SENSORY INFLUENCES ON CONSUMERS' WILLINGNESS TO PAY:

THE APPLE AND CHERRY MARKETS

By

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To the Faculty of Washington State University:

The members of the Committee appointed to examine the dissertation of YING HU find it satisfactory and recommend that it be accepted.

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Abstract

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This dissertation consists of four studies that incorporate sensory characteristics in the context of examining consumers' willingness to pay (WTP) for apples and cherries. Individual-level data, including sensory responses to apples and cherries, were collected. Effects of sensory attributes are compared across different cultivars of apples and cherries. Two methods of eliciting consumer preferences are also compared.

The first study uses individual consumer-level tasting data to estimate a predictive model of the relationship between sensory attributes and WTP for two cultivars of apples and tests whether these attributes play a different role across cultivars. Consumer survey data and apple tasting data for both Red Delicious (a traditional cultivar) and Gala (a newer cultivar) are compared. The results suggest that firmness and sweetness both positively affect consumers' WTP, but more so for Gala than Red Delicious. Older consumers are less likely to be willing to pay premiums for both cultivars. Apple-eating frequency is positively related to the WTP for Gala but not for Red Delicious.

Meanwhile, being Hispanic negatively influences the WTP for Gala apples, but it does not affect WTP for Red Delicious. The second study utilizes instrumental measurements of soluble solids and firmness levels as independent variables in the WTP model and compares the estimation results with the sensory model.

In the third study, an extended double-bounded dichotomous choice (DBDC) model, a mixed logit model, is estimated with cherry tasting data from a survey in which respondents evaluated five cultivars. Firmness and sweetness significantly influence WTP in a positive way. Age is an influential factor, as well as annual household income level under $75,000.

Lastly, two elicitation formats of contingent valuation approach, DBDC and payment card (PC), are compared over the WTP for cherries. They generate different parameter estimates, and mean WTP values of DBDC exceed those of PC. Even though declaring which format derives more realistic results is premature, the empirical results seem to somewhat favor the mixed logit DBDC.

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CHAPTER 1

INTRODUCTION

Evaluation of consumers' willingness to pay (WTP) for food products is generally accomplished by investigating the effect of extrinsic attributes (e.g. cultivar, size, grade), consumer demographics (e.g. age, gender, income), and/or consumption (frequency) without intrinsic variables. The omission of sensory attributes, such as taste, texture and flavor, is likely to lead to inaccurate estimation. This is because sensory characteristics have a major influence on consumers' expectations of quality and buying habits for food products. Apples and cherries are no exceptions in that sense. When it comes to purchasing apples, most consumers base their decisions on apples' internal attributes such as taste and flavor (Miller et al. 2005). Carew (2000) finds that consumers' preferences for apples in British Columbia have shifted from traditional varieties to newer cultivars owing to their eating quality rather than their appearance. Studies show that attributes such as taste, color, size, soluble solids, firmness, texture, and other market values are associated with the fruit quality of fresh sweet cherry, which motivates consumers' purchasing decisions (Roper, et al. 1987; Dolenc and Stampar 1998).

The general objective of this dissertation is to incorporate sensory attributes in the context of investigating consumers' WTP for apples and cherries. These sensory variables along with other factors are examined for their effects on WTP via the contingent valuation method (CVM), which facilitates estimation of WTP without actual purchases involved. There are a number of elicitation formats that fall under the CVM. When choosing from among them, one needs to take into consideration a few issues such as cost of administrating surveys, ease of taking surveys from the respondents' perspective, precision of the WTP estimates, and possible biases associated with the elicitation format in use. This study centers on a double-bounded dichotomous choice (DBDC) approach as the elicitation format, which has been endorsed in the literature due to its familiarity and ease in the decision making process (Boyle and Bishop, 1988; Brown et al. 1996; NOAA, 1993; Smith, 2000).

Different elicitation formats may induce different answering behavior and hence produce different WTP estimates (Carson et al. 2001; Welsh, 1998). And in general, estimates of WTP values from DC formats exceed those from payment card (PC) formats (Welsh, 1998). An empirical comparison between the estimates of DBDC and PC is accomplished in order to test the convergent validity of the two elicitation formats, even though the question of which available elicitation format produces the most accurate estimates is still under debate.

Dissertation Format

This dissertation is presented as four related but stand-alone studies. Chapter 2 is an empirical paper that analyzes the relationship between sensory attributes and WTP for two cultivars of apples, Gala and Red Delicious, using individual consumer-level data collected from a survey where each respondent only tasted apple pieces from a single cultivar. A number of demographic and consumption variables are also included to assess their effects on WTP. A single DBDC model for both cultivars is estimated, which increases efficiency by utilizing the entire data set and expedites the comparison of how sensory attributes and demographics affect WTP differently across cultivars. In Chapter 3, the destructive measurements of firmness and sweetness enter the same DBDC model analyzed in Chapter 2 (consumer model) and replace the two subjective variables of firmness and sweetness, so that an industry WTP model is formed. Estimates from this model are then compared with those from the sensory model.

Chapter 4 assesses the effects of sensory attributes and demographics on WTP for cherries. However, since the survey data used in the analysis was from individual respondents tasting and evaluating all five different cultivars of cherries, a modified DBDC model, a mixed logit model, is employed to capture the correlation among valuations from the same respondents and other unobserved attributes. Chapter 5 provides a theoretical review of most commonly used CVM elicitation techniques, namely the bidding game, open-ended questioning, PC method, and DC approach, and of comparisons between DC and PC. Then the empirical estimation results of the mixed logit DBDC model from Chapter 4 are compared with those of a PC model to test the convergent validity of these two approaches. Chapter 6 offers conclusions and draws generalizations that can be made across the studies.

Summary of Findings

Chapter 2 concludes that firmness and sweetness significantly affect WTP for both cultivars in a positive way but more so for Gala than for Red Delicious. The consumer's age and apple-eating frequency are significant factors for WTP for both apples, whereas the consumer's ethnic background affects WTP for Gala but not Red Delicious. Gender, formal education level, annual household income level, and whether or not the consumer buys organic food, do not affect the WTP.

The results of the industry model in Chapter 3 show that the physical measurement of firmness but not sweetness is significant as an influential factor on consumers' WTP for both apples, and that its effect is much less than the corresponding subjective variable in the consumer model.

Chapter 4 finds that as consumers become more satisfied with firmness or sweetness the probability that they will be willing to pay a higher price for cherries significantly increases. Percentage of organic purchases has a positive influence on WTP. The older the consumers, the more likely they are willing to pay more, and this is more so for consumers over 65. Annual household income level is only significant in a negative way for income level under $75,000. Consumers' gender does not appear to be a significant factor to WTP. Furthermore, variance of the random variable turns out to be highly significant, which justifies the specification of incorporating such a random coefficient in the model.

In Chapter 5, the empirical comparison between the results from the DBDC model in Chapter 4 and those from the PC model reveals that the two elicitation formats of the CVM generate different estimates, and that mean WTP values from the DBDC model exceed those from the PC model. Although it would be hasty to judge which elicitation format produces more accurate results, the empirical results indicate that the mixed logit DBDC approach might be somewhat preferred.

