Staff Paper

CONTINGENT VALUATION AND FOOD SAFETY: THE CASE OF PESTICIDE RESIDUES IN FOOD

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Abstract

CONTINGENT VALUATION AND FOOD SAFETY: THE CASE OF PESTICIDE RESIDUES IN FOOD

Contingent valuation was used to estimate willingness to pay for reduced pesticide residues. A simulated market for fresh apples with different levels of pesticide residues and pest damage was presented to a random sample of U.S. households. Respondents were asked about the quantities of apples they would likely purchase at different prices and their perceptions of changes in health risks that would likely result. A tobit model was used to estimate linear demand equations for the apples incorporating price, residue attributes, pest damage attributes, perceptions about health risks, and demographic characteristics. Price elasticities and willingness to pay estimates obtained from the model are comparable to those obtained in studies using market data. The results indicate that willingness to pay for reduced residues is large, but willingness to accept pest damage is low. Consumer perceptions of health risk probabilities had little impact on demand, suggesting that willingness to pay may be better explained by uncertainty about risks.

Contingent Valuation and Food Safety:

The Case of Pesticide Residues in Food

Consumer concern about pesticide residues in food has sparked debate about the need for change in food safety policy. Some argue that government and industry should educate the public about food safety so that consumers would focus more attention on the most serious hazards (bacteria) and less on the minor ones (pesticide residues). However, others argue that safety standards for pesticide residues should be toughened because consumers are willing to pay the costs of higher food prices or more pest damage.

Which policy is most appropriate depends on how consumers perceive health risks from pesticide residues and the tradeoffs they are willing to make to reduce those risks. However, it is difficult to observe the tradeoffs consumers prefer for two reasons. First, health risks are only one attribute of food that influences consumers' food choices, making it difficult to isolate the effect reductions in pesticide residues would have. Second, consumers are offered few choices about food risks in actual markets, making it difficult to observe the choices consumers prefer.

This paper addresses the first problem by specifying a theoretical model of consumer risk tradeoffs derived from Lancaster's attribute model of consumer choice. The second problem is addressed by developing a contingent valuation (CV) approach for collecting data on choices consumers would make about pesticide residues in a simulated market setting. The CV data are used to estimate demand for a food item with different pesticide residue and pest damage attributes. Shifts in demand due to attribute changes are used to estimate willingness to pay for product attributes. Fresh apple demand was chosen to demonstrate this method because apples are widely purchased, their quality varies with pesticide use, and the resulting parameter estimates may be compared with estimates obtained using market data.

Theoretical Framework

The framework for considering risk tradeoffs and valuation is derived from the Lancaster's (1971) attribute model of consumer choice as extended by Ladd (1982). In this model, a consumer has access to a range of products that offer a wide variety of different attributes. A consumer selects a particular product because of the attributes offered by the product. Given a budget constraint, a consumer allocates total purchases so as to maximize the well-being obtained from his or her overall expenditure.

To focus on the attributes of one product, we represent the range of alternative products as a product x_1 with price p_1 and a vector of alternative products $\mathbf{x} = (x_2 \ldots x_I)'$ with a corresponding price vector $\mathbf{p} = (p_1 \ldots p_I)$. The product x_1 offers a vector of J risk and quality attributes, $\mathbf{a}_1 = (a_{11} \ldots a_{1J})'$. The products $\mathbf{x}$ offer a matrix of attributes, $\mathbf{a} = [a_{ij}]$, $i \in \{1,\ldots,I\}$ and $j \in \{1,\ldots,J\}$.

A consumer purchases food products in order to obtain food quantities and food attributes. Quantities and attributes are combined using household production technology to produce a vector of final services. These services may include diverse concerns such as a full stomach, health maintenance, and aesthetic pleasure. It is these final services $s_k = s_k(x_1,\mathbf{a}_1,\mathbf{x},\mathbf{a})$, $k = \{1,\ldots,K\}$, that yield satisfaction to a consumer and it is the enjoyment of these services that motivates a consumer to search for the right combination of product attributes. In some cases, a product attribute such as pesticide residue may detract from a consumer's well-being. In this case, a consumer selects product bundles in order to avoid the negative or bad attribute.

