Consumer Willingness-to-Pay for Food Safety in Taiwan: A Binary-Ordinal Probit Model of Analysis

A probit model for whether or not consumers are willing to pay a premium for hydroponically grown vegetables (HGV) is estimated jointly with an ordered probit model analyzing the magnitude of such premiums for consumers who would pay them. Results of the joint estimation and the conventional single equation ordered probit model were presented for comparison. Unlike the single equation approach, the joint estimation allows the flexibility of parameterizing separately the probability and level of premiums that a consumer is willing to pay for a safer food. The results show that family health status and household income are the most important and significant factors that determine the amount of premium a consumer is willing to pay for HGV. However, they are insignificant in predicting the likelihood of a consumer's willingness-to-pay a higher price. In addition, marginal probabilities were calculated to assess the influence of various socio-economic and attitudinal variables on the likelihood that a consumer would be willing to pay a premium for HGV and the additional amount of premiums.

Consumers’ concerns about use of pesticide chemicals in food production have made food safety a priority issue on the public agenda. Several studies have focused specifically on consumer attitudes toward chemical residues and how the uses of pesticide chemicals affect consumer purchase decisions. For example, in a 1986 survey of Pennsylvania households 71.1 percent of respondents expressed concern about eating fruits and vegetables sprayed or dusted with pesticides (Sachs, Blair, and Richter 1987). By comparison, 41.5 percent of Pennsylvania respondents expressed a similar concern in 1965 (Bealer and Willits 1968). Following the Alar scare in 1989, public concern about the potentially adverse effects of pesticides or their residues on human health rose to an unprecedented level. Dunlap and Beus (1992) reported that 45 percent of their respondents indicated that they believe the use of pesticides for food supply is “somewhat” or “very” unsafe even when they are used...
properly (according to approved directions). They suggest that consumers continue to feel and express uneasiness about the safety of using pesticides for production of foods. Consumers’ demand for safer foods will translate into market behavior and alter demand for food products in the marketplace. Thus, producers, processors, wholesalers/retailers, and government regulators and policy-makers will have to respond to consumers’ risk preferences, concern about environmental quality, and demand for safe foods (Kramer 1990).

Previous surveys have consistently found that consumers have perceived both high and increasing levels of health risks about consuming fresh produce due to potential presence of pesticide residues. A more recent national survey conducted by researchers of the University of Kentucky suggests that pesticides pose a lower risk to consumers than does microbial contamination (Buzby and Skees 1994). However, to alleviate consumers’ pesticide fears, some food retailers have initiated their own residue-monitoring programs and advertise their produce as being specifically tested for chemical residues. Other food retailers are promoting the sale of organic foods. In a survey of supermarket shoppers, Ott (1990) reported that two out of every three shoppers were willing to pay 5 percent to 10 percent more for fresh produce that is certified free of pesticide residues. Similarly, Buzby and Skees (1994) found that more than half of the respondents indicated a preference to buy organically grown fresh fruits and vegetables and would be willing to pay more for produce that was certified pesticide residue-free.

Fresh produce is a very important dietary component in daily food intakes of the Taiwanese. In 1995, annual per capita consumption of fresh vegetables was about 280 lbs. in Taiwan compared with 176 lbs. in the U.S., where a majority of vegetables was consumed in processed forms. Consumer demand for safe and high quality food is an international phenomenon, especially in developed countries. Because of rapid economic growth and rising real income, similar concerns about potential problems related to the use of chemical pesticides are receiving increased attention in Taiwan. Located in a subtropical area, farmers in Taiwan rely heavily on various agricultural chemicals for pest and insect controls. Consumer awareness of potential food safety problems was heightened in the 1990s

Given that the climate is very hot and humid, especially in the summer, Taiwan has a relatively high density pest and insect population and, thus, a high demand for pesticide application. Vegetables are grown all year in Taiwan. After harvest they go through the wholesale markets, and tests for pesticide residues are performed by the provincial government agency, based on random samples, before all vegetables are distributed to retail markets.
after a series of incidences regarding high level of pesticide residues found in fresh produce were reported. Public concerns about the healthiness and wholesomeness of the food supply have led to the development and adoption of alternative production technologies, such as hydroponically grown or organically grown produce.²

How important is it to Taiwanese consumers that fresh produce should be free of pesticide residues? How much are they willing to pay for “cleaner” or safer produce? There are few empirical studies addressing these questions. Most previous studies are primarily descriptive in nature, and little research has focused on the analysis of factors that may affect consumers’ concerns or their willingness-to-pay. In their study of consumers’ willingness-to-pay for health-risk reductions, Fu, Liu, and Hammitt (1997) found that willingness-to-pay among Taiwanese women is positively related to a measure of risk perception and an attitudinal aversion to food risk. However, the difference in willingness-to-pay was found to be less than proportional to the difference in risk increment.

