The Effects of Consumer Beliefs on Responses to Pesticide Residue Concerns: Implications for Food Safety Policy

Using an ordered bivariate probit model, impacts of consumer beliefs about pesticide regulations, and in sources of pesticide residue information, on responses to perceived pesticide residue risks are analyzed. Policy implications are drawn emphasizing education of consumers about existing regulations and accuracy of government information. The importance of providing an integrated view of pesticide risks by various groups associated with the food processing system is also discussed.

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Consumers demand food items that are nutritious, fully flavored, cosmetically clean, convenient to prepare, and have year round availability. For decades, bringing together this diverse set of food attributes, and providing an abundant supply of food products has meant that agricultural products must be treated with pesticides. However, along with this necessity, society has also expressed a growing concern about health risks associated with pesticide residues. The recent enactment of the 1996 Food Quality Protection Act which deleted the Delaney Clause, and added a host of new pesticide related food safety provisions is a testimony to the fact that the issue is very much alive today (Waterfield, 1996).

In a study on grapefruits, Buzby *et al.* (1995) show that the benefits of a ban on pesticide use, measured in terms of willingness to pay (WTP), outweigh the costs of a ban stemming from increased post-harvest losses. However, consumers seem to make their decisions without full information about the health risks associated with pesticide residues (van Ravenswaay and Wohl, 1995). Wohl *et al.* (1995) show that ambiguity about health risks associated with pesticide residues is a factor affecting consumers' WTP for reduced pesticides in food. More importantly, consumers' assessments of the risks they face, and the adequacy of safety measures often diverge significantly from that of scientists. A study by Chipman *et al.* (1995) reported that only 31 percent of the respondents correctly identified the level at which pesticide residues were considered legally safe. About 36 percent of respondents mistakenly believed that food items must be totally free of pesticides to be legally safe. This lack of proper information, coupled with consumers' own lack of control over pesticide residues in food items is likely to affect their WTP for safety measures and their food consumption habits.

In this paper, the issue of the importance of accurate information about the occurrence and regulation of pesticide residue levels is addressed. A survey conducted in 1992 by Misra, Fletcher and Huang (1995) is used for this purpose. We ascertained whether or not perceptions about pesticide regulations and government reported pesticide residue levels affect consumers' responses concerning the importance of providing additional food safety measures at the cost of higher food prices. These responses, measured on an ordinal importance scale, can be interpreted as indicating the degree to which consumers will be willing to pay for additional pesticide safety measures through higher food prices. We will refer to this measure as "propensity to be willing to pay (PWTP)" for the remainder of the paper, keeping in mind that this usage of WTP is very different from the typical usage in the contingent valuation literature. In addition to examining impacts on PWTP, we also examine whether or not perceptions about pesticide regulations and government reported pesticide residue levels affect consumers' propensity to have altered their food consumption habits, referred to from this point forward as PTA.

These two response measures, PWTP and PTA, represent very important potential consumer behaviors in response to concerns about pesticide residues and their regulation. Lack of proper information about pesticide residues and regulations may strengthen consumers' PWTP, and/or cause them to alter their food consumption habits. If this is the case, then policy prescriptions may be more usefully targeted at educating and informing consumers about existing pesticide regulations and risks rather than wasting scarce resources on additional food safety measures of uncertain necessity. The paper is organized as follows: In section one, the importance of measuring PWTP and PTA is discussed. In section two, measurement of consumer beliefs about government regulations and pesticide risks is discussed and ambiguity, information and misinformation variables are defined. Hypotheses are presented about the probable effects of different belief structures on consumers' PWTP and PTA. In section three, relevant data is analyzed, and a bivariate ordered probit model is estimated to test our hypotheses. Finally, in section four, we summarize and suggest policy implications.

Consumer Beliefs and Impacts on PWTP and PTA

We hypothesize that consumer beliefs about government approvals of pesticides, and government reported levels of pesticide residues in foods are important determinants of consumers' behavioral responses to perceived pesticide risks. It is a fact that pesticides have to be approved by the Environmental Protection Agency (EPA) before they are sold in the United States (US). It is also a fact that Food and Drug Administration (FDA) has reported that occurrences of pesticide residues above legal levels in our foods generally appear to be minimal. However, many consumers are either unaware of these facts or believe them to be false. We hypothesize that these consumers will have higher levels of concern about food safety, and will thus feel it is more important to take additional food safety measures, even at the cost of higher food prices. In addition, consumers may have altered their food consumption habits due to a lack of information or belief about pesticide regulations and residue levels.

