AN EVALUATION OF CONSUMER PESTICIDE RESIDUE CONCERNS AND RISK INFORMATION SOURCES

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Abstract

Marginal probability effects of demographic variables on consumer concerns about pesticide residues were assessed as well as the likelihood of consumer beliefs given different channels of information on produce safety and risks. This was done using maximum likelihood estimation (MLE) of ordered logit models. The empirical results showed that pesticide residue concern levels appeared to be lower for more highly educated and high income households. Safety information from the academic community was found to have the highest likelihood of acceptance by consumers.

Key words: organics, food safety, pesticide residue, ordered logit

Over the years, food safety has become a growing concern for consumers (Kramer; Armbruster). Specifically, pesticide residues in the food supply have been consistently identified as a major concern among consumers (Misra, Huang, and Ott). Research conducted for the National Agricultural Chemical Association indicates that pesticide residues are the most significant food safety concern (NFO Research, Inc.). Other studies that concur with these findings are Fresh Trends 1991 (Zind) and a Louis Harris Poll (Organic Gardening). Furthermore, these studies suggest that fresh produce has received the most scrutiny of food products with respect to pesticide residues. Produce sales have grown from $23 billion in 1984 to $27.1 billion in 1988 (Beamer and Preston). However, it is expected that growing consumer concerns for pesticide residues could affect the growth rate of produce sales. Accordingly, the industry has stepped up education measures to assure the consumer of produce safety (Zind). The former U.S. Secretary of Agriculture, Clayton Yeutter, has stated that the domestic food supply is not unsafe and feels that the media has been manipulated to convince the public otherwise (Schertz). The Food and Drug Administration reports that pesticide residues in food are declining and that 96 percent of the U.S. food supply is residue-free or within legal tolerances set by the Environmental Protection Agency (Conner). In spite of these assurances, the consumer continues to exhibit considerable concern regarding pesticide residues.

The overall objective of this study was to determine consumer confidence in various channels utilized for the communication of potential risks of pesticide residues in the fresh produce supply. Specifically, the objectives were to: (1) compare consumer concern levels about pesticide residues with other food safety concerns and analyze the demographic effects on pesticide residue concern; (2) evaluate the likelihood of consumer belief based on statements on food safety provided by information groups; and (3) estimate the demographic effects on consumer confidence in these channels.

CONCEPTUAL FRAMEWORK

Hammitt discussed analyzing consumer demand based on Lancaster's theory of demand for attributes and characteristics of goods. Lancaster's framework suggests that consumers make purchase decisions based on the utilities of the attributes, where final choices are a direct result of utility maximization. However, application of the Lancasterian framework is limited to characteristics that are commonly known to consumers. In the case of food safety, pesticide residue risks are not generally known to the consumer (van Ravenswaay).

Randall and Stoll demonstrated that contingent valuations result in direct measurement of consumer attitudes and willingness to pay. Modified contingent valuations provide an actual range of options for the survey respondent. These valuations can then represent the consumer-defined attributes.

Studies of consumer demand behavior typically focus on the effects of prices and income on expenditure patterns. The theoretical justification for this

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approach originates from the utility maximization hypothesis and deriving the expenditure function. Extension of these demand studies has been made to include the effects of socio-demographic variables. Barnes and Gillingham have discussed the importance of demographic effects in demand analysis. Other studies have evaluated the impact of socio-demographic variables on U.S. food demand (Sexauer; Salathe).

The basic utility function is represented as:

(1) $U = U(q)$

where U is the utility function and q is the quantity vector of goods consumed. Generally, the derived expenditure function would specify that:

(2) $q = q(p,I)$

where p is the price vector of goods and I represents income level. Lancaster proposed that consumers demand products based on the characteristics or attributes of those products (K). In addition, as explained previously, socio-demographic variables (S) have also been found to affect consumer demand. Hence, we can expand the derived expenditure function:

(3) $q = q(p, I, K, S)$.

This equation states that the demand for a product depends on prices, income, attributes of the product, and socio-demographic variables. It is hypothesized that consumers with different socio-demographic characteristics may have different attitudes towards the positive and negative attributes of a particular product. Differences in consumer attitudes can ultimately effect the quantity demanded of the product in question.