Attribute bundles are selected to maximize a consumer's well-being. Algrebraically, the choice process is described by

$$(1) \qquad v(p_1,\mathbf{a}_1,\mathbf{p},\mathbf{a},m) = \max \ u(s_1,\ldots,s_K) \quad \text{s.t.} \quad m = \mathbf{p}'\mathbf{x}$$

$$s_k = s_k(x_1,\mathbf{a}_1,\mathbf{x},\mathbf{a})$$

$$k \in \{1,\ldots,K\}$$

where u(•) is a strictly increasing, continuous, and quasiconcave utility function and m is the individual's income. At initial price, p_1^0, and attribute level, $\mathbf{a}_1^0$, an individual's utility level is $u^0 = v(p_1^0,\mathbf{a}_1^0,\mathbf{p},\mathbf{a},m)$. The quantity of x_1 purchased at p_1^0 and $\mathbf{a}_1^0$ is

(2) $$x_1^0 = x_1(p_1^0,\mathbf{a}_1^0,\mathbf{p},\mathbf{a},m)$$

where $x_1(p_1,\mathbf{a}_1,\mathbf{p},\mathbf{a},m)$ is the individual's Marshallian demand function. Like a conventional demand function for homogeneous quantities, equation (2) incorporates how quantity demanded would respond to price. Unlike the conventional demand function, equation (2) is conditioned upon the attributes of purchased products. It therefore is capable of describing how quantities purchased shift as product attributes are modified. Overall, the demand function in equation (2) summarizes the tradeoffs between quantity, price, and attributes.

The total quantity of an attribute enjoyed or suffered by an individual is proportional to the product quantities that an individual purchases. If an individual purchases x_1^0 that contains a_{1j}^0 of the jth attribute for each unit of x_1 purchased, the individual consumes a total of

(3) $$A_{1j} = a_{1j}x_1^0$$

of the jth attribute.

The formulation thus far can be used to describe the relationship between food purchases, pesticide residue, and pesticide risk. Let a_{11} represent the pesticide residue consumed per unit of x_1.

The total residue that an individual consumes from x_1^0 is $A_{11} = a_{11}x_1^0$. Letting mortality risks be proportional to pesticide dose[1], the total risk posed by consumption of x_1^0 is

$$(4) \qquad r_1 = c_1A_{11} = c_1a_{11}x_1^0$$

where c_1 is the factor of proportionality that translates dose into mortality risk.

A reduction in residue can be modeled as a change in attribute a_{11} from a_{11}^0 to a_{11}^1. Through equations (3) and (4), a reduction in per unit residues from a_{11}^0 to a_{11}^1 results in a change in mortality risk from

$$(5) \qquad r_1^0 = c_1a_{11}^0x_1^0$$

to

$$(6) \qquad r_1^1 = c_1a_{11}^1x_1^0.$$

Total willingness to pay for risk reduction is measured using the information contained in the product demand functions. For an inelastically supplied product, total willingness to pay for an attribute induced change in risk from r_1^0 to r_1^1 is

$$(7) \qquad WTP = \int_{p_1^0}^{p_1^*} x_1(p_1, \mathbf{a}_1^0, \mathbf{p}, \mathbf{a}, m)\,dp_1 - \int_{p_1^1}^{p_1^{**}} x_1(p_1, \mathbf{a}_1^1, \mathbf{p}, \mathbf{a}, m)\,dp_1 + (p_1^1 - p_1^0)x_1^0$$

where p_1^* is a price such that quantity demanded is zero at the initial attribute level, p_1^{**} is a price high enough so that quantity demanded is zero at the post-change attribute level, and p_1^1 is a price so that quantity demanded is x_1^0 at the post-change attribute level (Neary and Roberts, 1980; Small and Rosen, 1981).[2] Equation (7) is the general conceptual model for our estimates of willingness to pay food attribute changes.

If the true demand function is linear or semi-logarithmic, the first two terms on the right hand side of equation (7) cancel each other out and willingness to pay reduces to

$$(8) \qquad WTP = (p_1^1 - p_1^0)x_1^0$$

In addition, average willingness to pay, wtp, for risk reduction is total willingness to pay divided by the total change in risk,

$$(9) \qquad wtp = WTP/(r_1^1 - r_1^0).$$

Equation (8) and (9) provide two measures of willingness to pay for risk reduction. These may be used to evaluate the benefits and costs of policies to reduce risk or to corroborate and compare research results with existing estimates of willingness to pay for risk reduction.[3]

The tradeoff between risk and another product attribute such a cosmetic food quality can also be obtained from the demand function. Using a linear approximation, the per unit change in an attribute a_{12} required to offset the per unit change in pesticide residue is

$$(10) \qquad a_{12} - a_{12}^0 = -[(\partial x_1/\partial a_{11})/(\partial x_1/\partial a_{12})](a_{11}^1 - a_{11}^0).$$

In a linear demand function, the term $\partial x_1/\partial a_{11}$ is the demand coefficient of pesticide residue and $\partial x_1/\partial a_{12}$ is the coefficient of an attribute measuring, say, cosmetic quality features such as pest damage.