The objective of this study is to provide some insights on Taiwanese consumers’ food safety concerns and to estimate their willingness-to-pay for safer food. The hydroponically grown vegetables (HGV), which are free of pesticide residues, are used in this study to elicit consumer willingness-to-pay for food safety.³ In this study, consumers’ food safety pref-

²The hydroponic culture system uses nutrient solution fluids to replace soil for vegetable production in greenhouses. This production technology minimizes the growth of pest and insect populations and, thus, eliminates the need for pesticide applications. It is also environmentally friendly because it reduces the potential of non-point pollution and degradation of soil quality because of chemical runoffs and continuing cultivation of the soil. This technology is particularly attractive to Taiwan because of its land scarcity. However, the requirements of substantial capital investments and sophisticated managerial knowledge and skills appear to be the major factors that would impede its rapid development and adoption. In 1995, the hydroponically grown vegetables accounted for only about 0.05 percent of total acreage planted for vegetables in Taiwan.

³Given that HGV is available in certain markets, one may question the need of using the contingent valuation method to find out the willingness-to-pay for HGV as pointed out by one of the referees. While some of these products may be found in a few supermarkets or designated specialty stores, the market is generally thin with a very limited choice of variety and supply. Also, the price information is not well developed. Most important, HGV is different from traditional soil-grown vegetables in many respects. Other than being pesticide-free, HGV differs from traditionally grown vegetables with respect to appearance, texture, taste, and packaging. Thus, the price margin between HGV and traditionally grown vegetables reflects all these different attributes and it is difficult to separate the value of safety from other attributes. In order to assess the value of the safety attributes, the respondents were asked to indicate their willingness-to-pay if HGV can be purchased “with the same quality as traditionally grown vegetables except that it is pesticide residues-free.” In this sense, we have a hypothetical product that may be considered as a “non-market” goods and, hence, it would be appropriate to use the contingent valuation method to elicit the willingness-to-pay for the specific food safety attribute, ceteris paribus. In addition, it is not unusual to ask for willingness-to-pay even if the product is available and has been sold in the market. For example, Hammitt (1990) conducted a study using the contingent valuation method to determine how large a premium that California consumers are willing to pay for organically grown produce.
erences and willingness-to-pay are hypothesized as an integrated joint decision-making process. Specifically, this study develops an econometric model that estimates jointly a probit and an ordered probit model to determine, respectively, if consumers are willing to pay more and the magnitude of price premiums that they are willing to pay.

ECONOMETRIC MODEL AND ESTIMATION PROCEDURE

The standard double hurdle model, which emphasizes the importance of participation and consumption as two separate individual choices, was proposed by Cragg (1971) as an alternative to the standard univariate tobit model. The advantage of the double hurdle model is that it allows for a more flexible framework to model the observed consumer's behavior as a joint choice of two decisions instead of a single decision. Nevertheless, when both the participation and consumption choices are observed qualitatively, the conventional double hurdle model may not be applicable. One example is provided by Boyes, Hoffman, and Low (1989) in their study of credit assessment problems. In order to provide accurate estimates on the probability of default or repayment, they developed a credit assessment model that consists of a credit granting and a loan default equation with binary dependent variables. Because only applicants who receive credit are observed either defaulting or repaying, the sample used to estimate repayment probabilities is censored and subjected to potential sample selection bias. Poirier (1980) showed that, under usual normality assumptions, the correct choice of distribution is a bivariate instead of a univariate probit model.

