INFORMATION EFFECTS ON CONSUMERS' WILLINGNESS-TO-BUY: THE CASE OF SPOTTED-WING-DROSOPHILA-INFESTED BLUEBERRIES

A Thesis

Presented to the Faculty of the Graduate School

of Cornell University

In Partial Fulfillment of the Requirements for the Degree of

Master of Science

by

Yawen Gao

May 2019

ABSTRACT

The production of blueberries and other soft-skin fruits in the U.S. has been severely threatened by the spotted-wing-drosophila (SWD), an invasive pest. Using data from a choice experiment with over 1,300 subjects, this paper analyzes how information of SWD problems and strategies to solve them affect consumers' purchase decisions on blueberries. The results indicate an insignificant decrease in consumer willingness-to-buy (WTB) after consumers are aware that blueberries might be infested with SWD. However, the results suggest a significant shift in consumer preference from choosing blueberries treated with lower to medium level of chemical pesticide application. Given that pesticide use and SWD information both provide negative information in consumer decision-making processes, our paper contributes to the literature by examining how two negative information messages jointly influence consumer purchase behavior. In addition, price discounts are estimated to quantitively measure consumer tradeoffs between product price and the use of pesticides to control for SWD. Our results provide valuable information for blueberry industry stakeholders and contribute to the literature of negative product information impacts on consumer demand.

Keywords: Spotted wing drosophila (SWD), Pesticide use, Willingness to buy (WTB), Consumer preferences, Negative information

BIOGRAPHICAL SKETCH

Yawen Gao received her B.S. in Applied Economics from the University of Minnesota—Twin Cities in 2017. She continued her graduate study at the Dyson School of Applied Economics and Management of Cornell University from 2017 to 2019. Her research interests are in the fields of consumer behavior, food safety, agricultural and food policy.

After her graduation at Cornell, she will start her career at NetsUnion Clearing Corporation in Beijing, China. NetsUnion Clearing Corporation is the operator of China's nationwide centralized platform for the processing of online transactions.

Outside of academics and work, Yawen enjoys hiking, yoga, and gardening.

To my parents, Hongrui Gao and Chunmei Liu, who support me unconditionally

AKNOWLEDGMENTS

I would like to use this opportunity to appreciate the help and support from those who made my study at Cornell University productive and fruitful in the past two years.

I would like to express my special thanks of gratitude to my committee Chair, Dr. Miguel I. Gómez for providing me the opportunity to work on the Spotted-Wing-Drosophila (SWD) project. I treasure him for his timely guidance and support in completing my research project. I am also deeply thankful to my committee Minor, Dr. Todd M. Schmit for his constructive and valuable suggestion during my thesis defense.

I would also like to extend my gratitude to Adeline Yeh, a Ph.D. student in the research group of Dr. Gómez, who works on the SWD project with me. I appreciate her patience and knowledge to help me understand the SWD project and her help on the writing of this thesis.

Last but not least, I sincerely thank all my family and friends. Thank you to my parents for their unconditional support for my study at Cornell and thank you to all my friends at Cornell for their accompany, encouragement, and the warmth that they bring in the past two years.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Introduction

Information, especially related to chemical pesticides, has played an important role in consumers' decision-making process to purchase fresh produce. Extensive literature and surveys have analyzed how information on pesticide use can affect consumers' purchase decisions on fresh produce. Most studies conclude that consumers are concerned about health risks due to the possible presence of chemical residues on fresh produce (Penner et al. 1985, Sachs et al. 1987, Food Marketing Institute 1987, Zellner and Degner 1989). Nevertheless, the use of pesticides is often in response to crop disease issues that might also affect the product quality. The issue of two negative messages impacting consumer choices has been largely ignored in the literature. In response, this study uses a nationwide survey of consumers to analyze the following questions: how would consumer preferences change when they believe fresh produce with lower chemical pesticide use are better not to eat? Will consumer demand decrease for such products or would they be willing to accept a higher level of pesticide applications? How much price discount or premium will consumers be willing to trade off to change from consuming the low to the high level of chemical pesticide treated alternatives, when they know the negative impacts on product quality of the possible crop infestation?

This study focuses on spotted-wing-drosophila (SWD)-infested berry crops. Berry fruits are widely consumed in our diet and have been praised for their nutrient value. However, the production of these soft-skin fruits has been suffering from SWD infestation since SWD was first detected in California in 2008 (PennState Extension, 2016). Female SWD can lay eggs inside fresh fruits, which then causes the infested fruit to damage and deform (Figure 1). The infested fruit is unmarketable in the fresh market.

Figure 1:3-4 days after SWD lays eggs on fruit

(Source: USDA ARS Horticultural Crops Research Unit, from left to right: blueberry, raspberry, and strawberry)

SWD has negative impacts on berry consumption. Consumers are likely to complain if they happen to purchase infested fruits. In addition, as early-stage infestation is barely visible on the fruit, consumers might have unpleasant experience and food safety concerns after the infestation is more revealed after purchasing the product. To prevent fresh fruits from being infested by SWD, growers often use intensive insecticide application during the production of berry crops. However, most consumers have a negative perception about the health impacts induced by pesticides because they may contain harmful residues in the final product.

The main objective of this study is to analyze how the provision of information on SWD can affect consumer willingness-to-buy (WTB) and to estimate the information effects of SWD problems on consumer preferences for the level of chemical pesticide application. We conducted a national-wide survey using the case of fresh market blueberries and employed a discrete choice modeling framework for analysis. Subjects were randomly assigned into one of the two treatments that offer surveys with and without SWD information. In both surveys, subjects were asked to make purchase options among blueberries alternatives that have the same attributes but with different attribute levels.

Our results show that the SWD information does not significantly affect consumer WTB, but it does change consumer preferences on pesticide application levels. In general, consumers prefer blueberries with a lower pesticide application level. However, when the SWD information is revealed to the consumers before they make the purchasing decision, consumers tend to switch to blueberries with a higher a pesticide level. In other words, consumers display a higher tolerance on pesticide level after knowing the SWD information. Additionally, given that higher pesticide level is regarded as a negative attribute to the consumer, we assess the price discounts needed for consumers to accept the attribute which they less desire using the tradeoff analysis. Results find that when consumers are told with SWD information, they request fewer price discounts to switch to their less preferred pesticide level.