The framework described by equations (2) through (10) outlines a procedure for estimating the relationship between product purchases and product risk attributes, willingness to pay for risk reduction, and the tradeoff between residue and price. The key relationship in this framework is a product's demand function.

Using contingent valuation data, we estimate household demand functions where a significant portion of the households do not purchase apples for some combination of prices, residues, and quality. Since a log-linear form cannot encompass dependent variables with zero values, we use a linear function to estimate the contingent market demands. The linear approximations given in equations (8), (9), and (10) are used to estimate, respectively, total willingness to pay, average willingness to pay, and the quality-risk tradeoff.

Survey Design Procedures

The major tasks in developing the contingent valuation survey were to develop detailed descriptions of the products that consumers would be offered (i.e., apples with different levels of residues and quality), the conditions under which they would be offered, and a method for eliciting valuations of those apples (Mitchell and Carson). Methods for eliciting perceptions about pesticide risks and quality, annual and seasonal apple purchases, and the demographic characteristics of households were also developed.

After extensive pretesting, three apple labels were selected to describe different levels of pesticide residues relative to a "no label" apple. These labels were "No Pesticide Residues," "No Detectable Pesticide Residues," and "No Pesticide Residues Above Federal Limits."

Extensive pretesting also was conducted to develop a method for eliciting respondents' perceptions of the health risks associated with changes in the residues. The method selected was to ask respondents their perception of the likelihood that a member of their household would experience *any* kind of health impairment someday because of pesticide residues in *all* foods. The response categories used permitted respondents to indicate different orders of magnitude of chance (e.g., zero, one in a million, one in 100,000, one in 10,000, one in 1,000, one in 100, one in 10, one in 5, one in two, certain to happen). Respondents were then asked to assess the percent reduction in risks if *all* foods were tested and certified to have "No Pesticide Residues," "No Detectable Pesticide Residues," and "No Pesticide Residues Above Federal Limits."

Pest damage was portrayed in four photographs of otherwise identical red delicious apples. Respondents were told that the side of the apple they could not see in the photographs was free of damage. The amount of damage was measured by the amount of surface area on the side of the apple shown in the photo, assuming that the area between two closely spaced areas of damage would count as well as the damaged areas themselves. The amount of surface area damage shown in each photo was 0%, 2.5%, 6%, and 24%. The types of damage portrayed were apple scab and plum curculio.

A scale measuring perceived apple quality was also employed to account for possible differences among respondents in quality perceptions. The scale used varied from 1 (inferior quality) to 7 (excellent quality).

The valuation questions were developed to reveal the *quantity* of apples respondents would likely buy at different prices during a typical grocery shopping occasion in the fall. Two prices were given for the four photos and three labels for a total of 14 questions. Prices ranged from $.39 to $1.49 per pound. Different subsamples of respondents were given different sets of prices and photo-label combinations. The quantities reported in response to these questions were converted into a measure of household apple purchases in the fall quarter (in pounds) using data obtained from survey questions on typical household apple purchases throughout the year.

Restrictions were placed on substitutes available in the shopping scenario. The respondent was instructed to assume that *all* apples were of the same price, quality, and risk level. Thus, consumers would not be able to make tradeoffs between the different quality levels or risk levels. The respondents were also asked to assume that all other fresh fruits were available at normal prices (no sales), and that the quality and risk levels applied only to apples, not to other fruits. Thus, respondents would be expected to substitute into apples and away from other fruits in order to reduce consumption of pesticide residues.

Response Rates and Sample Composition

A national random sample of 2,200 households was purchased from Survey Samples, Inc. Following the Total Design method of Dillman, the first mailing was sent on September 18, 1990, followed by reminder post-cards one week later. Duplicate mailings of the questionnaire packet were mailed to non-respondents on October 16th and November 6th.

Of the 2,200 households sampled, 312 or 14.2% could not be contacted by mail due to inadequate or inaccurate addresses. Thus, surveys were received by only 1,888 households. After four mailings, 906 completed questions were returned for a response rate of 48% (906/1,888). 681 respondents had sufficiently complete questionnaires to use in the econometric analysis.

