International Food and Agribusiness Management Review
Volume 6, Number 4, 2003

Canadian Consumer's Willingness-To-Pay For Pesticide Free Food Products: An Ordered Probit Analysist[1]

J. A. L. Cranfield [a] ⓘ and Erik Magnusson [b]

[a] *Assistant Professor, Department of Agricultural Economics and Business, University of Guelph, Guelph, Ontario, N1G 2W1*
[b] *Former Graduate Student, Department of Agribusiness and Agricultural Economics, University of Manitoba, Winnipeg, Manitoba*

Abstract

A new crop production system has emerged in western Canada. Pesticide Free Production™ (PFP™) emphasizes reduced pesticide use in conjunction with increased reliance on producer knowledge of agronomic practices that mitigate weed, insect and disease pressure. A contingent valuation survey was undertaken to determine if Canadian consumers would pay a premium for PFP™ food products. Over 65 percent of respondents would be willing to pay a one to ten percent premium relative to a conventional food product. Five percent of respondents would be willing to pay more than a 20 percent premium. Health and environmental concerns, willingness to switch grocery stores and youth are important characteristics of consumers who would be willing to pay higher premiums. Distribution channels geared towards health food stores (or health food centers within grocery stores) are likely targets for PFP™ food products.

[1] The authors acknowledge the financial support of the Manitoba Rural Adaptation Council and the Ontario Ministry of Agriculture and Food. Constructive comments from Gary Johnson, Rene van Acker and Martin Entz are gratefully acknowledged. Any remaining errors or omissions are the authors' responsibility.

ⓘ Corresponding author: Tel: + 1-519-824-4120 extension 53708
Fax: + 1-519-767-1510
Email: jcranfie@uoguelph.ca

Introduction

Conventional crop production, typified by large-scale monoculture, has led to fewer, but larger farming operations. A consequence of large-scale monoculture crop production is a reliance on chemical inputs to protect crops against disease, insect and weed pressures. However, the combination of expensive chemical inputs and low commodity prices means that profit margins have been small or negative for many producers. Increasingly, this has burdened many in agriculture with financial strain. Some producers also feel they have lost control over the production system, as agri-service companies bundle different inputs under the same brand name and marketing program. As well, the ecological sustainability of conventional production systems is an ever-present concern to many. Consumer awareness of pesticide use in agriculture also raises concerns related to food safety and/or environmental health.

These factors have contributed to the development of alternative crop production systems. Examples of such alternatives include organic farming and integrated pest management (IPM). Recently, agronomists in western Canada have developed a new production system that falls between organic agriculture and IPM. This system, referred to as Pesticide Free Production™ (PFP™), focuses on reduced input usage for field crop (*e.g.*, cereal grains, oilseeds *etc.*) production.[2] PFP™ crops are grown without the use of chemical pest control methods during the crop year. Pesticides cannot be applied while crops are growing, during harvest or while in storage. Certain fertilizers may be used throughout the year, and certain pesticides can be applied prior to seeding. However, PFP™ crops cannot be grown where pesticides remain commercially active in the soil. Emphasis focuses on replacing pesticide use with reliance on producer's knowledge of other agronomic practices that mitigate weed, insect and disease pressure.

PFP™ has the potential to alleviate some of the problems associated with conventional crop production systems. Reducing the reliance on chemical inputs and substituting agronomic knowledge to control pests is one-way producers can take control of their production systems. Growing crops in a PFP™ system requires the use of diverse cropping systems and pest control practices. Greater diversity can lead to more stable and sustainable agro-ecosystems. As well, PFP™ potentially offers a commodity that is more appealing to consumers, who might be willing to pay a premium for these products. Given the growing awareness of pesticides in agriculture and its relation to food, PFP™ food products may be able to generate additional revenue for producers. Increased revenue combined with reduced input costs could offer a viable alternative to expanding farm size. This study attempts to measure and model consumer willingness-to-pay (WTP) for PFP™ food products, and assess how consumers' demographic, attitudinal and behavioral profiles affects WTP for PFP™ food products.

[2] Pesticide Free Production™ and PFP™ are registered trademarks of the University of Manitoba. Additional information regarding PFP™ can be found at www.pfpcanada.com, and in Magnusson (2002) and Nazarko (2002).

Numerous studies have examined consumer willingness-to-pay for organic or IPM food products. Some have examined consumer willingness-to-pay for reduced pesticide fresh produce in the U.S. (Ott 1990; Misra, Huang and Ott 1991; Huang 1991; Eom 1994; Buzby, Ready and Skees 1995; Buzby *et al.* 1998; Baker 1999), in Taiwan (Fu, Liu and Hammitt 1999) and Italy (Boccaletti and Nardella 2000). Others have examined consumer willingness-to-pay for agricultural commodities produced using IPM techniques (Mullen, Norton and Reaves 1997; Govindasamy, Italia and Adelaja 2001), or the impact of agro-pesticide use and elimination (Roosen *et al.* 1998; Foster and Mourato 2000) on WTP. In general, results have shown that consumer WTP is modest, with most premiums falling in the five to ten percent range. Moreover, a broad range of factors have been found to affect WTP. It is important to recognize, however, that PFP™ differs from the IPM and organic production systems in a number of ways. These differences lessen the extent to which one can extrapolate findings from previous studies onto PFP™. Moreover, this study goes beyond the scope of most existing research, which has focused primarily on produce, and addresses PFP™ on field crops (*e.g.*, cereal grains, pulse crops, oilseed crops, *etc.*). As such, the focus is on the market for processed food products containing ingredients produced in a PFP™ system.[3] Lastly, this study is unique in its application to Canada.