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CHAPTER 2

DOES VARIETY MATTER? COMPARING CONSUMERS' WILLINGNESS TO PAY FOR SENSORY CHARACTERISTICS ACROSS APPLE CULTIVARS

I. Introduction

One would expect for eating quality characteristics to be significant factors affecting consumers' demand for apples. However, in assessing consumer preferences for a food product such as apples, an established approach is to investigate which factors have a significant effect on willingness to pay (WTP) from among extrinsic attributes (such as cultivar, size, grade), consumer demographics (such as age, income, education level), and/or consumption (frequency of consuming apples). Intrinsic factors such as taste, texture and flavor are typically not included in the analysis. This is unfortunate since consumers make purchase decisions of apples based on their internal attributes such as taste and flavor (Miller et al. 2005). Brennan and Kuri (2002) find that once consumers develop a preference for a product based on sensory characteristics, it is unlikely for them to change. Thus, sensory characteristics have a major influence on consumers' expectations of quality and buying habits.

Carew (2000) makes the case that consumers' preferences for apples in British Columbia have shifted from traditional varieties to newer cultivars based on their eating quality rather than their appearance. Winfree and McCluskey (2005) argue that the apple industry in Washington should establish minimum standards for what constitutes "eating quality" in addition to the normal grading standards which are based on color, shape, and size. Based on a hedonic price analysis of the Japanese market for imported apples, Kajikawa (1998) found that internal apple characteristics had a significant effect. She used publicly available varietal sample averages for growing regions by season to represent brix, brix/acid ratio, and juice as explanatory variables in her hedonic price estimation. Although Kajikawa's analysis is related to the current article, it includes aggregate data rather than individual apple-level data or consumer-level data.

Sensory analysis is a method that can be used to quantify and understand consumer responses to food products. Foster (2004) argued that this approach helps researchers to understand and manipulate formulations in a predictable fashion helping clients to develop a successful product. Sensory attributes have been analyzed in other economic studies of food products. Grunert et al (2004) investigated the effect of sensory experience with genetically modified (GM) cheeses on attitudes and purchase intentions of participants from the Nordic countries. Maynard and Franklin (2003) included sensory analysis in a WTP study of "cancer fighting" dairy products.

Sensory variables have also been used in wine studies. In a study of the sensory attributes of Bordeaux wines, Combris, Lecoq, and Visser (1997) showed that when regressing objective characteristics and sensory characteristics on wine price, the objective cues (such as expert score and vintage) are significant, while sensory variables such as tannins content and other measurable chemicals are not. Possible explanations for the insignificance of sensory cues in wine are the difficulty of isolating the effect of each chemical on the final flavor and smell and that only a small percentage of wine purchasers are connoisseurs.

The objective for this study is to develop a predictive model that determines the relationship between sensory attributes and WTP for two cultivars of apples and test whether these attributes play a different role across cultivars. Owing to their importance as internal attributes of apples, sweetness and firmness are chosen to be the representative tasting factors. Their effects on WTP are to be examined, along with a series of consumers' demographics and consumption characteristics.

The Red Delicious variety is the most widely produced and celebrated apple in the Northwest. However, in recent years, consumers have sought newer cultivars that are more flavorful, rather than redder or shapelier, resulting in lower prices for Reds. The comparison between a traditional cultivar (Red Delicious) and a newer cultivar (Gala) is important for understanding the market for fresh apples. Key insights to be gained are whether eating quality is valued differently across cultivars and if demographics affect valuations differently across cultivars.

II. Methodology

The contingent valuation method (CVM) is frequently applied to discrete survey responses to elicit opinions or preferences on various matters. Single-bounded and double-bounded dichotomous choice are two widely-used bidding methods in CVM for assessing market products or non-market resources. The double-bounded method engages respondents in two bids.[1] A second question associated with a higher or lower value is asked based on responses from the first question. If the initial offer is accepted, a premium will be asked; whereas if the initial offer is rejected, a discount will be offered. Using two sequential bidding questions, boundaries of WTP are therefore observed.

In the double-bounded model (Hanemann, Loomis, and Kanninen 1991) used here there are four possible outcomes: (1) the respondent's willingness to pay is lower than the discount offered so she/he is not willing to buy the apple at all, i.e. "no, no"; (2) the respondent's willingness to pay is between the lower bid price and the initial bid price, i.e. "no, yes"; (3) the respondent's willingness to pay is above the initial bid but lower that the premium offered, i.e. "yes, no"; (4) the respondent's willingness to pay is above the premium offered, i.e. "yes, yes."

The initial bid (B_0) equals zero and implies no price difference between the apple the respondent just tasted and other apples. The second bid is contingent upon the response to the first bid. It will be a discount bid (B_D), if the respondent answers she/he would not buy the apples at their usual price. If the respondent answers that she/he would buy the apples at their usual price, it becomes a premium bid (B_P). The sequence of questions isolates the range in which the respondent's true WTP for eating quality in apples lies. The second bid, B_D *or* B_P, in conjunction with the response to the initial preference decision, allows an upper bound and a lower bound to be placed on the respondent's unobservable true WTP.

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[1]There is a literature on the appropriate number of iterations to include in the bidding procedures used in the CVM. Cameron and Quiggin (1994) evidenced the problem of anchoring/starting point bias with iterations of bids. There is some bias with the double-bounded model, primarily due to inconsistencies which may be present between the consumers' first and subsequent bids (Hanemann and Kanninen, 1999). The benefit in efficiency from additional bid must be weighed against this possible bias.

Let WTP_i denote an individual's WTP (bid function) for the tasted apple. The following discrete outcomes (D_g) of the bidding process are

Group

$$D_g = \begin{cases} 1 & WTP_i < B_D \\ 2 & B_D \leq WTP_i < B_0 \\ 3 & B_0 \leq WTP_i < B_P \\ 4 & B_P \leq WTP_i \end{cases} \qquad (2.1)$$

Respondents who indicated they require no discount and would pay the premium price B_P fall into the fourth group (D_4). Those who indicated they require no discount and would pay a premium of less than B_P fall into the third group (D_3). Respondents who required a discount greater than or equal to B_D fall into the second group (D_2). Finally, the first group (D_1) contains respondents indicating the lowest WTP. Consumers in this group are not willing to purchase the tasted apple at the discount offered.

The WTP function for the tasted apple for individual i is specified as

$$WTP_i = \alpha - \rho B_i + \lambda' x_i + \varepsilon_i \text{ for } i = 1, 2, \ldots, n \qquad (2.2)$$

where x represents a vector of explanatory variables such as consumers' demographics and consumption. The variable ε is an error term, which captures unmeasured characteristics and is assumed to follow a cumulative distribution F with mean 0 and variance σ^2. The final bid that a respondent reaches is represented by B_i. In order to be more effective in eliciting consumers' true WTP, different prices, higher or lower than the initial price contingent on the first response, were offered to respondents. For example, \$1.19, \$1.29 and \$1.49 were randomly assigned to consumers who responded affirmatively to the initial price, \$0.99 per pound for Gala apples.