The average household size (2.8 persons) in the full sample and the subsample is comparable to the average for the U.S. The percent of households with children under 18 is also about the same as for all U.S. households. However, both samples underrepresent single-person households and households with incomes of less than $10,000. Households with incomes greater than $50,000 are overrepresented. Respondents in both the full sample and the subsample have a higher level of education than is typical of adults over 25 in the U.S. The age distribution of respondents in both the full sample and the subsample is similar to the age distribution of head of households reported by the census. Finally, female (52%) outnumber male (44%) respondents.

Apple Demand Estimates

Five linear demand equations were estimated. Each equation differs in the way labeling and health effect perceptions are incorporated into the demand model. Since approximately 50 percent of the contingent quantity demanded responses were zero at the prices and qualities given in the contingent valuation experiment, a tobit analysis (Maddala, 1983) was used to estimate a demand response censored at zero pounds per household. The variables used in the econometric analysis and their mean values (in parentheses) are listed in Table 1.

The coefficient estimates for price, socioeconomic characteristics, and apple quality are almost identical across the five equations (see Table 2). As expected, apple PRICE per pound shows a strong negative relationship to quantity demanded. The estimated coefficient in equations (A) through (D) in Table 2 yield a price elasticity of -1.86. This elasticity compares very closely with the elasticities ranging from 1.95 to 2.09 found in a study of the impact of Alar on fresh apple demand in the New York metropolitan area (van Ravenswaay and Hoehn).

All of the socioeconomic variables except gender are statistically important in explaining variation in quantity demanded. The coefficients of INCOME, HOUSEHOLD, AGE, and SCHOOLING are statistically different from zero at the 95 percent level. The INCOME and HOUSEHOLD coefficients are positive as expected.

The quantitative impact of the socioeconomic variables is small. The income coefficient yields an income elasticity of only 0.00042. A one person increase in HOUSEHOLD size increases quantity demanded by 2.15 pounds per person. This increase per person is small since it tends to reflect the impact of additional children as household size shifts from its mean of 2.8 persons. A ten year increase in a respondent's age reduces quantity demanded by 1.71 pounds while a one year increase in

SCHOOLING increase apple consumption by just less than 0.09 pounds. The impact of gender is small and statistically insignificant.

Regional variation in preferences or substitution possibilities have a statistically significant and large impact on quantity demanded. Average quantity demanded for respondents from the southern part of the United States is 12.9 pounds per household in the Fall quarter. According to the coefficients in equation (A) in Table 2, quantity demanded is almost 4.5 pounds greater for respondent from the NORTHEAST and 4.9 pounds greater for respondents from the MIDWEST. Quantity demanded for respondents in the WEST is 11.5 pounds less, on average, than those from the south.

The quality variables have a statistically significant and economically important impact on apple quantities demanded. A one unit improvement in perceived QUALITY increases quantity demanded by 11.3 pounds. A increase of one percent in surface area damage reduces apple quantity demanded by 1.7 pounds per household.

Two of the label variables are statistically significant in equation (A) in Table 2. A label offering assurance that pesticides residues meet Federal standards, FL, and the no detectable pesticides label, NPL, are both statistically and economically significant. FL increases quantity demanded by 11.7 pounds per household. NPL increases quantity demanded by 6.12 pounds per household. The label promising no detectable pesticides, NDL, has an effect that is relatively small and statistically insignificant.

Equation (B) in Table 2 includes the variable $\Delta\Pi$ that measures the reduction in the perceived probability of health impairment (PHI) that accompanies a label. The coefficient of $\Delta\Pi$ is positive and statistically significant as expected, but small. Reducing PHI by 1 in 10,000 increases quantity demanded by only 0.0036 pounds.

Equation (C) examines the impact of PHI when reduction in PHI, $\Delta\Pi$, is decomposed into the PHI of an unlabeled food, Π^0, and the PHI of a particular label, Π^1. Both coefficients are statistically significant from zero. The improvement in the log-likelihood value of equation (C) relative to equation (B) indicates that the decomposition is the statistically preferred manner of modeling the change in risk induced by a label (Chi-squared value of 6 with one degree of freedom). However, as in equation (B), a reduction in the perceived PHI of a label has a small impact on quantity demanded.