Conceptual Framework

Willingness-to-pay analysis can be cast in the context of a consumer choice problem. Suppose a consumer who purchases and consumes a conventionally produced food product encounters the same food product but in a PFP™ form. A consumer who shifts from purchasing a conventional product to the PFP™ version presumably does so because choice of the PFP™ product increases (or at least does not decrease) the utility of the consumption set, all other things being equal. If utility does not change, then a consumer will not, rationally, be willing to pay more, as an increase in price results in a lower level of utility compared to the base level of utility. If utility does increase, then a consumer may be willing to pay more for the PFP™ product, provided the price increase does not lower utility beyond the base level. Furthermore, economic theory would suggest that a consumer's WTP is influenced by their individual tastes and preferences, income, attitudes towards and perceptions of the different types of products, as well as household and demographic characteristics.

In this context, an individual's willingness to pay is a function of the change in utility arising from the consumption choice.[4] Since the choice of one product over another is a discrete one, it is convenient to cast choice in a random utility setting.[5]

---

[3] The paper by Foster and Mourato (2000) is one of the few studies to use a processed food product, in that case, a loaf of bread.

[4] Specifically, an individual's willingness to pay is a function of the change in utility: $WTP = f(\Delta U)$, where ΔU is the change in utility and $f' > 0$.

[5] The random utility model has been used extensively in the past. Examples include the assessment of consumer food safety valuation (Eom 1994; Veeman and Adamowicz 2000), participation in various

In this setting, an individual's utility function, and hence utility arising from the choice of the *i*th alternative, is composed of a deterministic component and a random component. The deterministic component reflects observable, alternative specific factors (i.e., attributes) that influence the level of utility realized by choosing the *i*th product. The random component represents unobservable factors, such as unobservable variations in preferences, random individual behavior and measurement error.[6]

Alternative *i* is chosen if and only if the utility arising from its choice exceeds the utility arising from the currently consumer product. Put another way, the ith alternative is chosen if and only if the change in utility (arising from a switch in products consumed) is positive. Since utility in the random utility model depends on deterministic and random components, then the change in utility associated with a switch in products consumed will equal the change in the deterministic and random components. Consequently, WTP depends on the change in the deterministic and random components of utility. [7]

Willingness to pay is driven by the extent to which utility changes via the consumption choice. The larger the increase in utility, the larger the maximum amount a consumer would be willing to pay. Also recognize that WTP is likely to vary across individuals. To capture this, one can include consumer (and household) characteristics in the factors thought to drive willingness-to-pay. One could then use the relationship between WTP and factors affecting WTP to predict the probability of a consumer's WTP being greater than a specified lower bound and less than a specified upper bound. The difference in these probabilities indicates the chance of that consumer's WTP being between the defined levels.[8] Such information could prove particularly useful in guiding pricing decisions for new products, such as PFP™ food products.

---

programs (Bell *et al.* 1994), assessment of consumer response to new (or different) products (Kuperis, Veeman and Adamowicz 1999; Quagrainie, Untershultz and Veeman 1998), *inter alia.*

[6] In the random utility model, the utility function is expressed as $U_i = \boldsymbol{X}_i'\boldsymbol{ß} + \varepsilon_i$, where U_i is the utility arising from the choice of the *i*th alternative, $\boldsymbol{X}_i'\boldsymbol{ß}$ is the deterministic component of the utility function, $\boldsymbol{X}_i$ is a vector of observable, alternative specific factors that influence utility, $\boldsymbol{ß}$ is a parameter vector and ε_i is the random component.

[7] Alternative *i* is chosen if and only if $U_i > U_j$ for all $j \neq i$ (or that $\Delta U = U_i - U_j > 0$). Willingness to pay can be re-written, without loss of generality, as $WTP = \boldsymbol{X}'\boldsymbol{ß} + \varepsilon$, where $\boldsymbol{X} = \boldsymbol{X}_i - \boldsymbol{X}_j$ and $\varepsilon = \varepsilon_i - \varepsilon_j$. Since WTP is likely to vary across individuals, one can include consumer (and household) characteristics in the matrix $\boldsymbol{X}$.

[8] Specifically, the probability of having a WTP between two defined WTP levels is:

$$\Pr\left(\underline{WTP} < WTP \leq \overline{WTP}\right) = \Pr\left(\boldsymbol{X}'\boldsymbol{ß} + \varepsilon \leq \bar{\gamma}\right) - \Pr\left(\boldsymbol{X}'\boldsymbol{ß} + \varepsilon < \underline{\gamma}\right)$$

where $\Pr(\cdot)$ is the probability operator, $\underline{WTP}$ and $\overline{WTP}$ are lower and upper limits of WTP that one is interested in, and $\underline{\gamma}$ and $\bar{\gamma}$ are threshold changes in utility consistent with the lower and upper ranges of WTP.

Willingness to pay is a function of the product attributes, characteristics of the consumer, and other factors thought to influence the choice. The probability of WTP falling within a range of values also depends on these factors. Furthermore, changes or differences in these factors will have a bearing on the actual willingness to pay and probability of being within a certain WTP range.