The bivariate probit model that exhibits a form of partial observability (censored probit) discussed by Meng and Schmidt (1985) was modified and extended to include a probit and an (censored) ordered probit for analysis of consumer demand for food safety. The development of the multivariate binary-ordinal probit model is of particular relevance for analyzing data collected from surveys that use a filter approach to reduce potential biased responses due to presupposition effects. Sterngold, Warland, and Herrmann (1994) argue that if survey participants are not asked first if they are concerned about an issue, many respondents may sense the question presupposes that they should be concerned and, hence, overstate their actual concerns. To overcome this presupposition effect, they suggest that survey questions should be framed in such a manner that a filter question is used to determine, first, if respondents have a particular concern about a topic. Then, the degree-of-concern question is asked only of those respondents
who indicate that they are concerned. Most recently, Herrmann, Sterngold, and Warland (1998) found that the main effect of the concern filter was to reduce the proportions of respondents who express some degree of concern and to increase the percentages of those who report no concern. They suggest that conventional form questions have particularly strong effects on responses for less familiar hazards and may produce results that suggest that such hazards merit higher priority attention than they deserve. Clearly, the analysis of survey data based on the filter approach would entail the estimation of a binary-ordinal probit model.

The filter design is used to solicit consumers’ willingness-to-pay for HGV in this study. Implicitly, it is assumed that a respondent actually has two joint decisions to make: (1) whether or not to pay more and (2) how much more to pay. Previous studies have typically treated this consumer choice as a single decision-making process and estimated the willingness-to-pay with an ordered probit model (Misra, Huang, and Ott 1991). As shown in Figure 1, the first decision of whether or not to pay more is denoted by \( d \) with \( d = 1 \) if an individual is willing to pay more for HGV and \( d = 0 \), otherwise. Conditional on \( d = 1 \), the individual decides on the magnitude of the premium, denoted by \( y^* \), that he or she would be willing to pay for HGV. What the researchers observed in the data is whether the amount of premium falls in the interval \( \{y_{j-1}^*, y_j^*\} \), for \( j = 1, 2, \ldots, n \). Researchers define \( y_j = 1 \) if \( y^* \in \{y_{j-1}^*, y_j^*\} \), and \( y_j = 0 \) otherwise.

The structure of the model that is exposed to the partial observability\(^*\) of the non-random sample selection rule is specified as

\[
d = \begin{cases} 
1 & \text{if } \alpha X + \varepsilon_d > 0, \\
0 & \text{otherwise};
\end{cases}
\]

and given \( d = 1 \) for

\[
y_j = \begin{cases} 
1 & \text{if } \mu_j - 1 < \beta Z + \varepsilon_y < \mu_j, j = 1, \ldots, n \\
0 & \text{otherwise};
\end{cases}
\]

where \( d \) denotes the decision of willing to pay more for HGV in the probit model and \( y_j \) the amount of premium that a consumer is willing to pay in

\(^*\)Partial observability is referred to the fact that the observation of how much to pay is conditional on the realization of the first decision of “whether or not to pay more.” In other words, the observations of the second decision is being censored because the price premium that a consumer is willing to pay is observed only if a positive response to the filter question is obtained.
the ordered probit model; $X$ and $Z$ represent matrices of explanatory variables measuring the consumers' risk perceptions, attitudes toward the use of chemical pesticides on food production, and the socioeconomic characteristics associated with the consumers; $\alpha$ and $\beta$ are vectors of unknown parameters to be estimated; $\mu_0, \ldots, \mu_n$ are the categorical thresholds for the underlying response variable ($y^*$) with $\mu_0 \leq \mu_1 \leq \ldots \mu_n$; and $\varepsilon_d$ and $\varepsilon_y$ are the disturbance terms with zero-mean, and normally distributed as standard bivariate, i.e., $\varepsilon_d, \varepsilon_y \sim f(\varepsilon_d, \varepsilon_y; \rho)$, where $f(\varepsilon_d, \varepsilon_y; \rho)$ is a standard bivariate normal density function, and $\rho$ is the correlation coefficient. The cumulative distribution function of $f(\varepsilon_d, \varepsilon_y; \rho)$ is denoted by $F(\varepsilon_d, \varepsilon_y; \rho)$. For estimation purposes, it can be assumed without loss of generality that $\mu_0 = -\infty$, $\mu_1 = 0$ and $\mu_n = +\infty$. Furthermore, it is noted that $(\beta Z + \varepsilon_y) \in \{\mu_{j-1}, \mu_j\} \iff y^* \in \{y^*_{j-1}, y^*_{j}\}$.