2 Background and Literature

2.1 Spotted Wing Drosophila

SWD is a fruit fly that attacks a wide range of soft-skinned fruits particularly for berry crops such as blueberries, raspberries, cranberries, and their wild relatives (Bolda et al. 2009, Acheampong 2010). This insect originated in East Asia but was first discovered in California in 2008, and subsequently found in Florida, Utah, North and South Carolina, and Michigan in 2010. By 2013, it has spread over most of the continental U.S. (PennState Extension, 2016). Unlike other vinegar or fruit flies that require ripe or overly ripen fruit to lay eggs, female SWD can cut a slit into the skin of the intact fruit to lay its eggs. The female can inject up to 7-16 eggs per day, leaving a small, barely visible scar on the fruit surface. The larval holes leak out the fruit juice and therefore the fruit skin becomes dimpled or wrinkled and collapses ultimately due to larval feeding (Acheampong 2010, Walsh et al. 2011).

SWD significantly reduces the shelf life of berries. Visible damage specific to SWD — wrinkling and softening become pronounced when infested blueberries are left alone for 3-4 days, and customers start noticing that their berries are filled with larvae, whereas uninfected blueberries can remain firm up to 6-7 days (Agricultural Research Service of United States Department of Agriculture (ARS, USDA), 2010). According to Dakota State University's Extension Service and the University of Vermont Extension in 2013, eating a few SWD eggs or larvae is not hazardous and there is no known risk to human health posed by ingesting SWD. However, given the undesired appearance of infested fruits, there is zero tolerance for SWD infestation by fruit retailers, brokers and consumers in fresh produce market.

Repeated insecticide treatments before harvest, right after fruit coloring starts to occur, has proved an effective way to control this pest (Cornell Cooperative Extension, 2017). Many conventional berry and cherry growers begin insecticide application as soon as one fly is detected in their field (or even before detecting SWD in the field) and the fruit is about to ripe. Insecticide application is targeted against adult SWD, although systemic insecticides may kill eggs and larvae inside of the fruit (Spears et al. 2017). Organic growers face even more challenges to manage SWD due to the limited number of organically approved and effective control strategies (USDA, 2014). As a result, chances for consumers to come across infested soft skin fruits do exist. In this study, we focus on conventionally grown blueberries for their large market share. Most conventional blueberries are treated with different levels of chemical pesticide to control for SWD and avoid undesirable quality in the final product. This leads to the discussion of the literature on the impact of pesticide use on consumer's demand for fresh produce.

2.2 Pesticide impacts on consumer's demand

Food safety and the use of pesticides in food production have been a major consideration for consumers, particularly in the fresh produce market. There have been a large number of studies that address consumer concerns about pesticide use on fresh produce over the past three decades. Most conclude that consumers have high levels of concern about health risks due to the possible presence of chemical residues on fresh produce. Results from Penner, Kramer, and Frantz (1985) show that consumers ranked pesticide residues as the third most important food safety concern in Kansas. Similarly, a household survey conducted by Sachs, Blair, and Richer (1987) finds that 71% of respondents reported concern about the danger with eating fruits and vegetables treated with pesticides. Similar results can also be found in a 1989 survey by the Food Marketing Institute (Food Marketing Institute 1989).

Given the negative consumer impression on pesticides, various studies have demonstrated that consumers would change their shopping behavior if alternative products were available. Poll (1989) and Packer (1990) suggest that a substantial portion of consumers express their concern on pesticide usage by seeking or purchasing organic or chemical-free produce instead. Particularly, evidence from a survey by Ott and Maligaya (1989) and Ott (1990) indicates that two-thirds of respondents would be willing to pay more than a 5% price premium for pesticide-free produce. Other studies examine changes in consumer attitudes toward pesticide use over time. For instance, the findings from Sachs et al. (1987) suggest that consumers were more concerned with pesticide issues in 1984 than in 1965.

One of the main findings among the previous studies is that consumers believe organic fresh produce or fresh produce with lower pesticide application are better choices compared to products that are treated with high level of pesticide during production. However, for fresh product that are susceptible to SWD, it exists a more complicated dilemma. Fresh produce with higher pesticide use might not be worse than with lower pesticide use because SWD infestations can deteriorate the quality of the product at consumption occasions.

2.3 Negative information effects

The potential existence of SWD maggots in berries represents certainly negative information to consumers and may influence their product perception at the time of purchase. Numerous theoretical and experimental approaches have investigated the effect of negative information on an individual's perception and choice decisions. Studies find that negative information attempting to influence beliefs, attitudes, preferences, or actions are likely to lead to alternative sets of ideas or behaviors (Janis and Feshbach 1953, Powell 1965, Capon and Hulbert 1973). Kanouse and Hanson (1971) use attribution theory to explain negative biases in people's evaluation and choice behavior. The study suggests that people tend to weight negative information more heavily than positive information when individuals form overall judgments about objects. A similar conclusion can be found in the work of Anderson (1974). The reason behind is that there are more positive cues in the individual's social environment, which leads to individual's paying more attention to negative cues and thus the negative cues become more attributable to the object and have strong impacts on personal evaluation. Some studies have found that negative information is more likely to have an enduring effect than positive information does (Cusumano and Richey 1979; Gray-Little 1973, Fiske 1980). Carlson (1980) finds that negative attributes and behaviors are often presumed to be more novel and distinctive so people can recall negative information more accurately and confidently when they are exposed to both positive and negative information about traits and events.

The prior research establishes a solid foundation and theoretical insights for later studies to test negative product information impacts on consumer's decision-making. Weinberger, Dillon, and Allen (1980) demonstrate a sharp drop in the market share of an automobile brand following the release of negative product news (i.e., swerving out of control). Using a computer-based experiment, Grankvist, Fahlstrand, and Biel (2004) investigate how negative labels with the information "worse for environment" and positive labels with "better for environment" affected consumer preference for several frequently consumed products. They find that the strength of information effects is associated with consumer characteristics. Consumers with a moderate interest in environmental protection were more affected by the negative information than by the positive information. Consumers with higher interest in environmental protection were equally affected by both positive and negative information. Another study concerning the effects of word-of-mouth information (i.e., the passing of information from person to person by oral communication) demonstrates that negative online customer reviews had a larger impact on consumer attitudes than positive information did (Lee, Park, and Han 2008).