Equation (E) eliminates the label variables in order to determine whether there is some confounding of the PHI and labeling coefficients. As expected, the coefficients of Π^0 and Π^1 increase in absolute value but nevertheless suggest the very slight impact of expected PHI. For instance, in equation (C), a reduction of 1 in 10,000 in the expected PHI associated with a label increases quantity demanded by only 0.00214 pounds per household. In equation (E), the same reduction increases quantity demanded by 0.00362 pounds per household.

Equation (D) lists coefficient estimates for a preferred specification of the impact of labeling and perceived PHI. The equation excludes the statistically insignificant variable for the no detectable pesticides label, NDL, and enters the impact of PHI in its decomposed form. The coefficients of this demand equation are used to calculate willingness to pay and the tradeoff between quality and pesticide residue.

Overall, unambiguous labeling has large impact on quantity demanded relative to a reduction in the perceived mean probability of health impairment. These results combined with the fact that the perceived mean probability of health impairment for the regular apple is small, indicate that respondents are primarily concerned about eliminating ambiguity and uncertainty. Further reductions in mean probabilities that are already rather small have little impact on the behavior of a typical consumer.

Willingness to Pay for Reduced Pesticide Labels

The added willingness to pay for each label over and above what is paid for no-label apples is calculated by taking the difference in their estimated prices at the current level of consumption. These prices are obtained from the inverse demand function for each type of apple (i.e., the inverse of model D).

The estimate of the average added price per pound was the same for the Federal label and the No Detectable label. That estimate was 23.6 cents per pound. The estimate of additional willingness to pay for the No Pesticide label over the no-label apple was 37.5 cents.

These results indicate a significant willingness to pay to reduce residues *under the set of circumstances provided to respondents in the survey*. These circumstances included the assumption that no other fruits would be labeled, that only one type of apple label would be available, the prices of substitutes are those prevailing at the time the survey was conducted, and that labeled apples would be marketed and displayed in stores as they are currently. Consequently, the estimates of added willingness to pay for the labels are *upper bound estimates*.

Since the measurement of risk perception used in this study explains little of the variation in apple purchases, there is less than a penny difference between the estimates of willingness to pay using the sample average for the perceived change in risks versus the median or mode. Essentially, the change in risk must be perceived to be 1 in 100 or greater to add a penny to the estimate of willingness to pay for the labels.

The estimates of the added willingness to pay for each label gives information about how consumers value residue reduction. However, they do not tell us how many consumers would actually purchase a particular label in the market. First, all the circumstances outlined in the willingness to pay questions would have to prevail. Second, purchases would depend on the total price of the apples, not just the added price of the label. This point is illustrated by the estimated probabilities of purchase at different prices for the no-label and labeled apples. For example, at $.79 per pound, the probability of purchase of a no-label apple was estimated to be .59. The probability increases to .69

for the Federal label and .74 for the No Pesticide apple. Similarly, at $1.49, the probability of purchase was .3 for the no-label apple, .4 for the Federal apple, and .45 for the No Pesticide apple.

The willingness to pay estimates are comparable to the estimates obtained in other studies. Van Ravenswaay and Hoehn estimated that people would have been willing to pay 31.3% more for Alar-free apples--or approximately 28.7 cents more per pound in 1990 dollars. The estimates are also comparable to the organic price premiums estimated by Hammitt, Rae, and Jolly et al. However, they higher than the percentage willingness to pay for pesticide-free fresh produce reported by Ott and Maligaya.

Willingness to Accept Pest Damage

The tradeoff consumers are willing to make between residue reduction and cosmetic quality is measured by the amount of pest damage that offsets the added willingness to pay for a labeled apple (equation (10)). The estimates were 11.9% for the No Pesticide label and 7.5% for both the Federal label and the No Detectable label.

The estimates require careful interpretation. Pest damage was measured as the amount of surface area on an apple in a photograph. The photograph, of course, is only two dimensional, whereas a real apple is a sphere. This means that the estimates of surface area are at least twice as large as what would be acceptable on a real apple.

With these caveats in mind, the results suggest that consumers would accept only very minor amounts of pest damage in order to obtain reductions in pesticide residues. There is a three cent price penalty for each 1% increase in surface area damaged in the photo. This penalty is even larger when the entire surface area of an apple is considered.

The results are similar to those of Ott and Maligaya and consistent with the findings of the Bunn et al. study of thrips damage on oranges.