The first equation that models the decision of whether or not to pay more for HGV, is postulated as a function of consumers' risk perception and attitudes toward use of chemicals on food production. If the consumer has a desire to purchase HGV and is willing to pay more, then the intensity of his or her willingness-to-pay will be observed. Differences in socioeconomic characteristics are considered the underlying determinants that influence the extent of consumers' willingness-to-pay. Thus, to estimate the likelihood of how much more they would pay for HGV, the equation that models the choice among different premium levels is hypothesized primarily as a function of consumers' socioeconomic characteristics.

For the ordered probit model, the term, $\beta Z$, may be considered as representing the unobserved utility of consuming HGV. When the utility derived from consuming HGV exceeds a certain threshold, such as $\mu_0$ (but less than $\mu_1$), then we observe a willingness-to-pay of up to 5 percent. The $\mu$s are threshold parameters to be estimated along with the $\beta$s. For further exposition on the formulation and estimation of the ordered probit model, see Johnson and DiNardo (1997).
Note that $d$ in equation (1) is fully observed, but $y_j$ in equation (2) is observed only among those respondents who chose to pay a premium for HGV. The distributional assumption of equations (1) and (2) results in a system consisting of probit and ordered probit models, which are to be estimated jointly. Although equations (1) and (2) can be estimated independently, there will be a loss of efficiency of the parameter estimates unless $p = 0$ (Meng and Schmidt 1985). More importantly, observations for equation (2) represent a choice-based or censored sample, which could be subject to potential selectivity bias if estimated separately.

The probability of the event $\{d = 0\}$ is given by

$$P(d = 0) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(\varepsilon, \varepsilon; \rho) = F(-\alpha X, \infty; \rho).$$

Moreover, the probability of the event $\{d = 1, y_j = 1\}, j = 1, \ldots, n$ is

$$P(d = 1, y_j = 1) = \int_{-\infty}^{\infty} \int_{-\infty}^{\mu_j - \beta Z} f(\varepsilon, \varepsilon; \rho) d\varepsilon_d d\varepsilon_y$$

$$= F(\alpha X, \mu_j - \beta Z; \rho) - F(\alpha X, \mu_{j-1} - \beta Z; \rho).$$

The model is to be estimated by the method of maximum likelihood. Thus, the likelihood function for the proposed model is specified as

$$L = \prod_{i=1}^{N} \prod_{j=1}^{n} P(d_i = 0)^{1-d_i} P(d_i = 1, y_{ij}) d_i^{d_i} y_{ij},$$

where $i$ is the index for individual observations in a sample of size $N$. In this study, efficient parameter estimates for $\alpha, \beta,$ and $\rho$ that maximize the above likelihood function are obtained using the GAUSS program.\(^6\)

**SAMPLE DATA**

The data for this study are obtained from a survey of consumers conducted in 1995 by the Survey Research Office of the Academia Sinica, Taipei, Taiwan. The participants were female homemakers selected for personal interviews from a stratified random sample of 400 households residing in the city of Taipei. The survey was designed to assess con-

\(^6\)The maximization of the log-likelihood function is obtained by using a Quasi-Newton optimization algorithm. The GAUSS program codes written for the estimation procedure used in this study are available from the authors upon request.
consumers’ awareness of potential health risk associated with pesticide residues on food, consumers’ evaluation of food quality and safety, and their willingness-to-pay to reduce exposure to pesticide residues on food. The survey obtained information with respect to food purchasing patterns and behavior, attitudes toward pesticide use on food production and assessments on the safety of food purchased, and willingness-to-pay for HGV to reduce exposure to pesticide residues on food. With respect to willingness-to-pay for HGV, the respondents were first asked if they would be willing to pay higher prices for hydroponic vegetables that are produced pesticide-free. If the responses were positive, the respondents were then queried to indicate how much more they would pay, relative to current prices, from a checklist of price premiums.