Empirical Framework

In many empirical analyses, including this study, WTP takes the form of a multiple response variable that has intrinsic order. As a result, ordered qualitative response models must be used. In this case, the WTP model can be written using a latent variable as follows: $WTP^* = \boldsymbol{X}'\boldsymbol{ß} + \varepsilon$, where WTP^* is the consumer's latent (or unobserved) willingness-to-pay, $\boldsymbol{X}$ is a vector of variables thought to influence willingness-to-pay, $\boldsymbol{ß}$ is a vector of parameters reflecting the relationship between willingness-to-pay and variables in $\boldsymbol{X}$ and ε is an independently and identically distributed error term with mean zero and variance one. If a consumer's WTP^* falls within a certain range, their WTP is assigned a numerical value that reflects the category in which their unobserved willingness-to-pay lies. In particular, if $\gamma_{j-1} < WTP^* \leq \gamma_j$, then, $WTP = j-1$ for all $j = 1,..., J$, where j is the WTP category selected by the respondent, and γ_k are category threshold parameters. Threshold parameters represent points at which the change in utility is sufficiently high to merit a consumer being willing to pay more for the selected good. While threshold parameters are unobserved, they can be statistically estimated. Furthermore, $-\infty = \gamma_0 < \gamma_1 < ... < \gamma_J = \infty$, with γ_1 being set equal to zero during estimation. The probability of a WTP being in one of J finite categories can now be written as:

$$\Pr(WTP = j-1) = \Phi(\gamma_j - \boldsymbol{X}'\boldsymbol{ß}) - \Phi(\gamma_{j-1} - \boldsymbol{X}'\boldsymbol{ß}) \; \forall j \in J \qquad (1)$$

where $\Phi(\cdot)$ is a cumulative density function (CDF), which measures the probability of WTP being less than the respective threshold level.

The empirical question is which CDF one ought to choose? Two broad choices, the logistic or standard normal density functions, are readily available. If $\Phi(\cdot)$ is the logistic density, the resulting probability model is the ordered logit; if $\Phi(\cdot)$ is the standard normal density, the resulting probability model is the ordered probit. Both of these densities are symmetric, bell-shaped curves, although the logistic distribution has heavier tails than the standard normal. Since the distributions are similar, the results derived using the two models will be quite similar.
An ordered probit model will be used here. Like all probability models, an ordered probit model allows for calculation of predicted probabilities for each WTP category and marginal effects. When calculated at the means of the data, predicted probabilities indicate the chance of the average consumer being willing-to-pay a premium falling within each of the categorical premium levels. These provide valuable insight into consumer preferences as they can be used to gauge the level of consumer WTP for PFP™ food products. Parameter estimates can also be used to calculate the marginal effects of explanatory variables on the predicted probabilities.

Marginal effects will indicate how a change in an explanatory variable affects the predicted probability that consumers are willing-to-pay each of the WTP classes.

A number of different explanatory variables can be included in the WTP model. These include demographic variables, regional variables, perceptional variables, factors reflecting shopping behavior, *etc*. Recognize that the variables that are included may depend on the manner by which the data is gathered (*i.e*., contingent valuation surveys, experimental methods, *etc*.)

Data and Methods

Currently, PFP™ food products are not available in the marketplace. Hence, they are a purely hypothetical product. As such, consumers' actual decisions to purchase and pay a premium cannot be observed. To address this issue, a contingent valuation (CV) survey was developed to gather consumers' stated preferences for different potential PFP™ food products and willingness-to-pay values.[9] The survey also collected demographic, attitudinal and behavioral information about the respondents and their households. A total of 2000 survey packages were sent to households in three Canadian cities (Toronto, Calgary and Winnipeg) in March 2001. One thousand surveys were sent to households in Toronto, while 500 surveys were sent to households in Winnipeg and Calgary. Household addresses were acquired from Watts List Brokerage Ltd. a division of the Watts Group.[10] Only names and addresses were purchased, and the mailing lists were generated from a random selection of the "Canadians at Home" database.[11] The survey was developed following many of the mail survey design principles outlined by Dillman's (1978) Total Design Method and is loosely modeled on a survey used by Govindasamy and Italia (1997).

Survey development began in the summer of 2000. A small pre-test was conducted in August 2000. A number of revisions were made in areas where respondents appeared to have difficulty. In the fall of 2000, the revised survey was circulated to a number of people involved in the PFP™ research program for additional feedback. A larger pre-test of 100 mail-out surveys was undertaken in January 2001. Returned pre-tests were examined, and further changes made to clarify questions, shorten the survey and reduce the effort required by respondents. The full survey

[9] Buzby *et al.* (1995), Kuperis *et al.* (1996), Govindasamy and Italia (1997), Baker (1999) and Boccaletti and Nardella (2000) are a few examples of food safety and reduced input food product related marketing research that use CV techniques. Much of the work on consumer food safety preferences has utilized the CV method (Baker, 1999). The technique is not without its limitations (see Caswell, 1998). Specifically, the CV method is hypothetical in nature, cast in a non-market environment, respondents face no budget constraint, scope exists for non-response bias and respondents may rely on personal experience rather than the information provided to them. For this study, concerns about hypothetical bias are minimal because it is not difficult for consumers to relate to the scenario. Furthermore, the CV methodology has the highest validity when the hypothetical scenario is similar to a familiar market choice situation (Buzby *et al.*, 1995).

[10] The Watts Group is a large Canadian direct marketing services organization.