Generally, the influence of unfavorable information on consumer preferences focusing on fresh produce have been examined on a very limited basis. Therefore, using the case of SWD, this research enriches the literature and sheds lights on the economics of consumer demand by quantitatively analyzing the impact of negative information induced by SWD relative to the use of pesticides to control for SWD. This study focuses on the trade-offs between pesticide use and SWD product damages (two negative information messages) on consumer choices. Therefore, this work differs from previous literature which mostly only examine one form of negative information. This study also demonstrates how consumers may maximize their utility by weighting these two forms of negative information. It provides insights on the extent of how one form of negative information can affect the other; how the two negative information messages jointly affect the end purchase made by consumers; and which form of negative information is dominant.

3 Methodology

3.1 Experimental design

A discrete choice experiment was designed to elicit the information effect of SWD on consumers preference and WTB of blueberries. The experiment was delivered by Qualtrics nationwide in the form of online surveys[1]. Qualtrics is an online software for collecting and analyzing data. Participants were randomly assigned to one of these two treatments in the experiment. In the first treatment, subjects do not receive any information about the SWD, while in the other treatment participants received a short introduction of SWD explaining that high level of pesticide use can efficiently control SWD in the very beginning (Figure 2). The rest of the survey content is identical.

Figure 2: SWD information in the survey

Background information of blueberry production in the U.S.

Blueberries in the U.S. have been heavily infested by an invasive pest, **Spotted Wing Drosophila (SWD)**, in recent years. SWD is a devastating pest of blueberries because female SWD are able to lay eggs in undamaged fruits. Larvae feed inside ripe or ripening blueberries, causing softness and opening the skin with holes.

To control the damage of SWD, growers commonly use chemical control method, such as spraying chemical insecticide. In general, **higher insecticide application yields a lower probability of infestation.**

Source: Authors' discrete choice experiment

[1] Website: https://cornell.ca1.qualtrics.com/ControlPanel/

For both treatments, regardless of receiving SWD information or not, participants then are asked to state their choice between two alternative blueberries given a generic picture of blueberry. A non-choice option is also provided in order to more closely resemble a real-world context (i.e., no purchase). In this survey, we select three attributes which are considered crucial for consumers when purchasing blueberries: price, the origin of the product, and the level of chemical insecticide application during production. The price levels are set based on existing market prices, and the origin of the product is categorized into "imported", "U.S", and "local". Additionally, three levels of chemical insecticide application have been set, which are low, medium, and high (Table 1).

Table 1: Attributes and Levels Used in the Choice Experiment

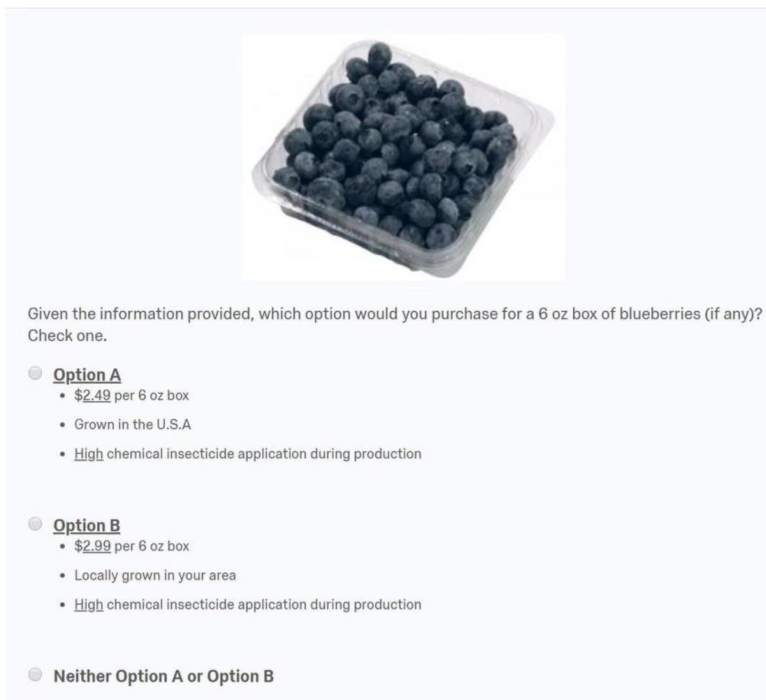
Attribute	Levels
price/6oz	\$2.49
	\$2.99
	\$3.49
	\$3.99
	\$4.49
Origin	Imported
	US
	Local
Chemical pesticide application	Low
	Medium
	High

This experiment is a 5x3x3 design, and we use JMP, a statistical software, to construct the choice profiles included in the experimental. We adopt the computer-generated locally D-optimality[2] designed by JMP for the combination of the level of attributes to create alternatives. A total of 12 choice sets are generated for this discrete choice experiment. Each choice set contains

[2] Local D-optimal design refers to containing the best subset of all possible experiment. It considers the prior of the mean which foresees the direction of the utility of each attribute after literature review and expert consultation but does not include any information from a prior covariance matrix (Huber & Zwerina, 1996)

two choice alternatives plus the neither option, and each respondent was asked to choose among the two choice alternatives and the neither option. A sample choice set is shown in Figure 3. Throughout the survey, each respondent was asked to evaluate a total of four choice sets. Each choice of blueberry is presented on a separate page, and participants cannot change their previous selection once they move to the next page. After finishing the choice questions, participants proceed to the demographic section of the survey where they provided their socio-demographic information, their purchasing behavior, and their attitudes towards food safety and pesticide residue.

Figure 3: Example questions in the survey



Source: Authors' discrete choice experiment

Hypothetical bias might exist in this discrete choice analysis. This bias is linked to an individual's behavior inconsistency which arises when individuals do not have to back up their choice with real commitment. For research of stated preference valuation, the respondent might report a higher willingness to buy or make choices that they normally would not make in real life (Carlsson, Frykblom and Johan Lagerkvist 2005; Loomis 2011; de-Magistris, Gracia and Nayga 2013). Considering that the focus of this study is the difference between treatments instead of the actual WTB of consumers, we assume that the results and conclusion in this paper will not be affected by the hypothetical bias.