Consumers who hold false beliefs about pesticide regulations and occurrences of pesticide residues can be characterized as being misinformed about these issues. Consumers who are uninformed about pesticide regulations and occurrences of pesticide residues can be characterized as being ambiguous about these issues. If these consumers act based on this misinformation or ambiguity, they may make non-optimal choices relative to correctly and fully informed consumers. These consumers may benefit from educational efforts to correct false information and provide missing information. We examine the hypothesis that misinformation and ambiguity increase both PWTP and PTA. We expect a positive impact given the fact that informed consumers will know that pesticides must be approved by EPA and that FDA reported occurrences of residues on food are very infrequent.

Consumers' PWTP and PTA may also depend on the amount of confidence they place in the opinions and information provided by manufacturers, marketers, scientists, and administrators who are associated with pesticide production, distribution, research and regulation. We construct indices of confidence in various vectors of information sources to investigate their impacts on PWTP and PTA. Theory does not provide any clear guidelines as to the direction of the impacts of confidence in different information sources. Thus, whether confidence in the opinions of particular groups increases or decreases PWTP and PTA will have to be determined empirically. We also hypothesize that households with young children will have higher PWTP and PTA.

In the past, in similar types of studies, researchers have used univariate ordered probit models (e.g., Pierre *et al.*, 1991). However, when two or more equations are estimated, one needs to take into account the correlation between the error terms of the equations. Given the similarity in the underlying factors potentially affecting PWTP and PTA, it is highly likely that the error structures of the two equations will be correlated. To account for the probable correlation between PWTP and PTA, we employ the bivariate ordered probit model. In this paper the dependent variables have five choices each, and the correlation between the error terms of the two equations, as described in the next section, is statistically significant. Therefore, for this analysis, an ordered bivariate probit system of two equations is formulated as follows:

$$\text{PWTP} = f\,(\text{intercept, PRCP1, PRCP2, ATTD, MSINF1, MSINF2, AMB1, AMB2, LABL, CONF1, CONF2, CONF3, RACE, MRST, EDCN, EMST, INCM, CHLD10, AGE, GNDR,}) + u_1 \quad (1)$$

$$\text{PTA} = g\,(\text{intercept, PRCP1, PRCP2, ATTD, MSINF1, MSINF2, AMB1, AMB2, LABL, CONF1, CONF2, CONF3, RACE, MRST, EDCN, EMST, INCM, CHLD10, AGE, GNDR,}) + u_2 \quad (2)$$

In the above formulations, PWTP represents propensity to be willing to pay higher food prices for additional pesticide residue safety measures, and PTA represents the propensity to have altered food consumption habits. The explanatory variables are defined in table 1. The $u_{(i)}$ are random error terms having a bivariate normal distribution, BVN(0,0,1,1,ρ) with ρ being the correlation between the error terms.

Data and Estimation

A survey of Georgia consumers conducted in 1992 by Misra *et al.* (1995) is used as the database. A total of 170 observations were used in the estimation. All variables in the bivariate probit model were constructed from corresponding survey questions..

In addition, three variables CONF1, CONF2, and CONF3 were constructed representing confidence in the comments made about food safety by various groups associated with food production, distribution, regulation and research. The choice of groups in each variable was made based on a factor analysis of nine variables measuring confidence in the following groups: university scientists, government agencies, independent laboratories, chemical manufacturers, consumer groups, growers' associations, supermarkets, popular media personalities, and friends, family, and fellow workers. These nine confidence variables were subjected to a principal components factor analysis using the PROC FACTOR routine in SAS. The analysis defined a smaller set of underlying source factors that account for the correlations among the nine confidence variables.[5]

The reduced set of three source variables explains 58% of the variance in the original set of nine confidence groups. Noting the factor loadings greater than 0.50, the following three source variables are defined: the first variable represents confidence in information provided by groups with a vested stake in preserving the use of pesticides. The second variable represents confidence in information provided by experts with no ties to pesticide use. The third variable represents confidence in information provided by non-experts and non-vested-stake groups. The CONF(i) variables are constructed by adding together the confidence variables within each factor i, i.e., CONF1 is equal to the sum of the confidence scores for chemical manufacturers, grower associations, and government agencies. Thus, CONF1 represents confidence in stakeholder information, CONF2 represents confidence in expert, non-stakeholder information, and CONF3 represents confidence in non-expert, word-of-mouth information. The summary statistics for these and all other variables are given in Table 1.