Prior to the survey, a focus group interview was conducted to pre-test and to improve the questionnaire design. The survey was conducted in the spring of 1995 and resulted in a total of 379 completed questionnaires—a 95 percent completion rate. Due to refusal and potential misreporting of income, the completed questionnaires from those who reported zero total household income were deemed unusable and excluded from the empirical analysis. In addition, a few household members who provided incomplete information were also deleted from the sample observations. The final sample used for this analysis consisted of 323 observations with complete information. In general, the majority of respondents were married women who were the primary food shopper in the household. More than half of the respondents, 52 percent, were employed wives. The average household size was about 4.8 persons. Respondents who were 35 years old or younger accounted for 23 percent of the sample. Approximately 42 percent of survey participants had a high school or above a high school education, and 36 percent had an average monthly household income greater than US$2,000. The definitions, means, and standard deviations of the variables used in the statistical analysis are shown in Table 1.

With respect to food purchasing behavior, almost 23 percent of the respondents indicated that they shop for groceries daily. However, the shopping frequency varies from once to four times a week for the majority, or 64 percent, of the respondents. A majority of the respondents, 77 percent, indicated that they do most of their shopping at traditional markets. Only 12 percent of the respondents purchased their groceries regularly from supermarkets. When asked to rank the most important factor that would influence their food purchasing decision, over 59 percent ranked pesticide residues on fresh produce as their top concern, 17 percent chose food poisoning, and 9 percent considered chemical food
preservatives. Fifty-seven percent of the respondents believed that pesticide residues on vegetables posed a serious health hazard. Similarly, more than 53 percent considered pesticide residues on fresh fruits a serious health risk. Interestingly, an overwhelming majority of the respondents cited television (96%) and newspaper reports (75%) as their major food safety and health information sources. Friends and consumer reports were mentioned by 39 percent and 22 percent of the respondents, respectively, as the major sources of obtaining food safety and health information.

Consumers can take some preventive measures to reduce the risk of exposure to pesticide residues, such as washing, peeling, and cooking produce, or buying HGV. The survey found that more than 88 percent of the respondents indicated that they washed their fresh produce thoroughly to reduce the risk of pesticide residues. The most popular preventive action, according to 89 percent of the respondents, appeared to be soaking the produce in salt water. Approximately 7 percent of the respondents indicated that they would purchase imported instead of domestically grown produce to reduce their exposure to pesticide residues. When asked about the purchase of HGV, the majority of the respondents, 56 percent, indicated that they had purchased HGV occasionally. A large proportion of the respondents, 36 percent, had never purchased the product and only 8 percent indicated that they bought HGV on a regular basis. A
majority of the respondents (73%) believed that pesticides could be used safely with stricter government inspections and regulations. However, some respondents wanted the government to take more preventive actions. While 18 percent of the respondents wanted to ban at least some of the chemical pesticides, 8 percent of the respondents indicated all chemical pesticides should be banned from use in production. More than 59 percent of the respondents indicted that they were either satisfied or very satisfied with the existing system of monitoring pesticide use and testing of pesticide residues. Furthermore, if fresh produce were to be tested and certified pesticide residue-free, most of the consumers indicated that they would prefer such assurance to be issued by the government (40%) or a consumer organization (34%). Only 16 percent of the respondents said they would trust the producers or their cooperatives to implement the pesticide residue-free testing and certification program.

EMPIRICAL RESULTS

Previous studies have identified a variety of demographic and attitudinal characteristics that may affect consumers' willingness-to-pay for food safety (Buzby and Skees 1994; Fu et al. 1997; Misra et al. 1991; Ott 1990). For empirical implementation, the explanatory variables of equation (1) are specified to include a set of sociodemographic characteristics of the household, such as age, education, income, number of small children, and health status of household members. In addition, the importance of price in making purchase decisions (PRICE) is also included in equation (1). Specifically, it is expected that consumers would be less willing to pay a premium for HGV if low prices were considered as an important attribute in making produce purchases. Equation (2) is specified to include primarily the set of sociodemographic variables.7

The maximum likelihood estimates of the generalized binary-ordinal probit model are presented in Table 2. For comparison, results of the conventional single-equation ordered probit estimation are also presented. It is evident from Table 2 that the single-equation model performs poorly as compared to the binary-ordinal probit model judging from the pseudo-R²'s that were computed as a measure of goodness-of-fit for the estimated