One intent of this study was to evaluate the relationships of socio-demographic variables to product attributes (e.g., pesticide residue). However, because actual measurement of pesticide residue was unavailable, the relationships of consumer socio-demographic characteristics with their perceptions of pesticide residue concerns was evaluated. Inasmuch as pesticide residue levels are not commonly known (van Ravenswaay), the consumer has to depend on various channels (e.g., federal agencies, news media) for information. Another objective of this study was then to evaluate the relationships of socio-demographic variables to channel beliefs.

PROCEDURES

Means were calculated for consumer responses to various food concerns, including pesticide and herbicide residues. Respondents rated their concerns through the contingent valuation method on a scale of 1 to 7. To achieve the first part of the first objective, paired difference t-tests were used to determine whether significant differences existed between residue concerns and other food concerns.

The Ordered Logit Models

The ordered logit procedure using maximum likelihood estimation (MLE) was chosen as the method to achieve the second and third objectives of this study. As discussed in Maddala, the logit technique is preferred over other categorical variable estimating techniques (e.g., discriminant analysis). In food stamp participation research, Capps and Kramer found only minimal differences between the logit and probit models for their binary choice model of a qualitative dependent variable. Amemiya, on the other hand, suggested that the ordered logit model is a better procedure for capturing the magnitude of independent variable effects for polynomial ordered models of qualitative dependent variables than are probit models.

For estimation purposes, the pesticide residue concern variable, Pest, was aggregated into three categories:

Pest = 0 for indifferent or unconcerned (Respondent ratings 4-7),

Pest = 1 for some concern to concerned (Respondent ratings 2-3), and

Pest = 2 for very concerned (Respondent rating 1).

The model used to analyze the dependence of pesticide residue concern level on demographic characteristics was specified as:

(4) $Pest = \beta_0 + \beta_1 Age + \beta_2 Male + \beta_3 Some\ College + \beta_4 Bachelor\ Degree+ + \beta_5 Post\text{-}Graduate + \beta_6 High\ Income$,

where Age is a continuous variable for respondent age in years and the remaining independent variables are dummy variables. The dummy variables were measured as follows: Male was 1 if male, Some College was 1 if attended only some college, Bachelor was 1 if completed bachelor degree but no graduate work, Post-Graduate was 1 if completed some graduate work, High Income was 1 if annual household income ≥ $40,000. The purpose of this model was to analyze the demographic effects on pesticide residue concern as stated in the first objective, not to predict concern levels for individuals.

To achieve the second and third objectives of this study, seven information groups were analyzed: federal agencies, university scientists, environmental groups, public health officials, news media, health food store owners, and public interest groups. The dependent variable was a belief likelihood rating for each group, pertaining to any statement the groups may make regarding risks of fresh produce. The rating was a contingent valuation of 1 to 7 and belief levels were collapsed into three categories:

Belief = 0 if do not believe (Respondent ratings 5-7),

Belief = 1 if neutral (Respondent rating 4), and

Belief = 2 if do believe (Respondent ratings 1-3).

The independent variables for this model were identical to the pesticide residue model in equation (4).

Overall probabilities for both models were calculated at their means, using the estimated intercepts and coefficients with respective means. Because the qualitative variables share slope coefficients in the ordered logit model, only the intercepts are different between outcomes. Estimation of probabilities for all outcomes excluding [y=0] is (Greene 1990a; Maddala) as follows:

$$(5)\quad P[y > 0] = \frac{e^{\beta'x}}{1 + e^{\beta'x}} \text{ and}$$

$$(6)\quad P[y = 0] = 1 - \left(\frac{e^{\beta'x}}{1 + e^{\beta'x}}\right) = \frac{1}{1 + e^{\beta'x}}.$$