Willingness to Pay for Risk Reduction

Annual total willingness to pay for residue reduction (equation (8)) is obtained by multiplying willingness to pay for the federal apple (23.6 cents) or the no residue apple (37.5) times average number of pounds of apples purchased by a household annually (100.7 pounds in our sample). Thus, for the federal apple, household annual willingness to pay is \$23.77. For the no pesticide residue apple it is \$37.75.

Developing an estimate of the annual change in perceived risk requires making some assumptions. First, perceived risks were annualized by dividing by an assumed average lifetime of 70 years. Second, perceived risks for apples were assumed to be proportional to perceived risks from all foods.

Two alternative assumptions about proportionality of risks in apples were used. One was that perceived risk from apples is simply a proportion of the pounds of the average total diet from apples as measured by the 1977 USDA Food Consumption Survey (i.e., 1.68%). The second was that perceived risk from apples is proportional to the risks from pesticide residues in apples compared to all food sources as estimated by the National Research Council (i.e., 5.5%)

Finally, the perceived risk and annual expenditure estimates are on a per household basis. Other studies report figures on a per capita basis. Consequently, the estimates of willingness to pay for risk reduction are divided by average household size (i.e., 2.8 persons).

The resulting estimates for willingness to pay for a one in a million reduction in risks under assumption one are \$2.20 for the Federal label and \$2.15 for the No Residue label. Under assumption two, the estimates are \$.67 and \$.59.

These estimates are comparable to other studies. For example, the Fisher et al. estimate of willingness to pay for a one in a million reduction in mortality risks, in 1990 dollars, is \$1.95 to \$10.37. The high estimates are within this range, but the low estimates are not. However, this is expected because the survey estimates are based on perceptions of any type of health risk while the studies reviewed by Fisher et. al, are based on mortality risks.

Similarly, in the Alar study, van Ravenswaay and Hoehn found that willingness to pay for risk reduction in 1989 was $4.01, $9.79, or $27.40, depending on assumptions about risk perceptions. In 1990 dollars, these would be $5.33, $13.02, and $36.42. Only the lowest estimate in the Alar study and the highest estimate here are comparable.

Conclusions

The market simulation approach of contingent valuation is an effective tool for examining consumer demand for changes in product characteristics such as safety and quality. The estimates obtained compare favorably with estimates based on actual market data, indicating that the contingent market approach is likely to provide more accurate results than survey questions which ask people if they would prefer lower pesticide residues in food. At the same time, the contingent market approach offers substantially more flexibility than analysis of past purchases since it permits examination of tradeoffs not presently available in actual markets.

The analysis indicates that consumers are willing to pay significant price premia for foods certified and tested to meet federal limits. This finding suggests that consumers believe federal standards give them significant risk reductions, but they are uncertain that federal standards are being met. Consumers would obtain significant value from learning that virtually all foods do meet federal standards. They would also see significant benefit from learning the results from monitoring and testing programs which provide proof that the standards are being met. Finally, consumers would see significant benefit from learning that the present system is designed to prevent errors in standard setting, pesticide use, and enforcement.

While consumers may see value in learning that residue standards are being met, information about the percentage of foods with detectable level so of residues would be unlikely to improve the confidence of many consumers. The average consumer perceives the percentage of foods with *any* residues to be very similar to what is actually detected by the FDA's monitoring program.

Consumers are willing to pay even higher price premia for foods certified and tested to have no pesticide residues, but not for "no detectable" residues. This finding suggests that consumers believe that federal standards do not eliminate all the risks from pesticide residues.

However, the additional willingness to pay may not be high enough to cover the costs--both in terms of higher food prices and pest damage--of eliminating all pesticides. This is an important point because consumers appear unwilling to accept more than a minor amount of pest damage. Even if apples were certified and tested to have no pesticide residues and were no higher in price, the amount of pest damage that would be accepted would be very small.

Perceptions of the likelihood of illness from pesticide residues explain little of the estimated willingness to pay for the different residue levels presented in this study. It is possible that it is people's uncertainty about what the risks *could be* that may better explain why people were willing to pay significant premia for guarantees that residues meet federal standards. If so, risk communication aimed at reducing people's perception of the *average* risks from pesticides may have little impact on consumer concerns. What may be needed instead is information about the safeguards in place that reduce the chance of mistakes--mistakes which could result in contamination problems or mistakes which could result in the need to revise tolerances for pesticide residues in food. This type of information would increase trust and reduce uncertainty about risks.

The methods used in this study provide a new approach for understanding consumer concerns about food safety. However, the results are contingent upon the specific market conditions presented to consumers. Different types of market conditions and products need to be examined to determine their impact upon willingness to pay for food safety improvements.