7 Other attitudinal variables, such as respondent's attitude toward pesticide use and reported food safety problems, that were initially expected to have important influences on willingness-to-pay were excluded from the final analysis. These variables were suspected to be jointly determined with the dependent variable of willingness-to-pay. The results would suffer from simultaneity bias unless a full simultaneous model is estimated, which is beyond the scope and purpose of this study.
### TABLE 2
Results of Joint Estimation of Probit and Ordered Probit and Single Equation Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Joint Estimation</th>
<th>Single Equation Estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Probit</td>
<td>Ordered</td>
</tr>
<tr>
<td>Constant</td>
<td>0.208**</td>
<td>0.900**</td>
</tr>
<tr>
<td></td>
<td>(3.801)*</td>
<td>(19.690)</td>
</tr>
<tr>
<td>AGE</td>
<td>-0.059</td>
<td>0.204**</td>
</tr>
<tr>
<td></td>
<td>(-1.099)</td>
<td>(3.584)</td>
</tr>
<tr>
<td>UNDER12</td>
<td>0.309**</td>
<td>-0.154**</td>
</tr>
<tr>
<td></td>
<td>(6.012)</td>
<td>(-3.035)</td>
</tr>
<tr>
<td>EDUC</td>
<td>0.092**</td>
<td>-0.062**</td>
</tr>
<tr>
<td></td>
<td>(14.719)</td>
<td>(-12.585)</td>
</tr>
<tr>
<td>SICK</td>
<td>-0.009</td>
<td>0.539**</td>
</tr>
<tr>
<td></td>
<td>(-0.170)</td>
<td>(7.370)</td>
</tr>
<tr>
<td>INCOME</td>
<td>-0.077*</td>
<td>0.288**</td>
</tr>
<tr>
<td></td>
<td>(-1.536)</td>
<td>(5.250)</td>
</tr>
<tr>
<td>EATOUT</td>
<td>-0.712**</td>
<td>-0.093</td>
</tr>
<tr>
<td></td>
<td>(-12.126)</td>
<td></td>
</tr>
<tr>
<td>PRICE</td>
<td>-0.190**</td>
<td>0.231</td>
</tr>
<tr>
<td></td>
<td>(-3.586)</td>
<td></td>
</tr>
<tr>
<td>(\mu_1)</td>
<td>1.303**</td>
<td>0.812**</td>
</tr>
<tr>
<td></td>
<td>(18.028)</td>
<td>(9.821)</td>
</tr>
<tr>
<td>(\mu_2)</td>
<td>1.910**</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\rho)</td>
<td>0.147**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.522)</td>
<td></td>
</tr>
<tr>
<td>Log-likelihood</td>
<td>-407.065</td>
<td>-421.681</td>
</tr>
<tr>
<td>Pseudo-R^2</td>
<td>0.139</td>
<td>0.045</td>
</tr>
<tr>
<td>Sample size</td>
<td>323</td>
<td>271</td>
</tr>
</tbody>
</table>

*Numbers in parentheses are t-ratios.

*Indicates statistical significance at the 0.05 level.

**Indicates statistical significance at the 0.001 level.

Models. Except for the variable SICK, none of the estimated coefficients is statistically significantly different from zero at the 0.05 significance level. In contrast, most of the estimated coefficients are highly significant from the joint estimation. The estimate of \( \rho \) that maximizes the likelihood function is 0.147 and significantly different from zero at the 0.001 significance level, based on the t-test. This suggests that the unexplained residuals of the probit and ordered probit equations are highly correlated, and that joint estimation is appropriate for correcting the potential selectivity bias and for yielding more efficient and consistent estimates.
More importantly, the results demonstrate the advantages of modeling the willingness-to-pay for HGV as a joint decision process. This approach allows the flexibility of parameterizing separately the probability and level of premiums that a consumer is willing to pay for a safer food. It also provides additional insights as to how each explanatory variable may affect the decisions differently from a more restrictive model when only a single-ordered probit equation was estimated (e.g., Misra et al. 1991). Unlike the single-equation approach, the signs and explanatory variables are not restricted to be the same. Thus, it should not be surprising to find that in many instances the same factor may have different effects on each of the decisions.\(^8\)

Results of the probit equation indicate that those respondents who had small children in their households would be more willing to pay a higher price for HGV. Similarly, the variable EDUC also shows a significant and positive effect, suggesting that the probability of willingness-to-pay a premium for HGV increases with the level of educational attainment. In contrast, those respondents who eat out more than three times a week (EATOUT) and consider price as an important factor in their purchasing decisions (PRICE) are found to be less likely to pay a higher price for HGV. It is somewhat surprising to see that the variable INCOME also shows a negative effect, though insignificant, suggesting that the probability of willingness-to-pay a premium decreases as household income increases.