The parameters ρ, λ' are unknown and need to be estimated, as well as the intercept α. As for ρ, it is natural to expect lower willingness to pay associated with higher bids and higher willingness to pay associated with lower bids, thus a negative relationship. The probabilities for the above WTP choice groups can be obtained as:

$$\begin{cases} \text{Prob(Y} = 1) = F(\tilde{\alpha} - \tilde{\rho}B_D + \tilde{\lambda}' x) \\ \text{Prob(Y} = 2) = F(\tilde{\alpha} - \tilde{\rho}B_I + \tilde{\lambda}' x) - F(\tilde{\alpha} - \tilde{\rho}B_D + \tilde{\lambda}' x) \\ \text{Prob(Y} = 3) = F(\tilde{\alpha} - \tilde{\rho}B_P + \tilde{\lambda}' x) - F(\tilde{\alpha} - \tilde{\rho}B_I + \tilde{\lambda}' x) \\ \text{Prob(Y} = 4) = 1 - F(\tilde{\alpha} - \tilde{\rho}B_P + \tilde{\lambda}' x) \end{cases} \tag{2.3}$$

Note that the tildes indicate that the coefficients are estimated parameters. Consequently, the log likelihood function is structured as:

$$LnL = \sum_i \begin{cases} I_{Y_i=1} \ln F(\tilde{\alpha} - \tilde{\rho}B_{D_i} + \tilde{\lambda}' x_i) \\ + I_{Y_i=2} \ln\left[F(\tilde{\alpha} - \tilde{\rho}B_{I_i} + \tilde{\lambda}' x_i) - F(\tilde{\alpha} - \tilde{\rho}B_{D_i} + \tilde{\lambda}' x_i)\right] \\ + I_{Y_i=3} \ln\left[F(\tilde{\alpha} - \tilde{\rho}B_{P_i} + \tilde{\lambda}' x_i) - F(\tilde{\alpha} - \tilde{\rho}B_{I_i} + \tilde{\lambda}' x_i)\right] \\ + I_{Y_i=4} \ln\left[1 - F(\tilde{\alpha} - \tilde{\rho}B_{P_i} + \tilde{\lambda}' x_i)\right] \end{cases} \tag{2.4}$$

where $I_{Y_i=j}$ is an indicator function for the occurrence of $Y_i = j$ (j=1, 2, 3, 4), and subscript i denotes the i^{th} individual observation. We assume the error term follows a cumulative logistic distribution.

The intercept α and the slope coefficient ρ in (2.2) can be estimated by setting $\lambda' = 0$. Then, the mean WTP is calculated as $\tilde{\alpha}/\tilde{\rho}$, which also serves as the base value for evaluating marginal effects of the explanatory variables. The marginal effect of an explanatory variable is essentially the difference between when the parameter estimate is added to the intercept (base) and when it is not:

$$\text{Marginal Effect of } \tilde{\lambda}_k = \frac{\tilde{\alpha} + \tilde{\lambda}_k}{\tilde{\rho}} - \frac{\tilde{\alpha}}{\tilde{\rho}} = \frac{\tilde{\lambda}_k}{\tilde{\rho}}. \qquad (2.5)$$

Maximum likelihood is employed as the method of estimation and an optimization program is performed in GAUSS.

III. Data

The data was collected through a consumer tasting survey using Gala and Red Delicious apples conducted at an outside public venue, the Portland (Oregon) Saturday Market in April 2004. The tastings and surveys occurred over two days, and on each day only samples of a single variety were distributed to participants. Each participant tasted slices from only one apple. Participants were instructed to taste the apple slices and respond to sensory questions regarding that apple. Participants were also asked about their purchase and consumption habits and preferences for apples and demographic questions. Contingent valuation questions were asked in conjunction with the taste tests. Overall, there were 487 responses from the Gala apple tastings and 290 responses from the Red Delicious tastings. All the responses were collected using ballots on tablet and laptop computers equipped with data collection software.

As presented in Table 2.1, the majority of the survey respondents for Gala were female (59.8%), as were the majority of the respondents for Red Delicious (58.6%). Women are over-represented in the experiment, but this is not a concern since a greater proportion of women do the household shopping. Among the seven age categories, ages 25 to 34 have the highest percentage of respondents for both Gala (21.1%) and Red Delicious (23.4%). Other age groups all have a considerable share except for ages 65 and above, which only capture 4.7% of the respondents for Gala and 2.1% of the respondents for Red Delicious. This is comparable to the general population of Portland. In terms of formal education, respondents with a 4-year college degree accounted for the highest percent of the respondents for both Gala (29.8%) and Red Delicious (23.4%). The percentage of Gala respondents with a 4-year degree is high compared to the general population of Portland with 21.3% (US Census, 2005). In the Gala survey, 21.8% reported education level as high school, 17% reported as 2-year college or technical degree, 19.90% reported as advanced degree, and 11.5% declined to answer. Among the Red Delicious respondents, 22.80% of them reported education level as high school, 22.8% of them reported as 2-year college degree, 16.2% of them reported as advanced degree, and 14.80% of them declined to answer.

Respondents were asked to place themselves in the following household income groups: less than $20,000 (with 18.5% and 15.5% of the Gala and Red respondents, respectively), $20,000 to $39,999 (with 15.6% and 22.1%, respectively), $40,000 to $59,999 (with 13.6% and 19.7%, respectively), $60,000 to $79,999 (with 12.5% and 9.7%, respectively), $80,000 to $99,999 (with 8.4% and 5.5%, respectively), and greater than $100,000 (with 14.6% and 13.1%, respectively). The income responses are comparable to the general population of Portland. The major ethnicity group was Caucasian, which accounts for 77% of the Gala survey respondents and 70% of the Red Delicious respondents. This is comparable to the general population of Portland, which is 79.5% Caucasian but this percentage includes Hispanic.

Respondents were also asked about their attitudes toward apple consumption and purchase, as well as their tasting preferences. Consumer responses are summarized in Table 2.2. Participants were first asked to rate degree of liking or hedonics on a 10 centimeter continuous scale anchored with 0 “Dislike Extremely,” 5 “Neither Like nor Dislike,” and 10 “Like Extremely.” They responded generally positively to the apple samples they tasted. The mean of overall liking is 7.0 for Gala and 6.8 for Red Delicious. Most of the respondents agreed that the firmness and sweetness of both apple samples were acceptable. For Galas, 79.7% of the respondents rated acceptable on firmness, and 83.0% of the respondents for Gala rated acceptable on sweetness. While for Red Delicious, 77.2% of the respondents rated acceptable on firmness and 86.2% of the respondents rated acceptable on sweetness. An overwhelmingly large portion of those who did not accept the firmness or sweetness of the samples stated that the apples were not firm enough or not sweet enough.

The majority of the respondents for Gala (57.7%) and Red Delicious (59.0%) were willing to pay $0.99 per pound for the apples. This is also the mode response amount that respondents report that they usually pay for apples for both Gala (18.5%) and Red Delicious (18.3%). The distribution of responses to the bids for Gala and Red Delicious are available in Tables 2.3 and 2.4, respectively.

In response to the question on apple eating frequency, a plurality of respondents indicated that they eat apples more than once a week for both Gala (39.8%) and Red Delicious (33.4%). The respondents were also asked about choice of buying organic apples. The greater part of respondents for both Gala (67.1%) and Red Delicious (66.6%) do not buy organic apples.

