81)	(-1.81)	(-0.62)	(-1.57)	0.10	0.04	0.04	-	0.03
CFDGRCA	0.0565	-0.1410	-0.1122	-0.2455**	-0.2699**					
	(0.41)	(-0.97)	(-0.78)	(-1.75)	(-1.71)	-	0.03	0.02	0.07	0.04
CFDGOVA	-0.1373	-0.0461	0.0096	0.1468	-0.0386					
	(-1.14)	(-0.37)	(0.08)	(1.24)	(-0.30)	0.03	-	-	-0.04	-
YOUNG	-0.0760	-0.2630	-0.0211	-0.5529*	-0.3127					
	(-0.39)	(-1.32)	(-0.11)	(-2.85)	(-1.53)	-	0.06	0.00	0.19	0.06
MIDAGE	0.0397	-0.3560*	0.1520	-0.3915*	-0.2509					
	(0.29)	(-2.47)	(1.10)	(-2.79)	(-1.68)	-	0.07	-0.03	0.11	0.04
MATAGE	-0.0357	-0.1134	0.0585	-0.2566	-0.1057					
	(-0.21)	(-0.64)	(0.34)	(-1.50)	(-0.57)	-	0.02	-	0.08	-
BELOWHS	-0.1127	0.1098	-0.2882**	-0.1668	-0.4862*					
	(-0.73)	(0.70)	(-1.79)	(-1.09)	(-2.76)	0.03	-	0.06	0.05	0.09
TWO_4YR	-0.2125	-0.0797	-0.3274*	-0.1123	-0.4029*					
	(-1.52)	(-0.56)	(-2.22)	(-0.81)	(-2.47)	0.05		0.06	0.03	0.07
RELIG	0.0651	-0.0139	0.0138	-0.0234	-0.1062					
	(0.68)	(-0.14)	(0.14)	(-0.25)	(-1.05)	-	-	-	-	0.02
LIBERAL	0.2195**	0.2074	0.1207	-0.0393	0.0209					
	(1.75)	(1.61)	(0.94)	(-0.32)	(0.16)	-0.05	-0.04	-	-	-
CONSERV	0.0123	-0.1150	-0.0683	0.0507	0.0519					
	0.12	-1.09	-0.65	0.49	0.47	-	0.02	-	-	-
WHITE	0.3701*	0.2096	0.2612*	0.2576*	0.2485*					
	(3.01)	(1.69)	(2.12)	(2.11)	(1.97)	-0.10	-0.05	-0.05	-0.08	-0.05
INCLT35	-0.1224	-0.3688*	-0.3250*	-0.2988*	-0.3110*					
	(-0.98)	(-2.91)	(-2.55)	(-2.40)	(-2.34)	0.03	0.08	0.07	0.09	0.06
INCOM35_50	-0.0216	-0.1739	-0.1411	0.0633	-0.1418					
	(-0.15)	(-1.20)	(-0.98)	(0.44)	(-0.93)	-	0.04	0.03	-	0.03
INCOM50_75	0.2212	0.1474	0.0936	0.0735	0.0288					
	(1.71)	(1.10)	(0.70)	(0.58)	(0.20)	-0.05	-	-	-	-
MIDWEST	0.2355	0.3813*	0.1860	0.1978	0.1732					
	(1.71)	(2.70)	(1.34)	(1.47)	(1.19)	-0.05	-0.07	-0.03	-0.06	-0.03
SOUTH	-0.0342	0.0893	0.0508	0.1942	0.1041					
	(-0.27)	(0.70)	(0.40)	(1.54)	(0.78)	-	-	-	-0.06	-
WEST	0.2234	0.1661	0.2766**	0.0346	0.1130					
	(1.59)	(1.16)	(1.91)	(0.25)	(0.76)	-0.05	-0.03	-0.05	-	-
μ	0.9612*	0.9654*	1.0428*	0.7523*	0.8929*	-	-	-	-	
	(16.94)	(16.29)	(16.87)	(15.40)	(14.65)					-

Note: Single asterisk denotes that the coefficient is significant at .05 level while double asterisk denotes that coefficient is significant at .10 level