Equation (6) can also be expressed as:

$$(7)\quad P[y = 0] = \frac{e^{-\beta'x}}{1 + e^{-\beta'x}}$$

where β' is the vector of coefficient estimates and x is the vector of independent variables. The estimated intercept, $M\mu$, is then added to $\beta'x$ to yield:

$$(8)\quad P[y < 2] = \frac{e^{M\mu - \beta'x}}{1 + e^{M\mu - \beta'x}} \text{ and}$$

$$(9)\quad P[y = 1] = \left(\frac{e^{M\mu - \beta'x}}{1 + e^{M\mu - \beta'x}}\right) - \left(\frac{e^{-\beta'x}}{1 + e^{-\beta'x}}\right).$$

Since the probabilities sum up to one, then

$$(10)\quad P[y = 2] = 1 - \left(\frac{e^{M\mu - \beta'x}}{1 + e^{M\mu - \beta'x}}\right).$$

Following Greene (1990a), the marginal effects for the continuous variable, Age, are derived as the first derivatives of equations (7), (9), and (10) yielding:

$$(11)\quad \left(\frac{\partial P[y = 0]}{\partial Age}\right) = -[P_{[y=0]}(1 - P_{[y=0]})]\,\beta_1$$

$$(12)\quad \left(\frac{\partial P[y=1]}{\partial Age}\right) = 0 - \left[\left(\frac{\partial P_{[y=0]}}{\partial Age}\right) + \left(\frac{\partial P_{[y=2]}}{\partial Age}\right)\right]$$

$$(13)\quad \left(\frac{\partial P[y = 2]}{\partial Age}\right) = [P_{[y=2]}(1 - P_{[y=2]})]\,\beta_1 .$$

An increase in Age with a possible positive β would result in a lower probability for the 0 outcome. If β is negative, then an increase in Age would increase the likelihood of a 0 outcome. Hence, the derivative of P[y=0] has a sign opposite to that of β, as shown in equation (11). Conversely, the derivative of the P[y=2] has the same sign as β, as shown in equation (13). Increases in Age with a positive β could result in an increase, decrease, or no change in the probability of the 1 outcome, depending on the two densities. Therefore, the sign of the marginal effect for this outcome is ambiguous, while the other outcomes are unambiguous. Thus, inferences made with regard to the marginal effects of the middle outcome should be considered cautiously. The signs of changes in the bordered outcomes are unambiguous, making possible a confident interpretation of the results. Marginal or probability effects of the dummy variables were estimated as:

(14) (P[y=i] for x=1) - (P[y=i] for x=0).

Model significance was verified through the chi-square value resulting as a difference of the restricted and unrestricted log likelihood functions. Parallelism was confirmed for all models through the Score Test for the Proportional Odds Assumption (SAS Institute, Inc.) with 6 degrees of freedom for both criteria. The LIMDEP econometric software was used for the logit procedures (Greene 1990b).

DATA

The data used in this research were collected from a consumer study on opinions about fresh produce, conducted in 1990 on the Delmarva Peninsula consisting of Delaware, the eastern shore of Maryland, and two counties in Virginia. A random mailing sample of 9,000 telephone subscribers, based on zip code population and including unlisted households, was obtained from Donnelly Marketing. There were 1,065 usable questionnaires returned for a response rate of 11.8 percent not including refused, unusable, and "deceased" returns. Because average household size for the survey was calculated to be 2.74, the response rate represents 0.3 percent of the total Delmarva population (Bureau of the Census, U.S. Department of Commerce). Based on the sample size relative to the total population and the use of random sampling procedures, there is a 95 percent confidence in the accuracy of the results within three percentage points (Dillman). More importantly, the various demographic and social subgroups of respondents were well represented. The demographic and social variables, collected in terms of categorical variables, are summarized in Table 1.

Table 1. Demographic and Social Characteristics of Respondents, Delmarva 1990

Characteristic	N	Percent
Age		
18-34	220	21.3
35-49	377	36.4
50-64	259	25.0
65 or older	179	17.3
Missing	30	na
Total	1065	100.0
Gender		
Male	532	51.5
Female	501	48.5
Missing	32	na
Total	1065	100.0
Education		
High School or less	342	33.2
Some College	225	21.8
Bachelor Degree	251	24.4
Post-Graduate	212	20.6
Missing	35	na
Total	1065	100.0
Annual Household Income		
Less than $10,000	23	2.4
$20,000 - 19,999	72	7.4
$20,000 - 29,999	135	13.8
$30,000 - 39,999	142	14.5
$40,000 - 49,999	188	19.2
$50,000 - 59,999	129	13.2
$60,000 - 69,999	84	8.6
$70,000 or higher	204	20.9
Missing	88	na
Total	1065	100.0

Source: Delmarva Consumer Survey and Calculations.