IV. Empirical Model

A single model for both cultivars of apples is estimated. Based on equation (2.2), the model with both cultivars is expressed as follows.

$$WTP_i = \alpha_1 - \rho_1 B_i + \lambda' x_i + \alpha_2 - \rho_2 B_i D_R + \lambda^{*}{}' x_i D_R + \varepsilon_i \quad i = 1, 2, \ldots, n \qquad (2.6)$$

where D_R is an indicator variable for Red Delicious, taking the value of 1 for Red Delicious and 0 otherwise. The asterisk is an indication of parameters corresponding to variables for Red Delicious. *Firmness* and *Sweetness* are both indicator variables coded as 1 when firmness or sweetness is acceptable. *Organic* indicates that the respondent buys organic apples. *Frequency* is an indicator variable coded as 1 when the eating frequency is daily or more than once a week and as 0 otherwise. *Gender* is an indicator variable that represents female if it is 1 and male if it is 0. *Age* is a semi-continuous variable consisting of the midpoints of all age groups except for 65+, the latter being denoted by a dummy variable *Senior*. *Education* is an indicator variable that takes the value of 1 if the highest form of education is four-year degree or higher and 0 otherwise. Since a substantial number of respondents did not reveal their annual household income, an ordered logit model is implemented to predict to which income category each of them belongs by treating other demographics as explanatory variables. *Income* is a semi-continuous variable corresponding to the scaled midpoints (divided by 10,000) of all income groups that are under $100,000. *High Income* is an indicator variable representing observations that belong to the income group above $100,000. *Asian, Hispanic* and *OtherRace* are all indicator variables representing Asian, Hispanic, and other races that are not Caucasian, respectively.

The first half of parameters in the model evaluates the effects on the WTP for the base case of Gala, whereas the other half evaluates the adjustments for Red Delicious. Essentially, the first set of parameters reveal how the explanatory variables affect the WTP for Gala and the sums of the corresponding parameters in both sets shed light on how the same explanatory variables affect the WTP for Red Delicious. Marginal effects of the explanatory variables are calculated using (2.5). The standard errors of the marginal effects are obtained from the asymptotic variance, calculated by following the delta method of deriving standard errors of non-linear function parameter estimates (Greene 2003). The marginal effects of the Gala variables are as reported. Since the Red Delicious variables are analogous to adjustments to the base case (Gala), the net marginal effect of a particular variable *k* for Red Delicious is the sum of the marginal effects of variable *k* for both cultivars, i.e. $\lambda_k + \lambda_k^*$.

V. Results

The estimated parameters, their standard errors, and P-values are reported in Table 2.5, and the corresponding estimated marginal effects, their standard errors and P-values are presented in Table 2.6. The probability of consumers paying more for both cultivars significantly increases as firmness or sweetness moves from being not acceptable to being acceptable. However, the adjustments for Red Delicious reduce the positive impact that firmness or sweetness has on WTP, i.e. firmness or sweetness being acceptable positively affects the WTP for both cultivars but more so for Gala than for Red Delicious.

Older respondents are less likely to be willing to pay a premium for both cultivars. It is an open research question whether older consumers are generally less willing to pay a premium for high quality in food. It has been reported that post-baby boom generations demand healthier and more sophisticated foods and are willing to pay for it (Ellison, 2004). In the particular case of apples, the elderly are more likely to have reduced mastication ability (Dan, Watanabe, and Kohyama 2003), which hinders apple consumption.

Income is positively associated with the WTP for both cultivars and to similar degrees. Gender does not play an important role in explaining the WTP for either cultivar as a result of estimation. It appears that buying organic does not significantly affect WTP for these (non-organic) apples, and so is formal education level.

Notice that *Final Bid(R), Frequency(R)* and *Hispanic(R)* all have similar magnitudes to their counterparts, but with opposite signs, suggesting that the additional effects of *Final Bid, Frequency* and *Hispanic* might have offset the base effects for both cultivars. The following test is thus conducted:

$$H_0 : \lambda_k + \lambda_k^* = 0 \qquad k = 2, 4, 12 \tag{2.7}$$

The P-values of this test for *Final Bid*, *Frequency* and *Hispanic* are 0.1422, 0.6903 and 0.8325, respectively. Thus, it is confirmed that *Final Bid*, *Frequency* and *Hispanic* affect Gala only and have no effect on the WTP for Red Delicious. The final bid outcome implies that lower prices are more likely to induce consumers to choose Gala and this is not the case for consumers who choose Red Delicious. This is interesting from the perspective of how habits affect demand for food products. Demand for a more traditional food product such as Red Delicious apples is less sensitive to price than a newer variety food product such as Galas. The probability of paying more for Gala grows as apple-eating frequency shifts from low to high, which implies that the more frequently consumers eat apples the more likely they are willing to pay more for Gala. On the other hand, the probability of paying more for Gala declines from race being

Caucasian to being Hispanic, suggesting that Hispanics are less willing to accept premium for Gala apples than Caucasians. This is an interesting result because the Hispanic culture places a high value on tradition, and Red Delicious is a traditional variety.

VI. Conclusions

As the demand for high quality and healthier food continues to increase, there are opportunities to sell high-end fresh apples at higher prices. Eating quality characteristics such as sweetness, firmness, and juiciness entice consumers to buy more apples through repeat purchases. There is a widespread perception that the traditional and still popular Red Delicious variety has sacrificed eating quality for appearance as marketers and nurseries selected naturally occurring strains, or mutations, in response to the perception that consumers want perfectly red apples. Now, there appears to be a general belief that persistent selection for higher color in the Red Delicious has reduced the internal quality, and this has in turn affected consumption. In response, many new varieties have been marketed such as Gala, Braeburn, Pink Lady, and Honeycrisp.

This study utilized individual apple-level tasting data to estimate a predictive model of the relationship between sensory attributes and WTP for two cultivars of apples and tested whether these attributes play a different role across cultivars. A double-bounded dichotomous choice model was employed to evaluate the effects, and the parameter estimates were obtained through maximum likelihood method. Firmness and sweetness both positively affect consumers' WTP, but more so for Gala than Red

Delicious. Older consumers are less likely to be willing to pay premiums for apples. Apple-eating frequency is positively related to the WTP for Gala but not for Red Delicious. Meanwhile, being Hispanic negatively influences the WTP for Gala apples, but it does not affect WTP for Red Delicious. Other variables, such as gender, education level, and whether they buy organic food, do not add significant explanatory power in estimating consumers' WTP.

In order to take advantage of market opportunities, the apple industry needs an accurate picture of what customers want and should produce it. Results from this study could be used in targeting consumers for specific cultivars. For example, Red Delicious apples could be a featured product in Hispanic markets, who value relatively more this traditional cultivar. In sum, the focus of the apple industry should be on market analysis and development, eating quality development, and reduction of low quality fruit in the marketplace.