Figure 1: Likelihood of Terrorist Attack: Foods

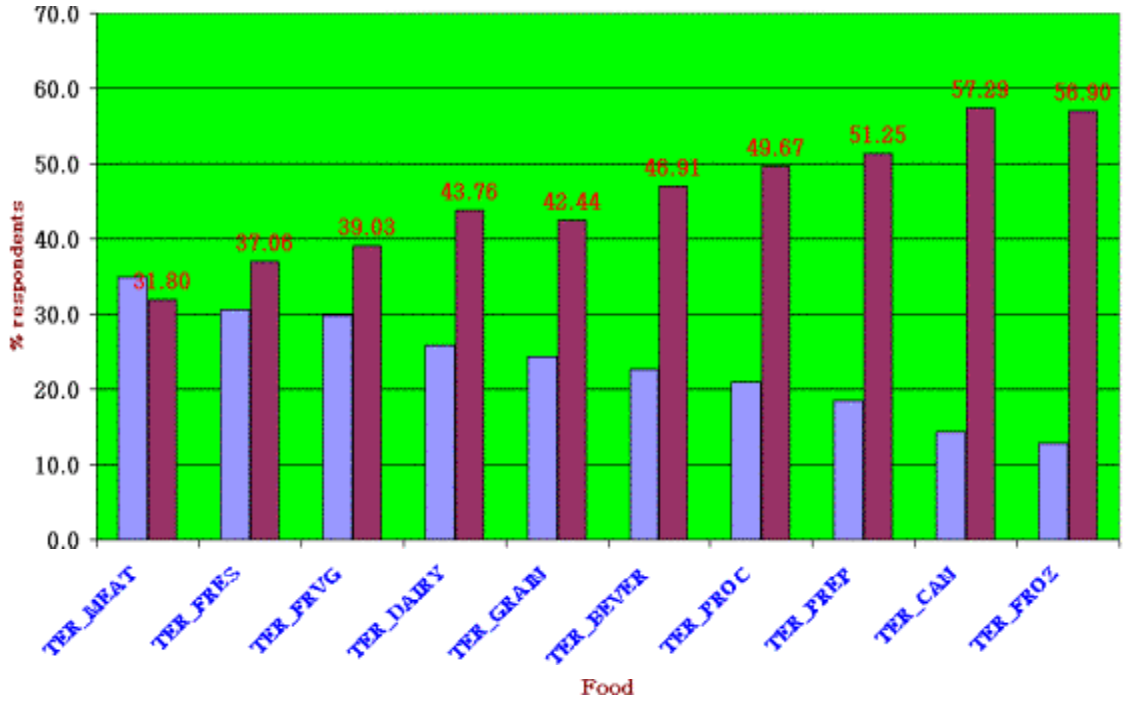

Figure 2: Likelihood of Terrorist Attack:Food Chain Points

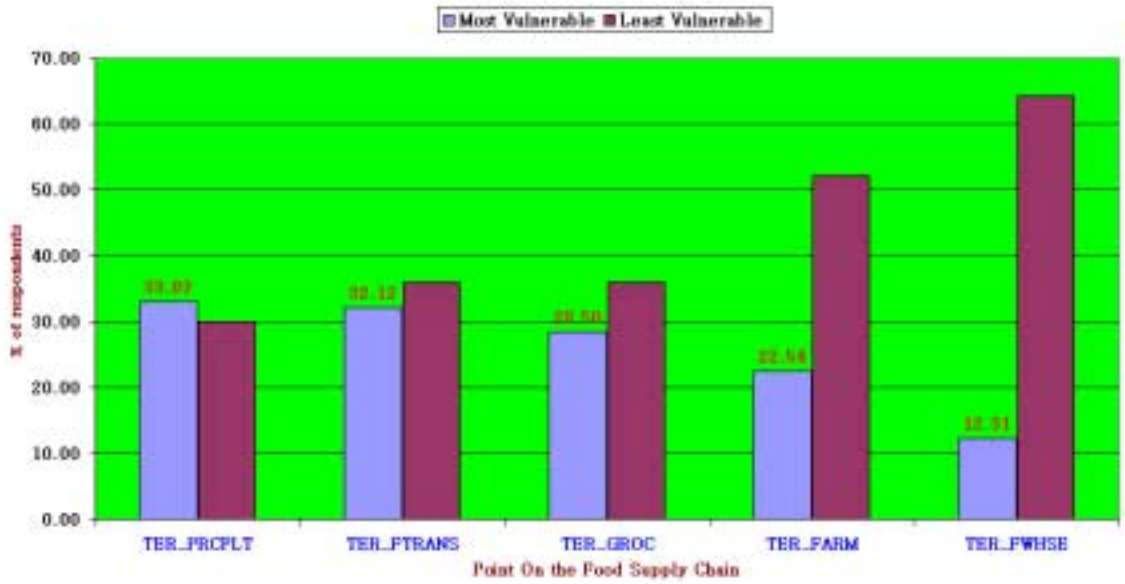

Figure 3: Ranking Vulnerability By Estimated Marginal Effects