TABLE 1: INDEPENDENT VARIABLES USED IN DEMAND ESTIMATION

Variable	Definition (Mean)
FL	A 0-1 dummy variable where 1 indicates the "no residues above the Federal limit" label, the "no detectable pesticide residue" label, or the "no pesticide residue" label (0.42).
NDL	A 0-1 dummy where 1 indicates the "no detectable pesticide residue" label or the "no pesticide residue" label (0.28).
NPL	A 0-1 dummy where 1 indicates the "no pesticide residue" label (0.14)
$\Delta\Pi$	The change in the perceived probability of health impairment (PHI) due to a particular label relative to the no label case (0.012).
Π^0	The perceived probability of health impairment (PHI) due to pesticide residues on food, no label case (0.054).
Π^1	The perceived probability of health impairment (PHI) due to pesticide residues on food, no label case or alternative label depending on the particular case (0.042).
QUALITY	Apple quality as perceived by respondents on a seven point scale (4.3).
SRA	Percent of surface area damaged as visible in a photograph and measured by a research assistant (5.3).
PRICE	Apple price per pound in cents (0.92).
INCOME	Household income in \$1000 (46.8).
HOUSEHOLD	Number of people in the respondent's household (2.8)
AGE	Age of respondent in years (48).
SCHOOLING	Respondent's last year of school (14).
GENDER	Gender of respondent, 0 equals male and 1 equals female (0.54).
NORTHEAST, MIDWEST, WEST	Dummy variables to indicate the respondent's region within the United States, 0 equals SOUTH (0.25, 0.30, 0.17, respectively).

[a]The dependent variable is pounds demanded per household during a Fall quarter (mean=13.5)

TABLE 2: APPLE DEMAND EQUATION ESTIMATES

Independent Variable	Demand Equation Coefficients (A)	(B)	(C)	(D)	(E)
CONSTANT	-13.0*	-12.9*	-14.0*	-14.0*	-21.0*
	(6.17)	(6.16)	(6.17)	(6.12)	(6.12)
PRICE	-54.2*	-54.2*	-54.1*	-54.1*	-39.8*
	(2.73)	(2.73)	(2.73)	(2.73)	(2.14)
INCOME	0.0589*	0.0585*	0.0589*	0.0589*	0.0569*
	(0.0174)	(0.0174)	(0.0174)	(0.0174)	(0.0174)
HOUSEHOLD	2.15*	2.08*	2.09*	2.09*	2.04*
	(0.446)	(0.445)	(0.445)	(0.445)	(0.445)
AGE	-0.171*	-0.176*	-0.177*	-0.177*	-0.170*
	(0.0436)	(0.0436)	(0.0436)	(0.0436)	(0.0437)
SCHOOLING	0.0889*	0.110*	0.139*	0.138*	0.123*
	(0.257)	(0.257)	(0.257)	(0.257)	(0.257)
GENDER	-0.127	-0.204	-0.353	-0.355	-0.234
	(1.28)	(1.28)	(1.28)	(1.28)	(1.28)
NORTHEAST	4.48*	4.30*	4.12*	4.12*	4.31*
	(1.72)	(1.72)	(1.72)	(1.72)	(1.72)
MIDWEST	4.88*	4.92*	4.90*	4.89*	5.21*
	(1.63)	(1.63)	(1.63)	(1.63)	(1.63)
WEST	-11.5*	-11.5*	-11.5*	-11.5*	-11.5*
	(1.99)	(1.99)	(1.99)	(1.99)	(1.99)
QUALITY	11.3*	11.3*	11.4*	11.4*	11.7*
	(0.479)	(0.478)	(0.478)	(0.478)	(0.476)
SRA	-1.70*	-1.70*	-1.70*	-1.70*	-1.88*
	(0.137)	(0.137)	(0.137)	(0.137)	(0.1326)
FL	11.7*	10.9*	11.2*	12.4*	-
	(2.17)	(2.18)	(2.18)	(1.87)	
NDL	2.68	2.28	2.42	-	-
	(2.23)	(2.23)	(2.23)		
NPL	6.12*	6.03*	6.07*	7.26*	-
	(2.20)	(2.20)	(2.20)	(1.91)	
$\Delta\Pi$	-	35.7*	-	-	-
		(7.61)			
Π^0	-	-	31.5*	31.9*	43.0*
			(7.77)	(7.77)	(7.66)
Π^1	-	-	-21.4*	-21.9*	-36.2*
			(9.40)	(9.40)	(9.27)
SIGMA SQUARED	2450*	2440*	2439*	2440*	2455*
	(62.6)	(62.4)	(62.3)	(62.3)	(62.7)
Log-Likelihood	-27278	-27167	-27164	-27164	-27210
d.f.	8942	8941	8940	8941	8943

*The coefficient is statistically different from zero at the 95 percent level.