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Table 2.1: Summary Statistics for Demographic Variables

Variable	Description and Coding	Distribution	
		Gala	Red Delicious
Gender	1 Female	59.80%	58.60%
	0 Male	40.20%	41.40%
Age	1 10-17	14.20%	14.80%
	2 18-24	18.30%	17.60%
	3 25-34	21.10%	23.40%
	4 35-44	12.50%	13.40%
	5 45-54	18.90%	18.60%
	6 55-64	10.30%	10.00%
	7 65+	4.70%	2.10%
Education	1 High School	21.80%	22.80%
	2 2-Year College or Technical Degree	17.00%	22.80%
	3 4-Year College Degree	29.80%	23.40%
	4 Advanced Degree	19.90%	16.20%
	5 Choose not to Answer	11.50%	14.80%
Annual Household Income	1 Less than $20,000	18.50%	15.50%
	2 $20,000-39,999	15.60%	22.10%
	3 $40,000-59,999	13.60%	19.70%
	4 $60,000-79,999	12.50%	9.70%
	5 $80,000-99,999	8.40%	5.50%
	6 Greater than $100,000	14.60%	13.10%
	7 Choose not to Answer	16.80%	14.50%
Race	1 Asian and Other Pacific Islander	7.40%	6.20%
	2 Black	0.80%	1.40%
	3 Caucasian, White, Non-Hispanic	77.00%	70.00%
	4 Hispanic	2.90%	7.60%
	5 Native American	1.80%	2.80%
	6 Some other Race/Ethnicity	1.80%	1.40%
	7 Choose not to Answer	8.20%	10.70%

Table 2.2: Summary Statistics for Consumer Responses

Variable	Description and Coding		Distribution	
			Gala	Red Delicious
Scale of Liking	Overall Liking on a 10cm Continuous Line Scale		Mean = 6.96 Std. = 2.17	Mean = 6.80 Std = 2.55
Firmness Acceptability	1 Firmness is Acceptable		79.70%	77.20%
	0 Firmness is Not Acceptable		20.30%	22.80%
	(Branch) 1 Too Firm		2.00%	4.50%
	0 Not Firm Enough		98.00%	95.5%
Sweetness Acceptability	1 Sweetness is Acceptable		83.00%	86.20%
	0 Sweetness is Not Acceptable		17.00%	13.80%
	(Branch) 1 Too Sweet		8.40%	15.00%
	0 Not Sweet Enough		91.60%	85.00%
Buy for $0.99/lb	1 Yes		57.70%	59.00%
	0 No		42.30%	41.00%
$/lb Usually Pay	Gala	Red Delicious		
	1 Less than $0.79	1 Less than $0.49	13.80%	6.90%
	2 $0.79	2 $0.49	9.40%	4.10%
	3 $0.89	3 $0.59	12.70%	6.20%
	4 $0.99	4 $0.69	18.50%	7.20%
	5 $1.09	5 $0.79	7.60%	10.70%
	6 $1.19	6 $0.89	4.90%	12.40%
	7 $1.29	7 $0.99	8.60%	18.30%
	8 $1.39	8 $1.09	2.50%	6.90%
	9 $1.49	9 $1.19	3.50%	6.90%
	10 $1.59	10 $1.29	0.80%	4.10%
	11 More than $1.59	11 More than $1.29	3.10%	3.40%
	12 Do not Know	12 Do not Know	14.60%	12.80%
Buy Organic	1 Yes		32.90%	33.40%
	0 No		67.10%	66.60%
Eating Frequency	1 Daily		19.10%	16.20%
	2 More than Once a Week		39.80%	33.40%
	3 Once a Week		16.80%	23.40%
	4 Every Few Weeks		15.80%	17.60%
	5 Once a Month		4.90%	4.80%
	6 Less than Once a Month		3.10%	3.80%
	7 Never		0.40%	0.70%

Table 2.3: Range and Distribution of Response Rates to the Randomly Assigned Premiums

	Premium (Prices)	Gala	Red Delicious
Yes to Premium	$1.19	12.96%	10.69%
	$1.29	8.85%	8.62%
	$1.49	5.97%	7.24%
No to Premium		30.04%	32.41%
Total		57.82%	58.97%

Table 2.4: Range and Distribution of Response Rates to the Randomly Assigned Discounts

	Discount (Prices)	Gala	Red Delicious
Yes to Discount	$0.79	3.50%	3.45%
	$0.69	7.82%	6.90%
	$0.49	9.88%	7.93%
No to Discount		20.99%	22.76%
Total		42.18%	41.03%

Table 2.5: Parameter Estimates of WTP for the Consumer Model

Parameter	Description	Estimate	Std Error	z-test	P-value
$\widetilde{\alpha}_1$	*Intercept*	2.7630	0.4879	5.6630	0.0000
$\widetilde{\rho}_1$	*Final Bid*	-5.8796	0.2710	-21.6920	0.0000
λ_1	*Firmness*	2.3193	0.2527	9.1790	0.0000
λ_2	*Sweetness*	2.3054	0.2698	8.5460	0.0000
λ_3	*Organic*	-0.2738	0.1981	-1.3820	0.1669
λ_4	*Frequency*	0.4573	0.1904	2.4020	0.0163
λ_5	*Gender*	0.0629	0.1879	0.3350	0.7377
λ_6	*Age*	-0.0288	0.0076	-3.7670	0.0002
λ_7	*Senior*	-0.8566	0.5213	-1.6430	0.1003
λ_8	*Education*	0.3052	0.2076	1.4700	0.1416
λ_9	*Income*	0.0716	0.0426	1.6800	0.0929
λ_{10}	*High Income*	0.5109	0.3258	1.5680	0.1169
λ_{11}	*Asian*	-0.2760	0.3866	-0.7140	0.4753
λ_{12}	*Hispanic*	-1.9461	0.5484	-3.5490	0.0004
λ_{13}	*Other Races*	-0.4000	0.2670	-1.4980	0.1341
$\widetilde{\alpha}_2$	*Intercept(R)*	-3.6475	0.7707	-4.7330	0.0000
$\widetilde{\rho}_2$	*Final Bid(R)*	5.3437	0.4178	12.7890	0.0000
λ_1^*	*Firmness(R)*	-0.9994	0.3982	-2.5100	0.0121
λ_2^*	*Sweetness(R)*	-1.3699	0.4441	-3.0850	0.0020
λ_3^*	*Organic(R)*	0.2551	0.3133	0.8140	0.4154
λ_4^*	*Frequency(R)*	-0.5466	0.2941	-1.8580	0.0631
λ_5^*	*Gender(R)*	-0.1247	0.2935	-0.4250	0.6709
λ_6^*	*Age(R)*	0.0088	0.0117	0.7530	0.4513
λ_7^*	*Senior(R)*	-0.4041	1.1110	-0.3640	0.7160
λ_8^*	*Education(R)*	0.0591	0.3220	0.1830	0.8545
λ_9^*	*Income(R)*	-0.0380	0.0693	-0.5480	0.5836
λ_{10}^*	*High Income (R)*	-0.1509	0.5444	-0.2770	0.7816
λ_{11}^*	*Asian(R)*	0.1048	0.6341	0.1650	0.8687
λ_{12}^*	*Hispanic(R)*	1.8579	0.6885	2.6980	0.0070
λ_{13}^*	*Other Races(R)*	0.1901	0.4052	0.4690	0.6390

(Note that *(R)* abbreviates for Red Delicious and indicates that the parameter estimate is for Red Delicious.)