[11] This database contained 1.75 million households in the three cities that were surveyed at the time addresses were acquired.

mail out took place in March 2001. Each household received one survey, a cover letter explaining the purpose of the study and a stamped, return-addressed envelope.[12] Of 2000 surveys, approximately 200 were returned as undeliverable. From the remaining surveys, 374 were completed and returned (a 20 percent response rate). Of the 374 returned surveys, another 77 were deemed unusable (due to non-response to certain questions), for a total of 295 usable surveys (72 surveys from Calgary, 143 from Toronto and 80 from Winnipeg).

Information was collected on consumer shopping habits, demographic characteristics and attitudes towards and knowledge of reduced input food products. The latter were included to develop a better understanding of how respondents might relate to different aspects of PFP™. These questions were posed using a modified Likert scale response (where a one equals strongly agree and five equals strongly disagree). Table 1 shows the specific questions and the proportion of respondents who selected the various response options. To use these responses in the empirical framework, they are added together to form a summated scale. Factor analysis indicated two groupings were appropriate, with the first three questions in one scale (referred to as the pesticide scale as these questions reflect concern over pesticides and food inputs), while the second scale (referred to as the sustainability scale as these questions relate more to sustainable farm and environmental aspects) included the fourth and fifth questions. These summated scales were normalized on their respective sample means.

A description of the explanatory variables included in the empirical model is provided in Table 2. Except for the summated scales and the ratio of the number of children in the household to number of people, all explanatory variables a binary (i.e., either zero or one). For each group of variables, the omitted reference variable was selected arbitrarily. Nevertheless, interpretation of results is relative to the omitted reference variable for that category of question. Table 3 shows the range of possible willingness-to-pay categories and distribution of responses.[13] Note that respondents were asked to indicate their WTP in actual monetary amounts, as opposed to percentage amounts. This helps to eliminate respondent's need to make mental calculations, and to be reflective of a retail market situation. Table 3 shows the WTP categories as a percent of the base value to facilitate comparison with other studies. The empirical model was estimated using the ORDPROB command in TSP, a maximum likelihood estimator for ordered probit models.

---

[12] The cover letter and survey are available from the authors upon request.

[13] Respondents were provided with a definition of PFP™ and then posed with the following WTP question: "Suppose your favorite food product regularly costs $2.00 for each unit you purchase. Assuming no difference in taste and nutritional content, would you pay slightly more for a PFP version of the same food product?

- ❑ No
- ❑ Yes, I would pay between 1 cent and 10 cents more for the PFP version
- ❑ Yes, I would pay between 11 cents and 20 cents more for the PFP version
- ❑ Yes, I would pay between 21 cents and 40 cents more for the PFP version
- ❑ Yes, I would pay more than 40 cents more for the PFP version"

The selected responses were then coded as WTP=0 if "No" was selected, 1 is the first WTP category, 2 for the second category, 3 for the third category and 4 for the fourth category.

Table 1. Summary of attitudinal question responses

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I feel the use of synthetic chemicals in agriculture has a negative effect on the environment.	41.6%	32.9%	19.4%	5.6%	0.6%
I am concerned about pesticide residues in our food supply.	60.3%	33.5%	5%	1.1%	0%
The labeling of food ingredients on food packaging is important to me.	64.7%	30%	4.7%	0%	0.6%
I feel it is important to maintain farm income at a level that keeps the family farm viable.	63.4%	26%	8.3%	1.9%	0.3%
I believe farmers should engage in sustainable agricultural production practices. That is, practices which adopt the goal of ensuring the productive future of agriculture, the environment and the economy of rural communities.	64.5%	29.9%	5.3%	0%	0.3%

Table 2. Description and summary statistics of explanatory variables

	Mean	Min	Max
Respondents city of residence			
1 = Calgary, 0 otherwise	0.2441	0	1
1 = Toronto, 0 otherwise	0.4848	0	1
1 = Winnipeg, 0 otherwise*	0.2711	0	1
Does respond try newly introduced food products			
1 = Among the first to try, 0 otherwise	0.1322	0	1
1 = In between the first to try and the last to try, 0 otherwise	0.7322	0	1
1 = Among the last to try, 0 otherwise	0.1085	0	1
1 = Never try new products, 0 otherwise*	0.0271	0	1
Shopping at health food stores or nutrition centers			
1 = Never shop at health food stores, 0 otherwise*	0.3491	0	1
1 = Occasionally shop at health food stores, 0 otherwise	0.5831	0	1
1 = Usually or always shop at health food stores, 0 otherwise	0.0678	0	1
Pesticide scale	1	-0.659	2.636
Sustainability scale	1	-0.719	2.156
Has respondent previously purchased alternative food products (*i.e.*, organic or IPM)			
1 = Yes, 0=No	0.2610	0	1
Has respondent heard of PFP™?			
1 = Yes, 0=No	0.3288	0	1
Would you switch grocery stores to purchase a PFP™ food product?			
1 = Yes, 0=No	0.5492	0	1
Number of children in household to number of people			
Continuous variable	0.1249	0	0.667
Gender of respondent			
1 = Female, 0=Male	0.6475	0	1
Age of respondent			
1 = Less than 36 years of age, 0 otherwise	0.2068	0	1
1 = 36 – 50 years of age, 0 otherwise	0.3661	0	1
1 = 51 – 65 years of age, 0 otherwise	0.2475	0	1
1 = Over 65 years of age, 0 otherwise*	0.1796	0	1
Education of respondent			
1 = High school graduate or less, 0 otherwise	0.2373	0	1
1 = Some University/College or University/College graduate, 0 otherwise	0.6136	0	1
1 = Some graduate school or higher, 0 otherwise*	0.1491	0	1
Annual household income			
1 = Less than $39 999, 0 otherwise	0.2779	0	1
1 = $40 000 to $59 999, 0 otherwise	0.1966	0	1
1 = $60 000 to $79 999, 0 otherwise	0.1627	0	1
1 = $80 000 to $99 999, 0 otherwise	0.1186	0	1
1 = $100 000 or higher, 0 otherwise*	0.2442	0	1

* Denotes variable was dropped during estimation.