The dependent variables PWTP and PTA are ordered multiple-choice response variables. These response variables may be highly correlated. As a result, the error terms from the univariate ordered probit regressions will be correlated. Therefore, equations (1) and (2) are estimated using the bivariate ordered probit model. Essentially we assume that the cumulative distribution of the error terms u_i is bivariate normal. The bivariate ordered probit program developed by Hanousek (1994) has been adapted for this analysis, and the maximum likelihood estimation is performed using TSP.

Tables 2 and 3 summarize the estimated marginal effects of important explanatory variables on PWTP and PTA. The model correctly classifies 57 percent and 39 percent of the actual outcomes of PWTP and PTA variables respectively. ρ, the estimated correlation between the error terms is 0.69, and is highly statistically significant. The high value of ρ, and its high significance justifies the application of the bivariate probit model to our study. The analysis shows that the hypotheses that misinformation increases PWTP and PTA are rejected. We also reject the hypotheses that ambiguity increases PTA. However, we fail to reject the hypothesis that ambiguity about EPA approval of pesticides increases PWTP. We reject the hypothesis that ambiguity about FDA reported occurrences of pesticide residues increases PWTP. Other consumer beliefs and opinions had significant impacts on PWTP and PTA. The statistically significant results are detailed below. Those who felt it to be important to provide pesticide information on food labels (variable LABL) are likely to be more willing to pay higher prices for additional food safety, and they are also more likely to have changed their food purchasing habits. Those consumers who believe in the information provided by government representatives, chemical manufacturers and grower associations (CONF1) are less willing to pay higher prices for food safety, but are more likely to have altered their food habits. A possible reason for this could be that growers and chemical manufacturers may not encourage any additional safety regulations on their operations, and would rather advise consumers to take safety precautions. Consumers influenced by such groups would try to alter their food habits, and not be willing to pay extra for additional safety measures.

Conversely, those who believe in the information provided by university scientists, independent lab representatives and consumer groups (variable CONF2) are less likely to change their food habits, but are willing to pay higher prices for