Table 2.6: Marginal Effects of the Parameters

Parameter	Description	Marginal Effect	Stad Error	P-value
$\tilde{\alpha}_1$	*Intercept*			
$\tilde{\rho}_1$	*Final Bid*			
λ_1	*Firmness*	0.3945	0.0409	0.0000
λ_2	*Sweetness*	0.3921	0.0440	0.0000
λ_3	*Organic*	-0.0466	0.0337	0.1665
λ_4	*Frequency*	0.0778	0.0323	0.0161
λ_5	*Gender*	0.0107	0.0319	0.7373
λ_6	*Age*	-0.0049	0.0013	0.0001
λ_7	*Old*	-0.1457	0.0886	0.1001
λ_8	*Education*	0.0519	0.0353	0.1415
λ_9	*Income*	0.0122	0.0072	0.0924
λ_{10}	*High Income*	0.0869	0.0554	0.1165
λ_{11}	*Asian*	-0.0469	0.0657	0.4751
λ_{12}	*Hispanic*	-0.3310	0.0926	0.0004
λ_{13}	*Other Races*	-0.0680	0.0453	0.1334
$\tilde{\alpha}_2$	*Intercept(R)*			
$\tilde{\rho}_2$	*Final Bid(R)*			
λ_1^*	*Firmness(R)*	-0.1700	0.0669	0.0111
λ_2^*	*Sweetness(R)*	-0.2330	0.0748	0.0018
λ_3^*	*Organic(R)*	0.0434	0.0533	0.4153
λ_4^*	*Frequency(R)*	-0.0930	0.0500	0.0630
λ_5^*	*Gender(R)*	-0.0212	0.0498	0.6705
λ_6^*	*Age(R)*	0.0015	0.0020	0.4508
λ_7^*	*Old(R)*	-0.0687	0.1890	0.7161
λ_8^*	*Education(R)*	0.0100	0.0548	0.8546
λ_9^*	*Income(R)*	-0.0065	0.0118	0.5836
λ_{10}^*	*High Income (R)*	-0.0257	0.0927	0.7819
λ_{11}^*	*Asian(R)*	0.0178	0.1078	0.8686
λ_{12}^*	*Hispanic(R)*	0.3160	0.1167	0.0068
λ_{13}^*	*Other Races(R)*	0.0323	0.0689	0.6390

CHAPTER 3

COMPARISON BETWEEN THE CONSUMER MODEL AND THE INDUSTRY MODEL

I. Instrumental Measurements of Apples

The Gala and Red Delicious apples used in the tasting survey were obtained from several packinghouses and pre-sorted using the non-destructive laboratory firmness instruments, Aweta Acoustical Firmness Sensor (Aweta), Greefa Internal Firmness Device (Greefa) and Sinclair Internal Quality firmness tester (SIQ). At Stemilt growers in Wenatchee WA, Gala apples were tested for soluble solids (SS) in percentage brix with Near Infrared Sorter (NIR) and sorted as low SS (0% to 12.9%), medium SS (13.0% to 14.0%) and high SS (above 14.1%). Then, half of the Gala apples and 15 boxes of Red Delicious apples were left at room temperature while the rest of the apples were stored in cold room. Later, all the apples were sorted as high firmness and low firmness according to Greefa firmness levels. High firmness apples were kept in cold room while low firmness apples were left at room temperature to provide less firm fruit for consumer ratings. Just prior to testing, apples were tested for firmness and then cut in two, one half for taste evaluation, and the other half for destructive testing for SS.

II. The Destructive Industry Model

The last two instrumental measurements for firmness and sweetness were recorded and are used in a destructive industry model by replacing the subjective variables *Firmness* and *Sweetness* in the consumer model (2.6) in Chapter 2. The rest of the variables in (2.6) remain intact. Eight observations are excluded from the estimation due to the lack of recorded SS measurements. The parameter estimates and their standard errors, z-tests, and P-values are shown in Table 3.1. Marginal effects of the explanatory variables and their standard error and P-values are reported in Table 3.2.

III. Conclusions

Clearly from comparing the estimation results in Tables 2.5 and 3.1, the major difference is that the physical measurement of sweetness is not significant as an influential factor on consumers' WTP in the industry model while the subjective variable sweetness is highly significant in the consumer model. This is most likely due to the subjective nature of sweetness evaluation so that SS measurements are not necessarily linked to consumers' satisfaction over sweetness and hence their WTP. Even though the physical measurement of firmness is significant in the industry model, its impact on WTP is much less compared to that of the subjective variable firmness in the consumer model. The reason for this lies in the same issue as what was just discussed for the evaluation of sweetness.

Consumers are a heterogeneous group, and not only will their tastes and preferences vary widely, but their perceptions of quality will change relative to the situation, which creates difficulty for the industry as it searches for fixed quantitative characteristics that will be most widely accepted.

Table 3.1: Parameter Estimates of WTP for the Industry Model

Parameter	Variable Description	Estimate	Standard Error	z-test	P-value
$\tilde{\alpha}_1$	*Intercept*	2.2947	1.0210	2.2470	0.0246
$\tilde{\rho}_1$	*Final Bid*	-5.0444	0.2301	-21.9270	0.0000
λ_1	*FTA*	0.2052	0.0402	5.1090	0.0000
λ_2	*SS*	0.0690	0.0855	0.8070	0.4197
λ_3	*Organic*	-0.1706	0.1918	-0.8900	0.3736
λ_4	*Frequency*	-0.0231	0.1785	-0.1290	0.8970
λ_5	*Gender*	0.1393	0.1841	0.7560	0.4495
λ_6	*Age*	-0.0345	0.0073	-4.7410	0.0000
λ_7	*Senior*	-0.4693	0.5031	-0.9330	0.3509
λ_8	*Education*	0.3320	0.2000	1.6600	0.0970
λ_9	*Income*	0.0629	0.0422	1.4920	0.1358
λ_{10}	*High Income*	0.5275	0.3117	1.6920	0.0906
λ_{11}	*Asian*	-0.4053	0.3652	-1.1100	0.2671
λ_{12}	*Hispanic*	-1.6922	0.5349	-3.1640	0.0016
λ_{13}	*Other Races*	-0.1117	0.2607	-0.4290	0.6682
$\tilde{\alpha}_2$	*Intercept(R)*	-3.6335	2.3641	-1.5370	0.1243
$\tilde{\rho}_2$	*Final Bid(R)*	5.2713	0.3810	13.8350	0.0000
λ_1^*	*FTA(R)*	-0.1153	0.0566	-2.0380	0.0415
λ_2^*	*SS(R)*	-0.0496	0.1707	-0.2910	0.7714
λ_3^*	*Organic(R)*	0.1616	0.3056	0.5290	0.5969
λ_4^*	*Frequency(R)*	-0.1637	0.2834	-0.5780	0.5635
λ_5^*	*Gender(R)*	-0.2381	0.2881	-0.8260	0.4087
λ_6^*	*Age(R)*	0.0188	0.0113	1.6660	0.0958
λ_7^*	*Senior(R)*	-0.8327	1.0755	-0.7740	0.4388
λ_8^*	*Education(R)*	0.0596	0.3146	0.1890	0.8498
λ_9^*	*Income(R)*	-0.0426	0.0686	-0.6200	0.5352
λ_{10}^*	*High Income (R)*	-0.4156	0.5254	-0.7910	0.4289
λ_{11}^*	*Asian(R)*	0.1999	0.6175	0.3240	0.7462
λ_{12}^*	*Hispanic(R)*	1.6125	0.6872	2.3470	0.0189
λ_{13}^*	*Other Races(R)*	0.0152	0.4009	0.0380	0.9697

(Note that *(R)* abbreviates for Red Delicious and indicates that the parameter estimate is for Red Delicious.)