Table 3. Distribution of WTP responses

WTP category	Frequency	Proportion
Not willing to pay	52	17.6%
Willing to pay a one to five percent premium	112	37.9%
Willing to pay six to ten percent premium	86	29.2%
Willing to pay 11-20 percent premium	30	10.2%
Willing to pay more than a 20 percent premium	15	5.1%

Results

Parameter estimates and summary statistics of the ordered probit model are presented in Table 4. Since the ordered probit model is non-linear, the estimated coefficients are not marginal effects. As such, coefficient estimates and marginal effect are discussed separately. The estimated model has a scaled R^2 of about 0.3.[14] The null hypothesis that the estimated coefficients are jointly equal to zero is rejected at the one percent level. Of the 24 estimated coefficients, nine are significant. Coefficients for the Calgary dummy variable, among the first to try new food products dummy variable, usually or always shop at health food stores dummy variable, and less than 36 years of age dummy variable are significant at the ten percent level. Coefficients for the in between first and last to try new food products dummy variable and among the last to try new food products dummy variable are significant at the five percent level. The constant, coefficient on the pesticide scale variable and the dummy variable indicating whether respondents would switch grocery stores to purchase a PFP™ product are significant at the one percent level. Estimated threshold levels defining the different WTP categories are all significant at the one percent level. Note that during estimation γ_1 was normalized to zero.

Table 5 shows the predicted probabilities for the five WTP categories evaluated at the sample means of the data. These predicted probabilities indicate a strong likelihood that the average consumer is willing-to-pay some premium for PFP™ food products. Naturally, producers would like to earn as much as possible for their product. If higher premiums are sought, marketing efforts will have to focus on the fraction of consumers who are willing-to-pay higher premiums. If the predicted probability for the fifth WTP category (i.e., WTP more than a 20 percent premium) is deemed to represent too small of a niche, there is the knowledge that consumers, in general, are willing-to-pay some sort of premium for PFP™ food products. This should provide assurance to producers who are concerned about the market potential for PFP™ food products. Nevertheless, when taken alone, these predicted probabilities are not very informative. What is informative, however, is the impact of a change in an explanatory variable on the predicted probabilities (*i.e.*, the marginal effects).

[14] The scaled R^2 measures how well the estimated model fits against a model that only includes a constant term (see Estrella 1998).

Table 4. Maximum likelihood estimates of the ordered probit model

Variable	Parameter Estimate	t-statistic (asymptotic)
Constant	1.286***	2.717
Respondent Lives in Calgary	0.322*	1.668
Respondent Lives in Toronto	0.231	1.256
Respondent is among the first to try new food products	-0.609*	-1.823
Respondent is between the first and last to try new food products	-0.684**	-2.381
Respondent is among the last to try new food products	-0.684**	-1.984
Respondent occasionally shops at health food stores	0.194	1.256
Respondent usually or always shops at health food stores	0.619*	1.828
Pesticide scale	-0.468***	-2.670
Sustainability scale	-0.046	-0.280
Has respondent previously purchased alternative food products?	0.315	1.522
Has respondent heard of PFP™	-0.211	-1.353
Would respondent switch grocery stores to purchase a PFP™ food product?	0.624***	3.683
Number of children in household to number of people	-0.459	-1.159
Gender of respondent	0.110	0.720
Less than 36 years of age	0.402*	1.660
51 – 65 years of age	0.335	1.435
Over 65 years of age	0.304	1.307
High school graduate or less	-0.164	-0.627
Some University/College or University/College graduate	0.034	0.149
Less than $39 999 in annual household income	-0.018	-0.080
$40 000 to $59 999 in annual household income	-0.068	-0.310
$60 000 to $79 999 in annual household income	0.160	0.718
$80 000 to $99 999 in annual household income	0.218	0.855
Threshold parameter 2	1.314***	11.725
Threshold parameter 3	2.352***	16.980
Threshold parameter 4	3.079***	16.230

Log likelihood = -368.722
Scaled R-squared = .299
Likelihood ratio test of zero slope coefficients= 98.537***
*: significant at the 0.10 level.
**: significant at the 0.05 level.
***: significant at the 0.01 level.