3.2 Data

A total of 1,306 valid responses were collected. Table 2 lists the number of respondents by treatment and summarizes the socio-demographic characteristics and the behavioral variables of the sample. Due to the random nature of the survey, the total counts of respondents in each treatment is slightly different. There are 660 participants in the treatment without SWD information and 646 participants in the treatment with SWD information. The summary statistics for demographics and behavioral variables are also listed in Table 2. Table 2 suggests that the socio-demographic characteristics and the behavioral variables are generally consistent between the two treatment groups. For each treatment, the median age of the sample is around 50 years old, as the survey is restricted to participants aged 21 and higher. Around 74% of the participants are female and 90% of the participants are the primary food shopper. With respect to the behavioral variables, the summary statistics show that for each treatment, around 30% of the grocery bought by consumers are organic on average. In general, participants are concerned about food safety and pesticide residues in their fresh produce purchase with the scale of concern of nearly 6 out of 7. A related paper by Yeh, Gomez, and Kaiser (2018) used the same sample as this paper and compared the socio-demographic characteristics of the sample with the 2010 U.S. Census for face validity. Their results show the sample is reasonably representative of the U.S. adult population.

Table 2: Summary statistics for demographic and behavioral variables

	Without SWD information	**With SWD information**
Number of total respondents	660	646
Median Age	51	52
Split between age groups:	Percentage to the total respondent	Percentage to the total respondent
Less than 25 years old	4.24%	4.02%
25-34	16.36%	17.18%
35-44	18.33%	17.96%
45-64	39.39%	39.47%
More than 65 years old	21.67%	21.36%
Education		
Up to high school	23.79%	23.53%
College or associate degrees	39.70%	34.83%
University and above	36.52%	41.64%
Household size		
1-2 Person	59.39%	63.93%
2-4 Persons	31.21%	27.09%
5 or more	3.94%	2.79%
Number of children		
Under 3	93.33%	93.96%
3-5	2.73%	1.08%
6 or more	0.30%	0.15%
	Percentage to the total respondent	Percentage to the total respondent
Female	74.74%	74.30%
Organic food purchase	29.19%	26.97%
Primary food shopper	90.00%	90.09%
Vegetarian or Vegan	4.70%	4.80%
	Average across all respondents	Average across all respondents
Political ideology (extremely conservative=7)	4.28 (1.582)	4.23 (1.614)
Concern about food safety (1 to 7)	5.94 (1.184)	5.93 (1.166)
Concern about pesticide residue in fresh produce (1 to 7)	5.74 (1.365)	5.66 (1.326)

Standard deviation in parentheses

3.3 Econometric model

3.3.1 Information effects analysis

In the survey, participants make decisions among three options: Option A, Option B, and the Neither Option for each choice set. Each option differs in the attribute levels. In the econometric model, the subscript *i* refers to the *i*th participant, and *j* denotes one of the three options. The purchase decision for blueberries is thereby denoted as $y_{i,j}$:

(1) $$y_{i,j} = \begin{cases} 1 & \text{if participants i chooses option j} \\ 0 & \text{otherwise} \end{cases}$$

A respondent is assumed to choose the option j among all alternatives if the utility derived from that alternative is greater than the utility from any other alternative *j* in the choice set, or the neither option. In this analysis, the neither option serves as the base alternative. We employed a random-effects logit model (Stiratelli, Laird, and Ware 1984) to estimate the information effects of SWD on participant's choices. The logit function of $y_{i,j}$ is specified in equation (2), which refers to the natural log of the odds that $y_{i,j}$ equals to one. The term ε_{ij} is unobservable and assumed to be identically and independently distributed extreme-value, and u_i is a mean-zero error term specific to the individual level and assumed to be identically and independently distributed. Therefore, given the vector of covariates X_{ij}, equation (3) refers to the WTB and represents the predicted probability of purchase under the random-effect logit model using the maximum likelihood. The explanatory variables are presented in Table 3.

(2) $$\log\left(\frac{\Pr\left(y_{i,j} = 1 \middle| X_{ij}\right)}{1-\Pr\left(y_{i,j} = 1 \middle| X_{ij}\right)}\right) = X_{ij}{}'\delta_j + \varepsilon_{ij} + u_i$$
$$= \beta_1 * price + \beta_2 * chemL + \beta_3 * chemM + \beta_4 * chemH$$
$$+ \beta_5 * local + \beta_6 * notlocal + \beta_7 * info + \beta_8 * info\_chemL$$

$$+\beta_9 * info\_chemM + \beta_{10} * info\_chemH + \sum_k \gamma_k * Demo_{ik} + \varepsilon_{ij} + u_i$$

(3) $$\Pr(\widehat{y_{i,j}}|X_{ij}) = \frac{\exp(X_{ij}'\delta_j)}{1+\exp(X_{ij}'\delta_j)}$$

Table 3: Notation of independent variables in information effect analysis

Variables	$\boldsymbol{X_{ij}}$
Price of blueberry	*price*
Chemical levels (dummy):	
Low	*chemL*
Medium	*chemM*
High	*chemH*
Local	*local*
Not local	*notlocal*
Information of SWD	*info*
Interaction of *info* and chemical levels:	
Low	*info_chemL*
Medium	*info_chemM*
High	*info_chemH*
Gender (1= female)	*gender*
Age	*age*
Education	*edu*
Household size	*familysize*
Number of children	*childnum*
Primary shopper or not	*mainshopper*
Vegan or not	*Vegan*
Concern over pesticide residue	*pesconcern*
Percentage of organic food purchase	*pcent_organic*
Political ideology	*conserv_scale*
Concern about food safety	*foodsafe_scale*

Price is coded as continuous variable. In the experimental design, we found perfect collinearity between the origin and pesticide use level variables given the inclusion of the Neither option in the choice set. To address this issue, we collapse the levels of "U.S." and "imported" into one level donated as *notlocal* and the level of "local" as the other level donated as *local* (Table 3). The level of chemical pesticide applications and product origins are coded as dummy variables.

3.3.2 Tradeoff analysis

Another issue of interest is to measure the trade-offs between two product attributes based on consumers' choice. In particular, we are interested in investigating the price discount that a consumer would need to switch from buying low-pesticide-treated blueberries to high-pesticide-treated blueberries. For this purpose, two random-effect logit models are calculated separately for the two treatments, with and without SWD information. Since we only care about this tradeoff for participants who purchase blueberries, i.e. whose purchase decision is either Option A or Option B, the sample of participants who didn't make purchase decision, i.e. whose purchase decision is the Neither Option, is excluded from this analysis.