Footnotes

1. The proportionality assumption is routine in risk assessment studies. See National Research Council (1987).

2. An exact compensating measure of willingness to pay would be calculated using the Hicksian compensating demands. However, estimation of the compensated demands presents practical difficulties. Willig (1976) has shown that where the budget share of a commodity is small, the Marshallian demands provide a very close approximation to the Hicksian demands. In the cases examined in this project, the budget shares are small and we expect the Marshallian demands to be very close to the Hicksian. Future work may permit us to substitute Hicksian estimates of demand for the Marshallian estimates.

3. In deriving our willingness to pay measure, we assume that quantity remains constant. This assumption assists in deriving a willingness to pay measure that is consistent with previous research. However, it may not be appropriate for certain types of policy analyses. A policy specific analysis of benefits and costs should be careful to describe the relevant price scenario and then derive the corresponding benefit measure in a manner consistent with the principles outlined in this subsection.

References

Bunn, David, Gail W. Feenstra, Lori Lynch, and Rober Sommer. 1990. "consumer Acceptance of Cosmetically Imperfect Produce." *The Journal of Consumer Affairs*. 24(2):268-279.

Dillman, Don A. 1978. *Mail and Telephone Surveys: The Total Design Method*. New York: John Wiley and Sons.

Fisher, A., L.G. Chestnut, and D.M. Violette. 1989. "The Value of Reducing Risks of Death: A Note on New Evidence." *Journal of Policy Analysis and Management*. 8(1):88-100.

Hammit, James. 1986. *Organic Carrots: Consumer Willingness to Pay to Reduce Food Borne Risks*. Santa Monica: The RAND Corp. R-3447-EPA.

Jolly, Desmond, Howard Schutz, Jagit Johal, and Kathy Diaz Knauf. 1989. "Marketing Organic Foods in California." University of California, Davis, CA: Sustainable Agriculture Research and Education Program, August.

Ladd, George W. 1982. "Survey of Promising Developments in Demand Analysis: Economics of Product Characteristics." In *New Directions in Econometric Modeling and Forecasting in U.S. Agriculture*, ed. Gordon C. Rausser, 17-53. New York: Elsevier Science Publishing Co.

Lancaster, Kelvin. 1971. *Consumer Demand: A New Approach*. New York: Columbia University Press.

Maddala, G.S. 1983. *Limited Dependent and Qualitative Variables in Econometrics*. New York: Cambridge University Press.

Mitchell, Robert C. and Richard Carson. 1989. *Using Surveys to Value Public Goods: The Contingent Valuation Method*. Washington, D.C.: Resources for the Future.

National Research Council, Board on Agriculture, Committee on Scientific and Regulatory Issues Underlying Pesticide Use Patterns and Agricultural Innovation. 1987. *Regulating Pesticides in Food*. Washington, D.C.: National Academy Press.

Ott, Stephen L. and Arlyn Maligaya. 1989. "An Analysis of Consumer Attitudes Twoard Pesticide Use and the Potential Market for Pesticide Residue-free Fresh Produce." Department of Agricultural Economics, University of Georgia: Paper presented at the Southern Agricultural Economics Meetings, Nashville, TN, January.

Rae, Douglas. 1987. "Risks of Consuming Pesticide and Fungicide Additives: Perceptions and Behavior of Organic Food Consumers." Final Report for the U.S. Environmental Protection Agency Benefits Staff. (Douglas Rae, 36 Gage Street, Needham, MA 02192).

U.S. Department of Agriculture. 1983. *Nationwide Food Consumption Survey 1977-78*. Washington, D.C.: NFCS 1977-78 Report No. H-7,8,9,10. August.

van Ravenswaay, Eileen O. and John P. Hoehn. 1990. "The Impact of Health Risk on Food Demand: A Case Study of Alar and Apples." Department of Agricultural Economics Staff Paper No. 90-31, Michigan State University: Paper presented at the Economics of Food Safety Workshop, Alexandria, VA, June.