Table 5. Predicted probabilities and marginal effects from the estimated ordered probit model

	WTP=0	WTP =1	WTP =2	WTP =3	WTP=4
Predicted probabilities	0.1296	0.4441	0.3157	0.0851	0.0255
	Marginal effects				
Respondent lives in Calgary	-0.0619	-0.0654	0.0602	0.0445	0.0227
Respondent lives in Toronto	-0.0486	-0.0419	0.0466	0.0299	0.0139
Respondent is among the first to try new food products	0.1609	0.0596	-0.1339	-0.0625	-0.0241
Respondent is between the first and last to try new food products	0.1206	0.1468	-0.1123	-0.0981	-0.0571
Respondent is among the last to try new food products	0.1874	0.0550	-0.1505	-0.0668	-0.0250
Respondent occasionally shops at health food stores	-0.0416	-0.0339	0.0397	0.0246	0.0112
Respondent usually or always shops at health food stores	-0.0946	-0.1476	0.0861	0.0945	0.0615
Pesticide scale	0.0988	0.0848	-0.0952	-0.0606	-0.0279
Sustainability scale	0.0096	0.0082	-0.0093	-0.0059	-0.0027
Has respondent previously purchased alternative food products?	-0.0610	-0.0634	0.0593	0.0433	0.0219
Has respondent heard of PFP^{TM}?	0.0464	0.0356	-0.0438	-0.0264	-0.0118
Would you switch grocery stores to purchase a PFP^{TM} food product?	-0.1366	-0.1027	0.1249	0.0778	0.0366
Number of children in household to number of people	0.0968	0.0831	-0.0933	-0.0593	-0.0273
Gender of respondent	-0.0237	-0.0193	0.0226	0.0140	0.0064
Less than 36 years of age	-0.0740	-0.0848	0.0717	0.0568	0.0303
51 – 65 years of age	-0.0673	-0.0645	0.0649	0.0449	0.0220
Over 65 years of age	-0.0588	-0.0614	0.0572	0.0418	0.0212
High school graduate or less	0.0364	0.0274	-0.0344	-0.0204	-0.0090
Some University/College or University/College graduate	-0.0071	-0.0060	0.0068	0.0043	0.0020
Less than $39 999 in annual household Income	0.0038	0.0032	-0.0036	-0.0023	-0.0011
$40 000 to $59 999 in annual household income	0.0146	0.0118	-0.0140	-0.0086	-0.0039
$60 000 to $79 999 in annual household income	-0.0317	-0.0315	0.0310	0.0216	0.0106
$80 000 to $99 999 in annual household income	-0.0418	-0.0445	0.0409	0.0301	0.0153

For a particular explanatory variable, the marginal effects across the five WTP categories must sum to zero by definition.[15,16] Interpretation of the marginal effects for continuous variables is straightforward; all other things equal, a one unit change in the explanatory variable will result in an increase or decease in the predicted probability equal to the size of the marginal effect. In the case of a binary variable, the marginal effect is the change in predicted probability based on whether a respondent falls into that category or not. When calculating marginal effects all remaining variables assume their respective average values. As such, the marginal effects show the change in the predicted probability for each WTP class for an average consumer, according to the variable being considered.

The bottom panel of Table 5 shows the marginal effect for all explanatory variables. Beginning with the city of residence dummy variable, we see that residing in Calgary or Toronto reduces the probability of being unwilling to pay a premium and the probability of being willing to pay a modest premium (*i.e.*, one to five percent). However, residing in Calgary or Toronto increases the probability of willingness to pay a premium of six percent or higher. (It is important to remember that these changes are relative to an individual who resides in Winnipeg.) City of residence marginal effects are also stronger for the Calgary dummy variable than for the Toronto dummy variable. All other things being equal, this suggests greater variability in willingness-to-pay in Calgary than in Toronto. Such difference comes as no surprise given the diversity of the Canadian population across the country.

The "try new food products" dummy variables have positive marginal effects for the first two WTP categories (*i.e.*, the not willing to pay more and the willing to pay between one and five percent categories), but a negative effect on all other willingness-to-pay categories. Moreover, these marginal effects tend to be stronger for the "in between the first and last to try" and "among the last to try" dummy variables than for the "among the first to try" dummy variable. Marginal effects for the "try new food products" variables indicate that innovators, early adopters, and early and late majority are more likely to be willing to pay no premium or a very modest premium (*i.e.*, one to five percent) for a PFP™ food product relative to those who do not try new food products.

---

[15] Since the probabilities for the WTP categories must sum to one, the change in probabilities for the WTP categories must sum to zero.

[16] Marginal effects for continuous variables are calculated as:

$$\frac{\partial \Pr(WTP = j-1)}{\partial x_k} = [\phi(\gamma_{j-1} - \boldsymbol{X}\boldsymbol{ß}) - \phi(\gamma_j - \boldsymbol{X}\boldsymbol{ß})]\beta_k ,$$

where $\phi(\cdot)$ is the standard normal probability distribution function. For binary variables, marginal effects are discretely approximated using the difference in predicted probabilities when the dummy variable under question is set equal to one and zero:

$$\frac{\Delta \Pr(WTP = j-1)}{\Delta x_k} = \Theta(WTP = j-1 | x_k = 1) - \Theta(WTP = j-1 | x_k = 0).$$

Relative to those who never shop at a health food store, the marginal effects for the "occasionally" or the "usually or always" shop at health food store dummy variables are negative for the "not willing to pay more" and the "willing to pay a premium between one and five percent" WTP categories, but are positive for the other WTP categories. As well, the marginal effects are stronger for the "usually or always" shop at a health food store dummy variable than for the occasionally shop at health food stores dummy variable. These results are in line with expectations; consumers who regularly shop at health food stores would be expected to be willing-to-pay a premium for PFP™ food products. Moreover, results suggest scope for differentiated marketing strategies according to the distribution channel being used. Such an approach could enable differentiated pricing in different distribution channels, with higher prices in the health food store channel.