The econometric model and notations used here follows the previous section. The $y_{i,j}$ donates consumers purchase decision and is coded as a dummy variable. The explanatory variables are focused on the attributes of blueberry, therefore, given the covariate X_{ij}, the random logistic regression to be estimated for each attribute *j* is as follows:

(4) $$\log\left(\frac{\Pr(y_{i,j}=1|X_{ij})}{1-\Pr(y_{i,j}=1|X_{ij})}\right) = X_{ij}{}'\delta_j + \varepsilon_{ij} + u_i$$
$$= \beta_0 + \beta_1 * price2.99 + \beta_2 * price3.49 + \beta_3 * price3.99 + \beta_4 * price4.99 + \beta_5 * local + \beta_6 * chemM + \beta_7 * chemH + \varepsilon_{ij} + u_i$$

In this model, the price is coded as a dummy variable to calculate the tradeoff values. The first level under each attribute variable is set as the base for comparison (the 'Neither' option is omitted for this estimation). The coefficient of each attribute level variable indicates the marginal utility gained from that level relative to the baseline. Assuming linearity between price and the marginal utility (Green, P.& Srinivasan V. 1979), equation (5) gives an example of how the price discount is generated when the attribute of chemical pesticide uses shift from the level of medium to the level of the high when the associated utility change falls between two adjacent price levels.

(5) $$price\ discount = \frac{\beta_{chemM} - \beta_{chemH}}{\beta_{price_j} - \beta_{price_i}} * (price_j - price_i)$$

4 Results

The regression results from the proposed econometric model of information effects analysis are presented in Table 4, along with the estimated marginal effects. Model 1 includes only the key variables of interest, while Model 2 adds the socio-demographic and behavioral variables. The outcome variables in both models represent consumers' purchasing probabilities (WTB), and the marginal effects give changes in purchasing probabilities associated with one-unit change in an explanatory variable, holding all other explanatory variables at the sample mean levels. For categorical variables such as product origin and chemical pesticide levels, marginal effects calculate the discrete changes in consumer's WTB as the factor level changes from the base level, holding other variables at their means. Table 4 suggests that the estimates of the key variables of interest are consistent across the two models.

However, the interaction terms do not have marginal effects as the value of interaction term cannot change independently of the values of the component terms. We cannot estimate the separate marginal effects for the interaction terms of info*_chemL info_chemM, info_chemH* in

Table 4. Due to the interaction terms, the marginal effects of *chemL*, *chemM*, *and chemH* depend on *info.* The marginal effects of *chemL*, *chemM*, *and chemH* in Table 4 is generated by keeping *info* at its sample mean, similarly, the marginal effect of *info* neither considers the value of *chemL*, *chemM*, *and chemH.*

Table 4: Regression output results

Variable	Model 1	Marginal effects (1)	Model 2	Marginal effects (2)
price	-0.593***	-0.125	-0.593***	-0.125
	(0.044)	(0.009)	(0.044)	(0.009)
ori_local	0.563***	0.119	0.561***	0.118
	(0.065)	(0.014)	(0.169)	0.036
ori_not local	0.041	0.009	0.038	0.008
	(0.039)	(0.008)	(0.161)	(0.034)
chemL	2.055***	0.450	2.055***	0.450
	(0.178)	(0.033)	(0.178)	(0.033)
chemM	0.462***	0.116	0.462***	0.116
	(0.164)	(0.030)	(0.164)	(0.030)
chemH	-0.345**	-0.036	-0.345**	-0.036
	(0.149)	(0.024)	(0.149)	(0.024)
info	-0.049	0.009	-0.049	0.009
	(0.055)	0.008	(0.056)	0.008
info_chemL	-0.183*	-	-0.183*	-
	(0.097)		(0.097)	
info_chemM	0.234**	-	0.234**	-
	(0.101)		(0.101)	
info_chemH	0.250**	-	0.250**	-
	(0.103)		(0.103)	
pesconcern			0.001	0.000
			(0.019)	(0.004)
gender			0.000	0.000
			(0.044)	(0.009)
age			0.000	0.000
			(0.001)	(0.000)
edu			0.000	0.000
			(0.013)	(0.003)
familysize			0.000	0.000
			(0.019)	(0.004)

childnum		0.000	0.000
		(0.022)	(0.005)
mainshopper		-0.001	0.000
		(0.063)	(0.013)
Vegan		-0.001	0.000
		(0.089)	(0.000)
pcent_organic		0.000	0.000
		(0.001)	(0.000)
conserv_scale		0.000	0.000
		(0.012)	(0.002)
foodsafe_scale		0.000	0.000
		(0.021)	(0.005)
Constant			
Observations	15672	15672	15672
Number of ID	1306	1306	1306

t statistics in parentheses
*p<0.05,**p<0.01,***p<0.001

The following result interpretation is based on the estimated marginal effects from Model 2. First, the marginal effect of price is in the negative sign, which means that higher price reduces the probability of purchase. Numerically, keeping other variables fixed at their mean values, one dollar in price leads to 12.5 percent decrease in consumers' purchase probability. Results also show that the locally grown attribute leads to an average 11.8 percent increase in consumer's willingness to buy from the baseline of not purchasing (i.e., the no-choice option). Across three chemical pesticide use levels, low, medium, and high, the results demonstrate strong evidence that lower chemical pesticide application leads to higher purchase probability. Holding the other variables at the sample mean values, when blueberries are treated with the low level of pesticide use, consumer's WTB is increased by 45.0 percent compared to the no-choice alternative; when blueberries are treated with the medium level of pesticide use, consumer's WTB is increased by 11.6 percent compared with the no-choice alternative; however, the high level of pesticide use reduced consumer's WTB by 3.6 percent relative to the no-choice alternative. The above marginal effects of the variables of *chemL*, *chemM*, and *chemH* are generated regardless the value of *info*—the variable of knowing SWD information. Given that we are interested in understanding the change in consumer's WTB when *info* changes from 0 to 1, Table 5 listed consumer's WTB in choosing low, medium, and high chemical pesticide application when *info* is equal to 0 and 1, which will be discussed later in this section.

One of the main objectives of this study is to understand the how SWD information affects consumer preferences, and whether there exist tradeoffs on consumer demand between two negative information—the SWD information and the level of chemical pesticide use. Both models suggest that SWD information does not significantly affect WTB. In other words, the overall consumer demand on blueberries is not affected by the exposure to SWD information. However, results indicate a significant interaction effects between SWD information and the level of chemical pesticide use on consumer demand. The positive sign of the coefficients of *info_chemM* and *info_chemH* indicates that for consumers who knows about SWD, their WTB in choosing medium and high chemical pesticide treated blueberries is higher than those who does not know SWD, while the negative sign of the coefficients of *info_chemL* means consumer's WTB in choosing low chemical pesticide treated blueberries will decrease when told with SWD information. To examine how SWD information affects consumers preference selection in depth, Table 5 calculates the estimated WTB under each chemical pesticide level when there is and isn't SWD information.