With respect to how much more a consumer would pay, the ordered probit results show that all the socioeconomic characteristics, as expected, have significant impacts on the amount of premium that a respondent would be willing to pay for HGV. The results suggest that respondents with small children and higher education are less likely to pay higher premiums for HGV. However, those respondents who have family members suffering from a chronic disease and have higher household income are more likely than their counterparts to pay a price premium for HGV. It is interesting to note that income does have a positive and significant effect on the amount of premium that a respondent is willing to pay, while it is insignificant in determining whether to pay a higher price. In other words, once a respondent has decided to pay a higher price

\(^8\)In effect, what one observes from the single-equation approach are the "net" effects. One can predict and expect the signs of the estimated coefficients in the single ordered probit model to be consistent with the sign of the probit or ordered probit equation depending on which one has the dominating influence. This interpretation can be easily verified with a causal observation of Table 2.
for HGV, the amount of premium that the respondent is willing to pay increases as his or her household income increases. To the extent that higher income households have the ability and can afford to pay more, it is logical that they would be willing to pay a greater premium for HGV if they have a demand for it.

In general, the results support the notion that whether a consumer will pay more for HGV and the amount of premium that a consumer is willing to pay can be viewed as two different but connected decisions. The results suggest socioeconomic characteristics as well as attitudinal inclinations are important factors that influence whether or not a consumer will pay a premium. In contrast, socioeconomic characteristics appear to be responsible primarily for the determination of the additional amount of premium that a consumer is willing to pay for HGV. Furthermore, even in cases where a variable is an important determinant in both decisions, the results show that in most instances it may have different effects on the two decisions. In particular, the EDUC has a positive impact on the binary decision of whether or not to pay more but a negative effect on the ordinal decision of paying a premium. Perhaps due to greater awareness of the potential health hazard associated with pesticide use, the result suggests that better-educated consumers are more likely than their counterparts to pay a premium for HGV. However, the better-educated consumers appear more reluctant to pay too much for HGV.

For discrete choice models, the estimated coefficients should be interpreted in the sense that they affect the probability that a certain event will occur. This interpretation can be obtained by computing the probability derivatives or marginal probabilities from the estimated model. The marginal probability measures the change in the probability of each choice with respect to a change in an explanatory variable, *ceteris paribus*. Table 3 presents the estimated marginal probabilities associated with the probit and the ordered probit equations computed from the joint estimation results. Note that the marginal probabilities of selecting any of the three categories of willingness-to-pay sum to zero. This is always true because an increase in the probability in one category must be offset by the corresponding probability decrease in another category or categories.

As shown in Table 3, the probability that a consumer will be willing to pay a higher price for HGV will increase by 7 percent if there are smaller children present in the family (UNDER12). This is followed by years of education (EDUC). The result suggests that the probability of willingness-to-pay a higher price for HGV increased by 2 percent for each additional year of schooling. On the other hand, those individuals
TABLE 3
Estimated Marginal Probabilities Based on the
Joint Estimation of the Binary-Ordinal Probit Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Probit</th>
<th>Willingness-to-Pay Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Up to 5%</td>
</tr>
<tr>
<td>AGE</td>
<td>-0.013</td>
<td>-0.059**</td>
</tr>
<tr>
<td>UNDER12</td>
<td>0.069**</td>
<td>0.045**</td>
</tr>
<tr>
<td>EDUC</td>
<td>0.020**</td>
<td>0.018**</td>
</tr>
<tr>
<td>SICK</td>
<td>-0.002</td>
<td>-0.158**</td>
</tr>
<tr>
<td>INCOME</td>
<td>-0.017</td>
<td>-0.084**</td>
</tr>
<tr>
<td>EATOUT</td>
<td>-0.158**</td>
<td></td>
</tr>
<tr>
<td>PRICE</td>
<td>-0.042**</td>
<td></td>
</tr>
</tbody>
</table>