Table 3.2: Marginal Effects of the Parameters

Parameter	Variable Description	Marginal Effect	Standard Error	P-value
$\tilde{\alpha}_1$	*Intercept*			
$\tilde{\rho}_1$	*Final Bid*			
λ_1	*FTA*	0.0407	0.0079	0.0000
λ_2	*SS*	0.0137	0.0169	0.4195
λ_3	*Organic*	-0.0338	0.0380	0.3734
λ_4	*Frequency*	-0.0046	0.0354	0.8970
λ_5	*Gender*	0.0276	0.0365	0.4492
λ_6	*Age*	-0.0068	0.0014	0.0000
λ_7	*Old*	-0.0930	0.0997	0.3508
λ_8	*Education*	0.0658	0.0396	0.0967
λ_9	*Income*	0.0125	0.0083	0.1353
λ_{10}	*High Income*	0.1046	0.0617	0.0901
λ_{11}	*Asian*	-0.0803	0.0724	0.2669
λ_{12}	*Hispanic*	-0.3355	0.1054	0.0015
λ_{13}	*Other Races*	-0.0221	0.0517	0.6681
$\tilde{\alpha}_2$	*Intercept(R)*			
$\tilde{\rho}_2$	*Final Bid(R)*			
λ_1^*	*FTA(R)*	-0.0229	0.0112	0.0405
λ_2^*	*SS(R)*	-0.0098	0.0338	0.7714
λ_3^*	*Organic(R)*	0.0320	0.0606	0.5969
λ_4^*	*Frequency(R)*	-0.0325	0.0562	0.5637
λ_5^*	*Gender(R)*	-0.0472	0.0571	0.4086
λ_6^*	*Age(R)*	0.0037	0.0022	0.0947
λ_7^*	*Old(R)*	-0.1651	0.2133	0.4391
λ_8^*	*Education(R)*	0.0118	0.0624	0.8498
λ_9^*	*Income(R)*	-0.0084	0.0136	0.5350
λ_{10}^*	*High Income (R)*	-0.0824	0.1041	0.4287
λ_{11}^*	*Asian(R)*	0.0396	0.1224	0.7462
λ_{12}^*	*Hispanic(R)*	0.3197	0.1358	0.0186
λ_{13}^*	*Other Races(R)*	0.0030	0.0795	0.9697

CHAPTER 4

COMPARING SENSORY RESPONSE IN CONSUMERS' WILLINGNESS TO PAY FOR CHERRYIES: A MIXED MODEL APPROACH

I. Introduction

Quality is a major marketing factor affecting consumer preferences, the price of the product, and the demand for alternative products (Sloof, et al. 1996). The quality of fresh sweet cherries is associated with attributes such as taste, color, size, soluble solids, firmness, and texture (Roper, et al. 1987; Dolenc and Stampar 1998). However, in assessing consumer preferences for a food product such as cherries, intrinsic factors such as taste, texture and flavor are typically not included in the analysis. This is unfortunate since consumers make purchase decisions based on their internal attributes such as taste and flavor (Miller et al. 2005). Brennan and Kuri (2002) find that once consumers develop a preference for a product based on sensory characteristics, it is unlikely for them to change. Thus, sensory characteristics have a major influence on consumers' expectations of quality and buying habits.

The Market for Cherries

Not only have cherries been a traditional fruit crop for centuries, they also provide a considerable quantity of antioxidants and other healthy nutrients. Research shows the connection between cherry consumption and health benefits such as easing the pain of arthritis and gout, and preventing cancer and heart disease (Blau, 1950; Jacob, et al. 2003; Kelley, USDA, 2004; Kelley, et al. 2006), which has promoted increased consumption of cherries.

Northwest sweet cherries are highly profitable and celebrated for their high quality. While its harvested acreage ranks as the world's sixth largest, the United States is the second largest cherry producer in the world, closely following Iran and Turkey in production (ERS, USDA 2002). In 2000, U.S. commercial cherry production produced $327 million in farm cash receipts, of which over 80 percent were from sweet cherries (ERS, USDA 2002). The USDA's National Agricultural Statistics Service (NASS) data shows that orchards in Washington, Oregon and California generate over 80 percent of U.S. sweet cherry commercial production with Washington being the leading producer. Sweet cherries are highly seasonal and usually marketed from May through early August (ERS, USDA 2002). Among more than 1,000 varieties of sweet cherries, the most famous variety is the Bing cherry, which mainly grows in the Northwest (Cherry Marketing Institute).

Previous Literature

There has been a substantial amount of research on the constituents of fruit quality that motivate consumers' purchasing decisions for cherries. This work has provided insights in terms of which attributes attract consumers and contribute to higher satisfaction during consumption. Miller, et al. (1986) investigated consumers' preferences and purchase patterns via a cherry consumer personal interview survey which was performed at five different retail stores in Tokyo, Japan during two time periods (late June and early July). The survey questionnaire was designed to gather information on Japanese consumers' cherry purchases, their opinions regarding characteristics affecting cherry purchases, and what they perceived to be substitutes for sweet cherries. Of all the characteristics listed as important in cherry purchasing, taste, freshness, color, shape/size, price, and seasonality were recorded in the order from the most important to the least.

Through laboratory measures of fruit weight, color, soluble solids, pH, titratable acidity, and firmness and a sensory test on 'Rainier' sweet cherries, Drake and Fellman (1987) found soluble solids to be the most important factor for representing edible quality, its highest correlation being with color and also having notable correlations with weight and firmness. Under the presupposition that eating quality affects cherry purchase behavior, Schotzko (1993) examined consumer preferences over a number of sweet cherry varieties. Respondents tasted halves of three cherry varieties (the other halves were measured for soluble solids) and noted their opinions about color, flesh color, skin texture, flesh texture, sweetness, flavor, and overall evaluation of the cherries which they tasted. Even though consumer evaluations of sweetness and flavor were highly correlated with soluble solids, soluble solids alone did not adequately represent them. Furthermore, due to the limited sample size (161 observations for all three cherry varieties) and multicollinearity amongst the variables, the final models were generally incapable of providing reliable insights in terms of identifying the principal factors characterizing eating quality.

Guyer, et al. (1993) analyzed the statistical correlation between overall product acceptance and sweetness, flavor, brix, brix/acid ratio, acidity, color, firmness and size for three Michigan sweet cherry cultivars. The evaluations of sweetness, flavor and overall acceptance were collected from 30 panelists in a sensory evaluation laboratory whereas the rest of the attributes were physically measured. They report that sweetness, flavor and firmness are significantly correlated with overall acceptability of all cultivars, but other sensory attributes such as acidity, color, and size may be significant for an individual cultivar. Lyngstad and Sekse (1995) indicated that both consumers and sales staff preferred dark and large sweet cherries, which was revealed from interviews with cherry-buyers, retailers and wholesalers in Norway.