Table 5 indicates the different consumer WTB when the level of chemical pesticide use varies. For both with and without SWD information, the low level of chemical pesticide application has the highest WTB level, followed by medium level, opt-out, and high level.

Therefore, SWD information does not reverse the negative role of chemical pesticide application on consumers purchase decision as low chemical pesticide treated blueberries remain the most preferred no matter consumers know the information or not.

The similar WTB of choosing neither option between the two treatments implies that consumers are not changing overall WTB. Instead, they are making trade-offs between pesticide use and SWD product damages. This is indicated by the slight shift in their choice-behavior from choosing low level of chemical pesticide use to the high level when consumers are told about SWD. Consumer utility of choosing low level of chemical pesticide application reduces from 0.666 to 0.621 in WTB while the utility for the medium level of chemical pesticide application rises from 0.350 to 0.385 and increases from 0.215 to 0.245 for the high. The direction of changes in WTB in Table 5 is consistent with the previous discussion about the negative sign of coefficient of the interaction term *info_chemL*, and positive sign of the interaction term *info_chemM* and *info_chemH*.

Table 5: Average predicted WTB under the given chemical pesticide level

	Opt-out	***chemL***	***chemM***	***chemH***
***info*=0 (without SWD information)**	0.268***	0.666***	0.350***	0.215***
***info*=1 (with SWD information)**	0.260***	0.621***	0.385***	0.245***

*** p<0.01, ** p<0.05, * p<0.1

5 Discussion

We conduct t-tests to compare the coefficients of the chemical pesticide application at different levels and their corresponding interaction terms with the treatment variable *info* (see Appendix Table #3 and Table #4). The results show that the coefficients of *chem_L*, *chem_M*, and *chem_H* are significantly different at the 1% level, indicating a strong negative relationship between pesticide application levels and consumer demand. However, the t-test fails to reject the null hypothesis that the coefficients of *info_chemM* and *info_chemH* are equal. Instead, the t-test result indicates that the coefficient of *info_chemL* is statistically different and negative in comparison to *info_chemM* and *info_chemH*. In sum, these statistic results suggest that SWD information exerts a similar influence on consumer choice between the medium and high level, but a different influence on the low level.

In this study, we focus on using the results of the proposed random logit model to generate price discounts. The full results from the proposed model, which includes variables other than prices and pesticide application levels, are posted in Appendix Table #2. Given that higher levels of pesticide is regarded as a negative attribute to consumers, Table 6 calculates the price discount needed to drive consumers to switch from the product with lower level of pesticide application to a product with relatively higher level of pesticide application. Without SWD information, consumers would require a discount of $1.80 to switch from blueberries sprayed with the low level of chemical pesticide to the medium level, $0.52 to change from medium to high, and $2.44 from medium to high. The results also suggest that consumers that receive the SWD information, require smaller price discounts: $1.52 from the low to medium, $0.44 from the medium to high, and $2.42 from the low to high. This implies that pesticide use becomes more acceptable for consumers after they know about the challenges faced by the produce industry to control for SWD.

Table 6: Price discount for changing the chemical pesticide from one level to another

	Low to medium	Medium to high	Low to high
***info*=0 (without SWD information)**	$1.80	$0.52	$2.44
***info*=1 (with SWD information)**	$1.52	$0.45	$2.42

6 Conclusion

In this study, we thoroughly analyzed the information effects of SWD on consumers' blueberry purchasing decisions using an experimental approach. Our results suggest that consumer demand for blueberries decreases. This result is consistent with findings in previous studies that high pesticide application is often associated with lower consumer demand for fresh produce. In addition, this study quantitatively examined the impacts of SWD information on consumer demand on crops that are susceptible. We found that SWD information by itself does not have significant impacts on the overall consumers' purchasing probability for blueberries. Nevertheless, the results suggest a significant shift in consumer behavior from preferring lower level of pesticide application to a higher level of pesticide application when consumers are informed about the product quality problems associated to SWD. Overall, SWD information does not alter the negative impacts of chemical use information on consumer purchase decisions. However, the high levels of applications to control for SWD may lead to price discounts and reduced demand; so alternative SWD management strategies should be identified to encourage a more rational use of insecticides. Based on how consumers value the attribute of chemical pesticide use on blueberries, this paper estimates the price discounts to be offered to consumers so they would be willing to switch from a lower level to a higher level of pesticide application. The above findings provide valuable insights for blueberry industry stakeholders and can be applied to other fruit crops that are also facing challenges controlling for SWD.

In addition, our study enriches the literature of negative information effects on the economics of consumer demand. Our findings reflect consumer purchasing behavior after weighing between two negative information messages in their decision-making process. We find that the overall WTB does not decline when consumers are presented with SWD information.

Instead, consumers make tradeoffs between the two negative attributes that are given. The shifts in consumers WTB show that information about SWD problems makes consumers less reluctant to purchase blueberries treated with higher levels of pesticids. It may be possible that SWD negative information offsets a consumer's reluctance to accept pesticide use. Without SWD information, a consumer does not know that growers are facing challenges to control pests and diseases, so consumers do not want pesticides. However, with SWD information, which reveals the truth about disease control management faced by the produce industry, consumers are likely to accept that growers use pesticides.

Due to the lack of studies on the effect of negative consumer information, more work should be done to continue exploring the effects of negative information on targeted product attributes. It is also useful to know what types of consumers are most influenced by negative information messages. Besides, how unfavorable information affects one's enjoyment of the product as a whole should be elaborated in further studies to provide additional evidence concerning the extent of the impacts of negative information. In this study, given the SWD information, consumers are only asked to make choices between different g product attributes. Future studies could examine if there are changes in consumer's evaluation about blueberries such as the taste of blueberries before and after they know the information of SWD or if the information will lead to unfavorable attitudes toward blueberries, thus affecting consumers' enjoyment of blueberries.

7 References

Acheampong, S. "Spotted wing drosophila (Drosophila suzukii), a new vinegar fly pest in British Columbia." British Columbia Ministry of Agriculture. 2010.

Anderson, Norman H. "Averaging versus Adding as a Stimulus-combination Rule in Impression Formation." *Journal of Experimental Psychology* 70, no. 4 (1965): 394-400.