The marginal effect of the pesticide scale is positive for the "not willing to pay more" and "willing to pay between one and five percent more" categories, but negative for the other WTP categories. As the scale increases, the probability of being unwilling to pay a premium or willing to pay a small premium increases, while the probability of being willing to pay a larger premium falls. Recall that the scales are developed from a modified Likert scale, where a one equals strongly agree and five equals strongly disagree. Hence, the higher the scale's value the stronger the respondent's disagreement with the set of statements it represents. Results accord with the notion that respondents who are concerned with the impact of pesticides on the environment, health and seek out information on the foods they purchase are, in all likelihood, consumers who would pay a higher price to avoid pesticides. A similar result is noted for the sustainable scale, which suggests that respondents who have holistic concerns related to primary agricultural production (*i.e.*, sustainability and economic viability of family farms) are more likely to pay a higher premium for PFP™ food products. Note, however, that the magnitudes of the marginal effect for the pesticide scale are stronger than the magnitudes for the sustainable scale. These results underscore the potential to develop marketing strategies designed to attract consumers who are willing to pay more for PFP™ food product based on attitudinal segmentation of the market place.

Previous purchase of food products originating from an non-conventional production system and willingness to switch grocery stores to purchase a PFP™ product reduces the likelihood of respondents being unwilling to pay a premium or a small premium (*i.e.*, one to five percent), but increases the chance of being willing to pay a premium of six percent or higher. The fact that respondents who are willing to switch grocery stores to purchase a PFP™ food product have a higher likelihood of being willing to pay a higher premium suggests these consumers are not price sensitive or that the switching and search costs are perceived to be low. Previous exposure to the PFP™ concept actually has the opposite effect – it increases the probability of a respondent being unwilling to pay a premium or willing to pay a small premium, but lowers the chance of being willing to pay a premium of six percent or higher. Recall, however, that the coefficient estimate for this variable was insignificant.

As the ratio of number of children in the household under the age of 17 rises relative to the number of people in the household, the probability of being willing to pay no premium or a premium less than six percent increases, while the probability of the higher WTP categories falls. Households with relatively more children under the age of 17 are less likely to pay a higher premium. One plausible explanation for this result is that as more children are in the home, the household's budget constraint limits the extent to which one can pay a higher price for food products that are desirable (*i.e.*, products that are in the choice set, but are not feasible), hence a lower WTP.

The marginal effects for the gender dummy variable indicate females respondents are less likely to be willing to pay no or small (*i.e.*, one to five percent) premium, but more likely to pay a premium of six percent or more (relative to male respondents). The same pattern emerges with respect to age. Respondents in the first three age categories are all less likely to be willing to pay no premium or a small premium, compared to those in the oldest age category, but more likely to pay a premium of six percent or more. Moreover, the youngest age category (those 35 years of age of younger) has the strongest marginal effects, followed by the second age category (36-50 year olds) and then the third age category (51-65 year olds).

Marginal effects also vary according the education and income categories. The marginal effect for the first education class (a high school degree or less) is positive for the first two WTP classes, but negative for the other WTP classes. This suggests respondents with a high school diploma or less have a higher probability of being unwilling to pay a premium and a higher probability of being willing to pay a small premium, but a lower probability of willingness to pay a premium of six percent or more. The reverse is true for respondents who are University/College graduates or have some University/College experience – they are more likely to be willing to pay a higher premium. A similar pattern emerges with respect to the income categories. The marginal effect for the first two WTP categories is positive for households with annual income less than $59,999 per year, but negative for households with annual income between $60,000 and $99,999 per year. For the last three WTP categories, the marginal effect is negative for low-income households (*i.e.*, annual household income below $59,999), but positive for households with annual income between $60,000 and $99,999. All other things equal, there is a higher probability of being unwilling to pay a premium and of being willing to pay a small premium for PFP™ food products when household income is low compared to when household income is high. In contrast, households with higher incomes are more likely to pay some premium in excess of five percent for PFP™ food products.

Summary and Conclusions

This study sought to measure and model consumer willingness-to-pay for Pesticide Free Production™ (PFP™) food products. PFP™ is a new production system that falls between organic and IPM agricultural production. It emphasizes reduced pesticide use in conjunction with increased reliance on producer's knowledge of other agronomic practices that mitigate weed, insect and disease pressure. As the current

focus of PFP™ relates to field crop production (*e.g.*, cereal grains, oilseeds, *etc.*) many of the goods consumers might encounter in PFP™ form would be processed food products. As such, it is difficult to extrapolate from previous research when trying to develop WTP measures for PFP™ food products.

Results of a contingent valuation survey of randomly selected households in three Canadian cities indicate that 67 percent of respondents would be willing to pay a modest (*i.e.*, one to ten percent) premium, while about five percent of respondents would be willing to pay more than a 20 percent premium. These results are consistent with other studies examining willingness to pay for other commodities in other regions. At a broad level, several factors influence willingness to pay for PFP™ food products in Canada. Consumers are more likely to pay a higher premium (i.e., over six percent) if they are younger, are willing to switch grocery stores to purchase a PFP™ food product (which suggests price insensitivity), shop at health food stores, are concerned pesticides in agriculture and food, and are concerned over sustainability of traditional agricultural production at a small scale *(i.e.*, family farms). As such, marketing efforts should focus on reaching consumers who fit this profile. Distribution channels geared towards health food stores (or even health food centers within grocery stores) are likely to emerge as a more successful avenue to market PFP™ food products. A strategy for PFP™ producers could be to market their products and their production system to processors who supply heath food stores. These processors already provide products designed for health conscious consumers, and may receptive to the idea of producing PFP™ food products.