EMPIRICAL RESULTS

Pesticide Residue Concern

Significant differences between residues and other concerns were detected through paired difference t-tests. The results were consistent with past studies (NFO Research, Inc.; Organic Gardening; Zind) in that concern for pesticide residues was significantly higher than for all other choices (Table 2). Herbicide residue concern was significantly lower than concern about pesticide residue but significantly higher than for all other choices. This indicates that herbicide residues are perceived as a considerable risk and should probably be thought of in a similar

Table 2. Consumer Concern Level Ratings, Delmarva 1990 (1=very unconcerned and 7=very unconcerned)

Variable	Mean	Std. Dev.
Pesticide Residue	6.098[a]	1.364
Herbicide Residue	6.045[b]	1.409
Fat	5.874	1.378
Cholesterol	5.818	1.391
Radiation By-Products	5.759	1.783
Fertilizer Residue	5.755	1.549
Salt in Food	5.591	1.512
Fiber	5.439	1.528
Sugar in Food	5.414	1.523
Preservatives	5.380	1.660
Calories	5.318	1.667
Growth Regulators	5.114	1.832
Artificial Coloring	5.107	1.779
N = 942		

[a] Pesticide residue concern is significantly higher than all other means at the .05 level by paired difference t-tests.

[b] Herbicide residue concern and is significantly lower than pesticide residue concern and significantly higher than all other means at the .05 level by paired difference t-tests.

Source: Delmarva Consumer Survey and Calculations.

context as pesticide residues. The observed frequency responses for pesticide residue concern were 0.1291, 0.3020, and 0.5688 for indifferent to unconcerned, some concern to concerned, and very concerned, respectively. The first logit model related pesticide residue concern to various demographic variables. The ordered logit model for the Pest variable had a significant overall chi-square value at the 0.01 level (Table 3). The probability to indicate at least some concern for pesticide residues was over 88 percent. As shown in Table 3, the marginal effects indicate that concern was substantially lower for males, persons with at least a bachelor's degree, and high income households. While the gender and education marginal effects had the expected results, the income effects pose a troubling issue for the organic produce market. The income effects indicated that those consumers who possessed the ability to pay for higher priced produce actually had less concern for pesticide residue risk. Advancing age and some college also reflected declining concern for product safety although the effects were not significant.

Channel Belief Likelihoods

The second model related the likelihood of consumers believing statements from various groups providing information on produce safety. The probability of respondents'not believing university scientists was the lowest among the groups, while the news media and health food store owners had the

Table 3. Ordered Logit Overall Probabilities and Demographic Effects for Consumer Concern Ratings of Pesticide Residues, Delmarva 1990

	P_0[b] Indifferent to Unconcerned	P_1[c] Some Concern to Concerned	P_2[d] Very Concerned
Overall (Chi-squared = 65.097[a])	.1189	.3095	.5716
Marginal Effects			
Age	.0000[e]	.0001	-.0001
Male[a]	.0523[f]	.0694	-.1217
Some College	.0022[f]	.0038	-.0060
Bachelor Degree[a]	.0575[f]	.0771	-.1346
Post-Graduate[a]	.0809[f]	.0973	-.1782
High Income[a]	.0464[f]	.0653	-.1117

[a] significant at the .01 level.

[b] computed as $P_0 = \frac{e^{-\beta'x}}{1 + e^{-\beta'x}}$ (Greene 1990a).

[c] computed as $P_1 = \frac{e^{M\mu-\beta'x}}{1 + e^{M\mu-\beta'x}} - P_0$ (Greene 1990a).

[d] computed as $P_2 = 1 - (P_0 + P_1)$ (Greene 1990a).