Bolda MP, Goodhue RE, Zalom FG. "Spotted wing drosophila: Potential economic impact of a newly established pest." *Agriculture and Resource Economics Update*. 2010. (No longer available online)

Capon, Noel, and James Hulbert. "The Sleeper Effect: An Awakening." Public Opinion Quarterly 37, no. 3 (1973): 333.

Carlsson, Fredrik, Peter Frykblom, and Carl Johan Lagerkvist. "Using Cheap Talk as a Test of Validity in Choice Experiments." *Economics Letters* 89, no. 2 (2005): 147-52.

Carlson, Michael, and Norman Miller. "Explanation of the Relation between Negative Mood and Helping." *Psychological Bulletin* 102, no. 1 (1987): 91-108.

Cornell Cooperative Extension. "Berry News." *Spring Berry "To Do" List* 5 (2017): 1. Accessed May 1, 2019.

Cusumano, Donald R., and Marjorie H. Richey. "Negative Salience in Impressions of Character: Effects of Extremeness of Stimulus Information." *Psychonomic Science* 20, no. 2 (1970): 81-83.

De-Magistris, Tiziana, Azucena Gracia, and Rodolfo M. Nayga. "On the Use of Honesty Priming Tasks to Mitigate Hypothetical Bias in Choice Experiments." *American Journal of Agricultural Economics* 95, no. 5 (2013): 1136-154.

Demchak, Kathy, Kathy Demchak, Bloom, and Bloom. "Spotted Wing Drosophila Part 1: Overview and Identification." Penn State Extension. 2016. Accessed February 20, 2019.

Fiske, Susan T. "Attention and Weight in Person Perception: The Impact of Negative and Extreme Behavior." *Journal of Personality and Social Psychology* 38, no. 6 (1980): 889-906.

Food Marketing Institute. "Trends: Consumer Attitudes and the Supermarket, " Washington, DC, 1989.

Grankvist, Gunne, Ulf Dahlstrand, and Anders Biel. "The Impact of Environmental Labelling on Consumer Preference: Negative vs. Positive Labels." *Journal of Consumer Policy* 27, no. 2 (2004): 213-30.

Gray-Little, Bernadette. "The Salience of Negative Information in Impression Formation Among Two Danish Samples." *Journal of Cross-Cultural Psychology* 4, no. 2 (1973): 193-206.

Green, Paul E., and V. Srinivasan. "Conjoint Analysis in Consumer Research: Issues and Outlook." *Journal of Consumer Research* 5, no. 2 (1978): 103.

Grubinger, Vern. "Garden Pathways Vermont's Local Banquet." Vermont's Local Banquet. August 08, 2013. Accessed May 03, 2019.

Huber, Joel, and Klaus Zwerina. "The Importance of Utility Balance in Efficient Choice Designs." *Journal of Marketing Research* 33, no. 3 (1996): 307.

Janis, I. and Feshbach, S. (1953) "Effects of fear arousal", *Journal of Abnormal and Social Psychology* 48 no.1 (1953): 78–92

Kramer, Carol S., and Karen P. Penner. "Consumer Response to Food Risk Information: Demographic Differences." *New Risks: Issues and Management*, 1990, 667-78.

Lee, Jumin, Do-Hyung Park, and Ingoo Han. "The Effect of Negative Online Consumer Reviews on Product Attitude: An Information Processing View." *Electronic Commerce Research and Applications* 7, no. 3 (2008): 341-52.

Loomis, John. "Whats To Know About Hypothetical Bias in Stated Preference Valuation Studies*?" Journal of Economic Surveys* 25, no. 2 (2011): 363-70.

Ott, Stephen L. and A. Maligaya, "An Analysis of Consumer Attitudes Toward Pesticide Use and the Potential Market for Pesticide Residue-Free Fresh Produce," paper presented at the Southern Agricultural Economics Association Meetings, Nashville, TN, 1989.

Ott, Stephen L. "Supermarket Shoppers Pesticide Concerns and Willingness to Purchase Certified Pesticide Residue-free Fresh Produce." *Agribusiness*, 6, no. 6 (1990): 593-602. Parent, Emily, Thomas Whitney, and Jana Lee. "Recognizing Fruit Damaged by Spotted Wing Drosophila." USDA Horticultural Crops Research Unit. Accessed February 20, 2019.

Poll, Gallup. Gallup Poll Report #286, 1989, Princeton: Gallup Poll Publishing.

Packer, "The Fresh Trends Survey 1988: A Profile of Fresh Produce Consumers." Overland Park, KS: Vance Publishing Co., 1988.

Powell, Fredric A. "The Effect of Anxiety-arousing Messages When Related to Personal, Familial, and Impersonal Referents." *Speech Monographs* 32, no. 2 (1965): 102-06.

Sachs, C., D. Blair, and C. Richter, "Consumer Pesticide Concerns: A 1965 and 1984 Comparison," *The Journal of Consumer Affairs*, v 21. 1987

Spears, Lori R., Cami Cannon, Diane G. Alston, Cory Stanley-Stahr, Ricardo A. Ramirez, and Ryan S. Davis. "Utah Pests Fact Sheet." *Spotted Wing Drosophila*, September 2017, 6. Accessed May 1, 2019.

Stiratelli, Robert, Nan Laird, and James H. Ware. "Random-Effects Models for Serial Observations with Binary Response." *Biometrics* 40, no. 4 (1984): 961.

Walsh, Douglas B., Mark P. Bolda, Rachael E. Goodhue, Amy J. Dreves, Jana Lee, Denny J. Bruck, Vaughn M. Walton, Sally D. Oneal, and Frank G. Zalom. "Drosophila Suzukii (Diptera: Drosophilidae): Invasive Pest of Ripening Soft Fruit Expanding Its Geographic Range and Damage Potential." *Journal of Integrated Pest Management* 2, no. 1 (2011).

Weaver, Robert D., David J. Evans, and A. E. Luloff. "Pesticide Use in Tomato Production: Consumer Concerns and Willingness-to-pay." *Agribusiness* 8, no. 2 (1992): 131-42.

Weinberger, Marc G., Chris T. Allen, and William R. Dillon. "The Impact of Negative Marketing Communications: The Consumers Union/Chrysler Controversy." *Journal of Advertising* 10, no. 4 (1981): 20-47.