Results of this study are consistent with previous studies in the fact that health and environmental concerns are important factors in consumers' preference for reduced input food products. Other studies have found that socio-demographic factors play a role in consumer WTP for reduced input food products, although different studies report conflicting effects of such factors. Here, socio-demographic factors prove to be relatively unimportant as compared to shopping behavior and concern over pesticide use in agriculture.

References

Baker, G. (1999). Consumer Preferences for Food Safety Attributes in Fresh Apples: Market Segments, Consumer Characteristics, and Marketing Opportunities. *Journal of Agricultural and Resource Economics*, 24, 80-97.

Bell, C., Roberts, R., English, B., & Park, W. (1994). A Logit Analysis of Participation in Tennessee's Forest Stewardship Program. *Journal of Agricultural and Applied Economics*, 26, 463-472.

Boccaletti, S. & Nardella, M. (2000). Consumer Willingness to Pay for Pesticide-free Fresh Fruit and Vegetables in Italy. *International Food and Agribusiness Management Review*, 3, 297-310.

Buzby, J., Ready, R. & Skees, J. (1995). Contingent Valuation in Food Policy Analysis: A Case Study of a Pesticide-Residue Risk Reduction. *Journal of Agricultural and Applied Economics*, 27, 613-625.

Buzby, J., Fox, J., Ready, R. & Crutchfield, S. (1998). Measuring Consumer Benefits of Food Safety Risk Reductions. *Journal of Agricultural and Applied Economics*, 30, 69-82.

Caswell, J. (1998). Valuing the Benefits and Costs of Improved Food Safety and Nutrition. *Australian Journal of Agricultural and Resource Economics*, 42, 409-424.

Dillman, D. (1978). *Mail and Telephone Surveys: The Total Design Method*. New York: John Wiley and Sons, Inc.

Eom, Y. (1994). Pesticide Residue Risk and Food Safety Valuation: A Random Utility Approach. *American Journal of Agricultural Economics*, 76, 760-771.

Estrella, A. (1998). A New Measure of Fit for Equations with Dichotomous Dependent Variables. *Journal of Business and Economic Statistics*, 16, 198-205

Foster, V. & Mourato, S. (2000). Valuing the Multiple Impacts of Pesticide Use in the UK: A Contingent Ranking Approach. *Journal of Agricultural Economics*, 51, 1-21.

Fu, T., Liu, J., & Hammitt, J. (1999). Consumer Willingness to Pay for Low-Pesticide Fresh Produce in Taiwan. *Journal of Agricultural Economics*, 50, 220-233.

Govindasamy, R. & Italia, J. (1997). *Consumer Response to Integrated Pest Management and Organic Agriculture: An Econometric Study*. Working Paper, Department of Agricultural, Food and Resource Economics, Rutgers University.

Govindasamy, R., Italia, J. & Adelaja, A. (2001). Predicting Willingness-to-Pay a Premium for Integrated Pest Management Produce: A Logistic Approach. *Agricultural and Resource Economics Review*, 30, 151-159.

Huang, C. (1991). Simultaneous-Equation Model for Estimating Consumer Risk Perceptions, Attitudes and Willingness-to-Pay for Residue-Free Produce. *The Journal of Consumer Affairs*, 27, 377-396.

Kuperis, P., Veeman, M. & Adamowicz, V. (1999). Consumer's Response to the Potential use of Bovine Somatotrophin in Canadian Dairy Production. *Canadian Journal of Agricultural Economics*, 47, 151-163.

Magnusson, J. (2002). *Consumer Interest in and Willingness-to-pay for Pesticide Free Production Food Products: A Probit Analysis.* Master of Science Thesis, Department of Agribusiness and Agricultural Economics, University of Manitoba.

Misra, S., Huang, C. & Ott, S. (1991). Consumer Willingness to Pay for Pesticide-Free Fresh Produce. *Western Journal of Agricultural Economics*, 16, 218-227.

Mullen, J., Norton, G., & Reaves, D. (1997). Economic Analysis of Environmental Benefits of Integrated Pest Management. *Journal of Agricultural and Applied Economics*, 29, 243-253.

Nazarko, O. (2002). *Agronomic and Demographic Assessment of Fields and Farmers Involved in a Pesticide Free Production (PFP) Pilot Project in Manitoba.* Master of Science Thesis, Department of Plant Science, University of Manitoba.

Ott, S. (1990). Supermarket Shoppers' Pesticide Concerns and Willingness to Purchase Certified Pesticide Residue-Free Fresh Produce. *Agribusiness: An International Journal*, 6, 593-602.

Quagrainie, K., Untershultz, J. & Veeman, M. (1998). Effects of Product Origin and Selected Demographics on Consumer Choice of Red Meats. *Canadian Journal of Agricultural Economics*, 46, 201-216.

Roosen, J., Fox, J., Hennessy, D., & Schreiber, A. (1998). Consumers' Valuation of Insecticide Use Restrictions: An Application to Apples. *Journal of Agricultural and Resource Economics* 23, 367-384.

Veeman, M., & Adamowicz, V. (2000). *Consumers Perceptions of Environmental Risks and the Demand for Food Safety*. Project Report 00-01, Department of Rural Economy, University of Alberta.