Table 1.
Descriptive Statistics

Variable	Definition	Mean	Std. Dev.
PWTP	= Response to question "On a scale of 1 to 5, is it important to take additional measures against pesticide residues, even if it might result in higher food prices, to provide additional assurance in the safety of the food we eat." Scale is from 1='not important' to 5 = 'extremely important.'	4.00	1.16
PTA	= Response to question "On a scale of 1 to 5, have you changed your food consumption habits due to pesticide residues." Scale is from 1='no change' to 5='taking extreme precautions to only buy items that are guaranteed to be safe.'	3.07	1.41
PRCP1	= Respondent's perception about treatment of foods by pesticides. Scale is from 1='no problem' to 5='extremely serious problem.'	3.65	1.15
PRCP2	= Respondent's opinion about the adequacy and effective enforcement of food safety regulations. Binary variable equal to 1 if consumer believes food safety regulations are not adequate and not effectively enforced; equal to 0 otherwise.	0.44	0.50
ATTD	= Binary variable equal to 1 if respondent does not want a chemical to be used in food production even if its benefits outweigh its potential health and environmental risks; equal to 0 otherwise.	0.60	0.49
MSINF1	= Binary variable equal to 1 if respondent responded 'false' to the statement "All pesticides must have the approval of the Environmental Protection Agency before they can be sold in the U.S."; equal to 0 otherwise.	0.20	0.40
MSINF2	= Binary variable equal to 1 if respondent responded 'false' to the statement "According to the Food and Drug Administration, occurrences of pesticide residues above legal levels in our food generally appear to be minimal."; equal to 0 otherwise.	0.11	0.31
AMB1	= Binary variable equal to 1 if respondent responded 'don't know' to the statement "All pesticides must have the approval of the Environmental Protection Agency before they can be sold in the U.S."; equal to 0 otherwise.	0.25	0.43
AMB2	= Binary variable equal to 1 if respondent responded 'don't know' to the statement "According to the Food and Drug Administration, occurrences of pesticide residues above legal levels in our food generally appear to be minimal."; equal to 0 otherwise.	0.43	0.50
LABL	= Respondent's opinion on the importance of labeling to convey information about chemicals used to produce a food product and its safety. Scale is from 1='not important' to 3='very important.'	2.71	0.56
CONF1	= Confidence index measuring confidence in comments made about food safety by government agencies, chemical manufacturers, and growers' associations. Scale ranges from 3 to 15.	7.71	2.48
CONF2	= Confidence index measuring confidence in comments made about food safety by university scientists, independent labs, and consumer groups. Scale ranges from 3 to 15.	10.96	2.26
CONF3	= Confidence index measuring confidence in comments made about food safety by supermarket representatives, celebrities, and friends. Scale 3 to 15.	7.41	2.24
RACE	= Binary variable equal to 1 if white; 0 otherwise.	0.87	0.34
MRST	= Binary variable equal to 1 if married; 0 otherwise.	0.72	0.45
EDCN	= Ordinal variable equal to 1 if respondent has less than a high school diploma, 2 if respondent has a high school diploma and some college, and 3 if respondent has a college degree or above.	2.10	0.64
EMST	= Binary variable equal to 1 if employed full-time or part-time; 0 otherwise.	0.62	0.49
INCM	= Ordinal income variable ranging from 1= under $10,000 to 8=$70,000 and over.	4.10	2.12
CHLD10	= Binary variable equal to 1 if the household has children under 10 years of age; 0 otherwise.	0.22	0.42
AGE	= Age in number of years.	48.51	14.63
GNDR	= Binary variable equal to 1 if respondent is male; 0 otherwise.	0.40	0.49

additional food safety. This might be explained by the fact that scientists are increasingly able to detect minuscule amounts of pesticide residues in foods; and consumer groups would rather prefer producers and regulators tackling this problem than burdening consumers with the responsibility of changing their food habits. Results also show that those who are ambiguous about the fact that all pesticides need EPA approval before they are sold in the U.S. (variable AMB1), are more willing to pay higher prices for additional food safety. Thus, information ambiguity seems to be pushing consumers 'to be on the safer side', willing to incur extra costs which could possibly be avoided if full information was known. In regard to other explanatory variables, a positive and statistically significant relationship exists between perception variables PRCP(i) and the dependent variables. If respondents think that pesticide residues are a serious problem, and, if they think that government regulations are neither adequate nor enforced effectively, they are willing to pay higher prices for food safety, and are more likely to have altered their food habits significantly. With regard to attitudes towards pesticide use, those who would like

Table 2
Marginal Effects on PWTP Probabilities

	PWTP				
Variable	1	2	3	4	5
PRCP1	-0.003	-0.06[a]	-0.16[a]	0.08[a]	0.29[a]
PRCP2	-0.02	-0.05[b]	-0.13[a]	0.07[b]	0.25[a]
ATTD	0.00	-0.011	-0.03	-0.014	0.05
AMB1	-0.001	-0.03[c]	-0.09[c]	0.06	0.17[c]
AMB2	0.00	0.013	0.04	0.02	-0.07
MSINF1	0.002	0.004	0.012	0.01	-0.022
MSINF2	0.00	-0.01	-0.03	-0.013	0.047
LABL	-0.02	-0.16[b]	-0.22[a]	0.01	0.40[a]
CONF1	0.00	0.003	0.01	0.004	-0.02
CONF2	0.00	-0.01[c]	-0.02[a]	-0.01	0.04[c]
CHLD10	-0.001	-0.04[b]	-0.12[a]	0.08[c]	0.24[b]

[a]Significant at .01, [b]significant at .05, [c]significant at .05 one-tail test.