**Indicates statistical significance at the 0.001 level.

whose family eats out more than three times a week (EATOUT) are found to have the most negative effects on the probability of willingness-to-pay a premium for HGV. The probability of willingness-to-pay a higher price will decrease by 16 percent if the household has a stronger tendency to consume food away from home more frequently than three times a week. This result appears plausible because households that allocate more of their food budgets to away-from-home food expenditures can be expected to be less willing than their counterparts to pay a higher price for food consumed at home.

In terms of the choice of premium levels, the impact on the marginal probabilities associated with each willingness-to-pay category is the greatest if there was a family member suffering from a chronic disease. The results show that having a family member suffering from a chronic disease will shift a respondent’s willingness-to-pay from the lowest categories of “up to 5 percent” to the higher categories of “6 percent to 15 percent” and “16 percent or more.” In particular, the probability that a respondent would be willing to pay at least 6 percent more for HGV will increase by 16 percent if there is a family member suffering from a chronic disease in the household. Similarly, as a result of shifting from the lowest premium category to higher ones, the probability of a respondent’s willingness-to-pay will increase by 8 percent as household income rises. In contrast, the effect of an additional year of formal education is to shift the probability of willingness-to-pay from the higher premium categories to the lowest one. Thus, individuals with a higher level of educational attainment are more likely than their counterparts to pay a price premium of less than 6 percent.
CONCLUSIONS

This study proposes a generalized binary-ordinal probit model to estimate a consumer’s decision of whether or not to pay a premium and how much more to pay for hydroponic vegetables. The analysis is based on data collected from a consumer survey conducted in Taipei, Taiwan. Given that the sample on choice of price premiums was censored, a joint maximum likelihood estimation procedure, which accounts for sample selectivity bias, was developed in this study. The results show that unexplained residuals of the two estimated equations are highly correlated and that more efficient parameter estimates are obtained from the joint estimation. Marginal probabilities were calculated to assess the influence of various attitudinal and socioeconomic characteristics on the likelihood that a consumer would be willing to pay more and the additional amount of premium that he or she is willing to pay for HGV.

Based on the empirical evidence, this study finds that those respondents who have small children in the household are more likely than their counterparts to be willing to pay a higher price for HGV. With respect to amount of premium, the results suggest that socioeconomic characteristics are the major determinants that influence the respondents’ choice of additional premiums that they are willing to pay. The study shows that family health status and household income, followed by age of the respondents, are the most important and significant factors that determine the amount of premium a consumer is willing to pay. These factors are, however, insignificant in predicting the likelihood of a consumer’s willingness-to-pay a higher price for HGV. The results show that, conditional on willing to pay more, a respondent would be most likely to pay 16 percent or more for HGV if there is a family member suffering from a chronic disease in the household. Similarly, as household income increases, those consumers who are willing to pay a premium for HGV most likely would pay a price premium at least 16 percent or more than the prevailing market price.

The findings of this study should be helpful to the produce industry in assessing the market potential for pesticide-free food products, such as HGV, in developing its marketing and pricing strategies. The study finds that HGV seems to have a special appeal to more affluent consumers in Taiwan and its market potential appears promising. The findings also suggest that those consumers who are willing to pay a higher price for HGV most likely would be willing to pay 16 percent or more above the market price for conventional soil-grown vegetables. However, caution should be
exercised in the interpretation of the results. It is noted that the study is based on information collected from purchase intentions or indicated levels of willingness-to-pay instead of the actual or observed willingness-to-pay. This finding, nevertheless, is incompatible with Ott’s (1990) findings for certified residue-free produce in the U.S. market. His results indicate that U.S. consumers would be willing to pay only a moderate level of a premium at 5 percent or 10 percent more than the prevalent market price for certified residue-free produce. The discrepancy, however, is to be expected because there is a host of different social and cultural factors that may influence the attitudes and behaviors of the consumers in the two countries. Further research is needed to explore and compare how consumers’ perceptions and attitudes toward food safety problems may vary among different cultures and countries.

REFERENCES