[e] marginal effect (ME) of continuous variable Age calculated:
P_0: $-[P_0 \bullet (1 - P_0)] \bullet \beta_{age}$
P_2: $[P_2 \bullet (1 - P_2)] \bullet \beta_{age}$
P_1: $0 - (P_0 + P_2)$.

[f] ME of dummy variables calculated:
$ME = P_i[y=1] - P_i[y=0]$.

Source: Delmarva Consumer Survey and Calculations.

highest probabilities of non-belief (Table 4). The overall chi-square values for the seven group models were all significant at the 0.05 level. It is interesting to note that the high probability of not believing the news media seems to negate the fact that it is the most popular form of information collection by the public (Kotler). On the other hand, consumers appear to place significant faith in the academic community for produce risk information. However, information from university scientists is not as easily disseminated as are news media pronouncements.

Table 4. Ordered Logit Overall Probabilities for Consumer Belief Outcomes for Risk Communication Groups, Delmarva 1990

Group	P_0[c] Don't Believe	P_1[d] Neutral	P_2[e] Believe	Chi^2
Federal Agencies	.2762	.2409	.4829	14.77[b]
University Scientists	.0852	.1379	.7769	14.23[b]
Environmental Groups	.2600	.1800	.5600	53.30[a]
Pulbic Health Officials	.1811	.2098	.6091	16.84[a]
News Media	.4702	.2912	.2386	36.37[a]
Health Food Store Owners	.4893	.2608	.2499	44.44[a]
Public Interest Groups	.3189	.2221	.4590	36.65[a]

[a] significant at the .01 level.

[b] significant at the .05 level.

[c] computed as $P_0 = \frac{e^{-\beta'x}}{1 + e^{-\beta'x}}$ (Greene 1990a).

[d] computed as $P_1 = \frac{e^{M\mu-\beta'x}}{1 + e^{M\mu-\beta'x}} - P_0$ (Greene 1990a).

[e] computed as $P_2 = 1 - (P_0 + P_1)$ (Greene 1990a).

Source: Delmarva Consumer Survey and Calculations.

The effects of the demographic characteristics on belief probabilities are shown in Table 5. The variables Age, Bachelor, and Post-Graduate were found to be significant for federal agencies. Older age had a positive effect on the belief level, while respondents with a bachelor's degree or at least some graduate work were more likely (8.18 percent and 11.52 percent, respectively) to trust produce safety statements made by federal agencies than were those with a high school degree or less. Only higher levels of education were significant for university scientists, with advanced education having a positive effect on belief levels. The high overall probability and the lack of difference among age, gender, and income suggest a wide acceptance of university risk communication.

The overall high probability to believe public health officials (Table 4) coupled with only the gender and some college variables being significant (Table 5) again suggests wide acceptance of risk communication. Males showed a lower probability to believe public health officials, as compared to females. This male skepticism is noted for all groups, except federal agencies. The effects of some college suggest diminishing respondent belief of public health officials.

Table 5. Marginal Effects *(ceteris paribus)* of Demographic Influence on Belief Probabilities, Derived from the Ordered Logit Estimated Parameter Coefficients, Delmarva 1990