Table 3
Marginal Effects on PTA Probabilities

	PTA				
Variable	1	2	3	4	5
PRCP1	-0.03 [c]	-0.02 [c]	-0.002	0.02 [c]	0.04 [c]
PRCP2	-0.15[a]	-0.11 [a]	-0.02	0.06 [a]	0.21 [a]
ATTD	-0.10 [b]	-0.06 [b]	-0.001	0.04 [c]	0.12 [b]
AMB1	0.01	0.01	0.00	-0.01	-0.01
AMB2	0.03	0.02	0.01	-0.012	-0.033
MSINF1	0.15[a]	0.08 [a]	-0.02	-0.07 [b]	-0.14 [a]
MSINF2	-0.03	-0.02	-0.004	0.01	0.04
LABL	-0.17 [b]	-0.08 [b]	0.03	0.07	0.14 [b]
CONF1	-0.02 [c]	-0.01 [c]	-0.001	0.01 [c]	0.02 [c]
CONF2	0.001	0.00	0.00	0.00	-0.001
CHLD10	-0.09[a]	-0.08 [b]	-0.03	0.04 [b]	0.16 [b]

[a]Significant at .01, [b]significant at .05, [c]significant at .05 one-tail test.

pesticides banned are likely to have altered their food habits. However, this belief has an insignificant effect on PWTP. For these consumers, banning pesticides may substitute for other pesticide safety measures, or they may feel that only banning pesticides is a worthwhile safety guarantee. This may be due to their belief that government safety measures could be costly, and still may not provide any guarantees of residue-free/risk-free food. Households with children under the age of ten are likely to have altered their food habits in the face of food safety concerns, and are ready to pay higher price for additional food safety measures. This may reflect the fact that parents are responsible for a greater portion of young children's daily food consumption, and thus the safety of the food they eat. In addition, recent publicity about children's relatively high sensitivity to pesticide residues may have increased consumer concerns about children's exposure to pesticide residues. (National Research Council, 1993)

Conclusion and Implications

Most pesticide food safety studies in the past focused on the effects of socio-economic, demographic, and attitudinal variables on WTP for food safety. However, with the exception of the study by Wohl *et al.* (1995) who considers ambiguity as one of the important determinants of WTP higher prices, none have considered the impacts of ambiguity, information and misinformation. While the previous studies consider ambiguity per sé, this study considers a broad range of variables that incorporate ambiguity, information and misinformation about food safety issues. A bivariate ordered probit model is formulated to determine the impacts of these variables on the propensity to be willing to pay for additional food safety and the propensity to have altered food consumption habits. The model is empirically estimated using data from a 1992 survey of Georgia consumers.

Our results show that some information variables do matter in determining PWTP and PTA. However, the results suggest that perceptions about pesticide risks and the efficacy of existing pesticide regulations have larger effects on the two response variables. Ambiguity about safety measures does make consumers more likely to feel it is important to take additional costly food safety measures, but does not affect averting behavior. Misinformation does not increase either PWTP or PTA. Consumers who feel that it is important to provide pesticide information on food labels have both higher PWTP and PTA. This may be due to these consumers feeling that adequate information is not already available (hence the higher PWTP) and that they are already engaged in costly search behavior for safer foods (hence the higher PTA).

Confidence in information sources had varying impacts. While consumers influenced by scientists are more willing to pay for additional safety, others, influenced by chemical manufacturers and growers are more willing to alter their food habits. Households with children under the age of ten have particularly strong desires for additional food safety, even if at additional cost, and they are also more likely to have changed their food consumption habits.

These findings are important from the standpoint of food safety policies. With the advent of modern monitoring technologies it is practically impossible to find no trace of pesticides in foods. It may no longer be optimal to seek a zero residue standard of safety. In fact, there is most likely a diminishing return to reducing the levels of residues on crops that are, for the most part, residue free. Reducing residues further may result in significant costs, both to producers and consumers. The repealing of the Delaney Clause in the recently enacted Food Quality Protection Act represents a recognition of these issues and may allow for a better weighing of the benefits and costs of residue reductions. However, along with it comes the responsibility of educating consumers about the standards for pesticide residues in foods, and what those standards mean. Moreover, information about the enforcement of those standards will be also allow consumers to better understand the risks they face from pesticide residues. The emphasis of the Food Quality Protection Act on protecting children from pesticide residue risks should help to reduce the concerns of parents with young children as indicated in our model. Finally, our analysis indicates that consumer confidence in pesticide information provided by various groups associated with food production, research, and regulation indicate that there is a need to bring these groups together at a common forum, and present an integrated assessment of pesticide residue risks to consumers.

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Endnotes

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