Yeh, D. Adeline, Miguel I. Gómez, and Harry M. Kaiser. *Signaling Impacts of GMO Labeling on Fruit and Vegetable Demand*. Working paper. Dyson School of Applied Economics and Management, Cornell University.

Zellner, J.A. and R.L. Degner, "Consumer Willingness to Pay for Food Safety," paper presented at the Southern Agricultural Economics Association Meetings, Nashville, TN, 1989.Kanouse, David E., and L. Reid. Hanson. *Negativity in Evaluations*. Morristown, NJ: General Learning Press, 1972.

Appendix. Additional Tables

Table #1: Notation of independent variables in consumer tradeoff analysis

Variables	$\boldsymbol{X_{ij}}$
Price levels (dummy):	
$2.49	*Price2.49*
$2.99	*Price2.99*
$3.49	*Price3.49*
$3.99	*Price3.99*
$4.49	*Price4.49*
Product origin levels (dummy)	
Not local	*nolocal*
Local	*local*
Chemical levels (dummy):	
Low	*chemL*
Medium	*chemM*
High	*chemH*

Table #2: Regression output of consumers tradeoff analysis

Variable	Without SWD	With SWD
price_2.99	-0.125	-0.149
	(0.120)	(0.115)
price_3.49	-0.857***	-0.958***
	(0.139)	(0.135)
price_3.99	-1.179***	-1.206***
	(0.149)	(0.145)
price_4.49	-1.976***	-1.806***
	(0.207)	(0.200)
local	0.426***	0.495***
	(0.096)	(0.093)
che_m	-2.158***	-1.683***
	(0.117)	(0.112)
che_h	-2.924***	-2.403***
	(0.129)	(0.122)
Constant	0.929***	0.640***
	(0.148)	(0.144)
Observations	5055	4960
Number of ID	660	646

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table #3: T-test results among coefficient of *chemL*, *chemM*, and *chemH*

H null hypothesis	***chemL=chemM***	***chemL=chemH***	***chemM=chemL***
T-significance	***	***	***

*** p<0.01, ** p<0.05, * p<0.1

Note: H null hypothesis refers to the coefficients of the two variables are equal.

Table #4: T-test results among coefficient of *info_chemL*, *info_chemM*, and *info_chemH*

H null hypothesis	***info_chemL=info_chemM***	***info_chemL=info_chemH***	***info_chemM=info_chemH***
T-significance	***	***	

*** p<0.01, ** p<0.05, * p<0.1

Note: H null hypothesis refers to the coefficients of the two variables is equal to each other.

Appendix. Supplementary Material

Below is the sample survey that reveals SWD information to participants

Background information of blueberry production in the U.S.

Blueberries in the U.S. have been heavily infested by an invasive pest, **Spotted Wing Drosophila (SWD)**, in recent years. SWD is a devastating pest of blueberries because female SWD are able to lay eggs in undamaged fruits. Larvae feed inside ripe or ripening blueberries, causing softness and opening the skin with holes.

To control the damage of SWD, growers commonly use chemical control method, such as spraying chemical insecticide. In general, **higher insecticide application yields a lower probability of infestation.**

Given the information provided, which option would you purchase for a 6 oz box of blueberries (if any)? Check one.

- Option A
  - $2.49 per 6 oz box
  - Grown in the U.S.A
  - High chemical insecticide application during production

- Option B
  - $2.99 per 6 oz box
  - Locally grown in your area
  - High chemical insecticide application during production

- **Neither Option A or Option B**

Given the information provided, which option would you purchase for a 6 oz box of blueberries (if any)? Check one.

Option A
- $2.49 per 6 oz box
- Locally grown in your area
- High chemical insecticide application during production

Option B
- $3.49 per 6 oz box
- Grown in the U.S.A.
- High chemical insecticide application during production

Neither Option A or Option B

Given the information provided, which option would you purchase for a 6 oz box of blueberries (if any)? Check one.

Option A
- $4.49 per 6 oz box
- Grown in the U.S.A.
- Low chemical insecticide application during production

Option B
- $3.99 per 6 oz box
- Imported
- Medium chemical insecticide application during production

Neither Option A or Option B

Given the information provided, which option would you purchase for a 6 oz box of blueberries (if any)? Check one.

- **Option A**
  - $3.99 per 6 oz box
  - Locally grown in your area
  - Low chemical insecticide application during production

- **Option B**
  - $2.99 per 6 oz box
  - Grown in the U.S.A.
  - Medium chemical insecticide application during production

- **Neither Option A or Option B**

What is your gender?

- Male
- Female

What is your year of birth?

What is the highest level of school you have completed or the highest degree you have received?

- Less than high school degree
- High school graduate (high school diploma or equivalent including GED)
- Some college but no degree
- Associate degree in college (2-year)
- Bachelor's degree in college (4-year)
- Master's degree
- Doctoral degree
- Professional degree (JD, MD)

What is your ZIP code?

How many people are living or staying in your household? This includes yourself and any person(s) who have lived with you for at least two months and with whom you share living expenses.

- Do NOT include anyone who is living somewhere else for more than 2 months, such as a college student living away or someone in the Armed Forces on deployment.

○ 1
○ 2
○ 3
○ 4
○ 5
○ 6
○ More than 6

Do you have any children (under 18 years old) currently living with you?

○ No
○ Yes, the number of children currently living with me is: ______

Are you the primary food shopper of your household?

○ Yes
○ No

Are you vegetarian or vegan?

○ Yes
○ No

What percentage of food that you typically buy is Organic?

Percentage

0 10 20 30 40 50 60 70 80 90 100

From extremely liberal (scale = 1) to extremely conservative (scale = 7), where would you place yourself on this scale?

Extremely liberal | Extremely conservative

1 2 3 4 5 6 7

From not concerned at all (scale = 1) to extremely concerned (scale = 7), how concerned are you about **animal welfare**?

Not concerned at all | Extremely concerned

1 2 3 4 5 6 7

From not concerned at all (scale = 1) to extremely concerned (scale = 7), how concerned are you about **food safety**?

Not concerned at all | Extremely concerned

1 2 3 4 5 6 7

From not concerned at all (scale = 1) to extremely concerned (scale = 7), how concerned are you about **food safety**?

Not concerned at all Extremely concerned

1 2 3 4 5 6 7

From not concerned at all (scale = 1) to extremely concerned (scale = 7), how concerned are you about **pesticide residues in your fresh produce**?

Not concern at all Extremely concerned

1 2 3 4 5 6 7