Group	Age[1]	Male[2]	Some College[2]	Bachelor[2]	Post-Graduate[2]	High Income[2]
Federal Agencies						
Don't Believe	**-.0015**[c]	-.0033	.0130	**-.0656**[c]	**-.0897**[b]	-.0083
Neutral	**-.0003**[c]	-.0008	.0017	**-.0162**[c]	**-.0255**[b]	-.0020
Believe	**.0018**[c]	.0041	-.0147	**-.0818**[c]	**.1152**[b]	.0103
University Scientists						
Don't Believe	.0005	.0159	-.0198	**-.0335**[c]	**-.0513**[a]	-.0067
Neutral	.0007	.0196	-.0220	**-.0388**[c]	**-.0631**[a]	-.0080
Believe	-.0012	-.0355	.0418	**.0723**[c]	**.1144**[a]	.0147
Environmental Groups						
Don't Believe	**.0029**[a]	**.1509**[a]	.0073	.0091	.0374	**.0578**[b]
Neutral	**.0008**[a]	**.0385**[a]	.0021	.0027	.0099	**.0171**[b]
Believe	**-.0037**[a]	**-.1894**[a]	-.0094	-.0118	-.0473	**-.0749**[b]
Public Health Officials						
Don't Believe	-.0002	**.0574**[a]	**.0555**[c]	-.0019	-.0365	.0215
Neutral	-.0002	**-.0350**[a]	**.0277**[c]	-.0011	.1167	.0132
Believe	.0004	**-.0921**[a]	**-.0832**[c]	-.0030	-.0802	-.0347
News Media						
Don't Believe	**.0027**[b]	**.1333**[a]	.0317	.0257	-.0266	**.0826**[b]
Neutral	**-.0007**[b]	**-.0350**[a]	-.0090	-.0071	.0062	**-.0207**[b]
Believe	**-.0020**[b]	**-.0983**[a]	-.0227	-.0186	.0204	**-.0619**[b]
Health Food Store Owners						
Don't Believe	**.0038**[a]	**.1307**[a]	.0422	.0254	.0695	**.0780**[b]
Neutral	**-.0009**[a]	**-.0316**[a]	-.0099	-.0056	-.0592	**-.0181**[b]
Believe	**-.0029**[a]	**-.0991**[a]	-.0323	-.0198	.0103	**-.0599**[b]
Public Interest Groups						
Don't Believe	**.0021**[b]	**.1288**[a]	-.0154	.0040	-.0086	**.0578**[c]
Neutral	**.0003**[b]	**.0188**[a]	-.0024	.0005	-.0012	**.0093**[c]
Believe	**-.0024**[b]	**.1476**[a]	.0178	-.0045	.0098	**-.0671**[c]

[†] Bold print depicts significance of the actual parameter estimate at $\alpha \leq .10$.

[a] Significance of actual parameter estimate at .01.

[b] Significance of actual parameter estimate at .05.

[c] Significance of actual parameter estimate at .10.

[d] Marginal effect (ME) of continuous variable Age calculated:

P_0: $-[P_0 \bullet (1 - P_0)] \bullet \beta_{age}$

P_2: $[P_2 \bullet (1 - P_2)] \bullet \beta_{age}$

P_1: $0 - (P_0 + P_2)$.

[e] ME of dummy variables calculated:

$ME = P_i[y=1] - P_i[y=0]$.

Source: Delmarva Consumer Survey and Calculations.

The variables for age, gender, and income were significant for environmental groups, news media, health food store owners, and public interest groups (Table 5). In all four situations, belief probabilities were higher for younger ages, females, and lower income households, while education was not significant.

In general, belief probabilities appeared to be significantly influenced by the level of consumer education when information is provided by federal agencies and the academic community. This seems logical considering the fact that most safety pronouncements from these groups tend to be more technical, particularly with the academic scientists, than pronouncements from the other groups. On the other hand, the belief likelihoods for the other groups (environmental groups, news media, health food store owners, and public interest groups) appeared to be influenced by age, gender, and income.

CONCLUSIONS

The objective of this study was to assess the effects of demographic variables on consumer concerns about pesticide residues and the likelihood of consumer beliefs given different channels of information on produce safety and risks. The results of the study indicate several points of interest. First, pesticide residues were found to be of higher concern to consumers relative to other food-risk qualities of produce. This result is consistent with other studies (NFO Research, Inc.; Organic Gardening; Zind). Second, the pesticide residue-logit model results show that although consumers in general are concerned with food safety, concern levels appear to be lower for males, persons with at least a bachelor's degree, and high income households. Third, the belief-logit model results indicate that safety information from the academic community had the highest likelihood of acceptance by consumers. This result is similar to findings from a study conducted by Halbrendt et al. Education was found to be an important variable in the belief-logit models for the university group and federal agencies. Age, gender, and income were found to be important variables for the environmental groups, news media, health food store owners, and public interest groups. Demographically, these results could be utilized as indicators of confidence strengths and weaknesses for these information sources. Further, these channels may be able to improve confidence levels, if their information and/or claims are substantiated by university research. These results imply the importance of disseminating university research results on food safety issues. The academic community may also provide information through other channels of communication.

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