In a study of quantifying cherry fruit quality attributes, Kappel, et al. (1996) revealed optimum ranges for fruit size, color, firmness, and sweetness/flavor of red sweet cherries by regressing the “just right” (JR) ratings or hedonic evaluations from sensory panelists inspecting and tasting sample cherries on the corresponding physical measures of the matching sample cherries. They suggest that these ranges characterize an ideal red sweet cherry and can be utilized by growers and marketers as standards by which new cultivars and breeding practices are compared and selected. Cliff, et al. (1996) conducted two experiments with the aim of identifying sensory attributes related to cherry cultivar preferences in British Columbia (BC), and found that uniformity of color and size, but not the other visual attributes such as speckles, stem length and external firmness, were most effective in explaining visual preference, and that flavor intensity and sweetness were the major attributes rather than attributes flesh firmness, juiciness and sourness in determining flavor/texture preference. From personal interviews with personnel working in the cherry supply chain, Wermund and Fearne (2000) learned that the industry believed consumers in the United Kingdom (UK) preferred large, dark full red or black glossy cherries that were sweet and juicy. Later, via a consumer survey consisting of 480 personal interviews with cherry-buyers in four regions, Wermund, et al. (2005) confirmed that the majority of consumers in UK preferred large, black, and sweet cherries while the preference for a glossy cherry was not verified. By studying cherry cultivars ‘Brooks’ and ‘Bing’, Crisosto, et al (2003) showed that consumer acceptance was influenced by soluble solids concentration (SSC), SSC and titratable acidity (TA) ratio and visual skin color, and that consumers were more likely to buy cherries of darker skin color, which was not affected by gender and ethnicity but by age.

The current study investigates consumers’ WTP for cherries in the context of their perception and opinion of fruit quality as well as their demographics. Appearance of fresh fruits has been believed to be the main factor as to consumers’ purchase decision making (Kays, 1999). However, other sensory attributes also play important roles, and even more so in sustaining consumers’ repeated purchases. In this study, firmness and sweetness are selected as the representative sensory attributes whose influence on consumers’ perception of cherries and their purchase decisions are to be evaluated.

The econometric model implemented in this study is a mixed logit model in which a random coefficient is incorporated in the double-bounded dichotomous contingent valuation model to account for unobserved attributes, as well as the correlation arising from the evaluations of more than one cultivar by the same respondent. The theoretical framework of this model is described in Section II followed by the data summary in Section III. Section IV presents estimation results and discussions, while Section V draws conclusions from the overall study, and describes prospects for further research.

II. Econometric Model

The contingent valuation method (CVM) is frequently applied to discrete survey responses to elicit opinions or preferences on various matters. Single-bounded and double-bounded dichotomous choice are two widely-used bidding methods in CVM for assessing market products or non-market resources. The double-bounded method engages respondents in two bids. A second question associated with a higher or lower value is asked based on responses from the first question. If the initial offer is accepted, a premium will be asked; whereas if the initial offer is rejected, a discount will be offered. Using two sequential bidding questions, boundaries of WTP are therefore observed.

In the double-bounded model (Hanemann, et al. 1991) used here there are four possible outcomes: (1) the respondent's willingness to pay is lower than the discount offered so she/he is not willing to buy the cherry at all, i.e. "no, no"; (2) the respondent's willingness to pay is between the lower bid price and the initial bid price, i.e. "no, yes"; (3) the respondent's willingness to pay is above the initial bid but lower that the premium offered, i.e. "yes, no"; (4) the respondent's willingness to pay is above the premium offered, i.e. "yes, yes."

The initial bid (B_0) equals zero and implies no price difference between the cherry the respondent just tasted and other cherries. The second bid is contingent upon the response to the first bid. It will be a discount bid (B_D), if the respondent answers she/he would not buy the cherries at their usual price. If the respondent answers that she/he would buy the cherries at their usual price, it becomes a premium bid (B_P). The sequence of questions isolates the range in which the respondent's true WTP for eating quality in cherries lies. The second bid, B_D *or* B_P, in conjunction with the response to the initial preference decision, allows an upper bound and a lower bound to be placed on the respondent's unobservable true WTP.

Let WTP_{ij} denote an individual's WTP (bid function) for the tasted cherry. The following discrete outcomes (D_g) of the bidding process are

Group

$$D_g = \begin{cases} 1 & WTP_{ij} < B_D \\ 2 & B_D \leq WTP_{ij} < B_0 \\ 3 & B_0 \leq WTP_{ij} < B_P \\ 4 & B_P \leq WTP_{ij} \end{cases} \tag{4.1}$$

Respondents who indicated they require no discount and would pay the premium price B_P fall into the fourth group (D_4). Those who indicated they require no discount and would pay a premium of less than B_P fall into the third group (D_3). Respondents who required a discount greater than or equal to B_D fall into the second group (D_2). Finally, the first group (D_1) contains respondents indicating the lowest WTP. Consumers in this group are not willing to purchase the tasted cherry at the discount offered.

The WTP questions in the survey for this study were conveyed in a double-bounded model format, however since each respondent was asked to taste and evaluate all five cultivars of cherries, correlation among responses on different cherries from the same respondent arises. To address this issue, a special case of the double-bounded model, a mixed logit model with a random coefficient is implemented. The WTP function for the tasted cherry cultivar *j* for individual *i* is specified as

$$WTP_{ij} = \alpha_j - \rho B_{ij} + \lambda' x_{ij} + \eta_i + \varepsilon_{ij} \quad i = 1, 2, \ldots, n; j = 1, 2, \ldots, 5 \tag{4.2}$$

where α_j captures the differences in WTP due to the different cherry cultivars being evaluated. B_{ij} denotes the final bid that was reached by individual *i* evaluating cultivar *j*. In order to be more effective in eliciting consumers' true WTP, different prices, higher or lower than the initial price depending on the first response, were offered to respondents. For example, \$2.99, \$3.49 and \$3.99 were randomly assigned to consumers who responded affirmatively to the initial price, \$2.49 per pound for cherries. x_i is a vector of explanatory variables such as demographics and consumption characteristics for individual *i*. η_i denotes the added random coefficient that accounts for the correlation between responses from the same respondent, as well as other unobserved effect on WTP. Note that if $\eta_i = 0$, (4.2) represents WTP as in a typical double-bounded model.

It is assumed that η is normally distributed with mean 0 and variance σ_η^2 over respondents. ε is assumed to have an extreme value distribution that is i.i.d. over all observations. ρ, λ' are unknown parameters that need to be estimated, along with the intercepts, the α 's. As for ρ, it is natural to expect lower WTP associated with higher bids and higher WTP associated with lower bids, thus a negative relationship (i.e., a negative sign in front of ρ) is proposed.

The probabilities for the above WTP choice groups can be obtained for the mixed logit model. The conditional probabilities of WTP choices are expressed as

$$\begin{cases} \text{Prob}(Y_i = 1 \mid \eta) = \dfrac{e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}} \\ \text{Prob}(Y_i = 2 \mid \eta) = \dfrac{e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}} - \dfrac{e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}} \\ \text{Prob}(Y_i = 3 \mid \eta) = \dfrac{e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}} - \dfrac{e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}} \\ \text{Prob}(Y_i = 4 \mid \eta) = 1 - \dfrac{e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}} \end{cases} \tag{4.3}$$

Since η is unknown, to obtain the unconditional probabilities, the logit model needs be integrated over all values of η weighted by the density of η as follows.

$$\begin{cases} \text{Prob}(Y_i = 1) = \int \left[\dfrac{e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}} \right] f\left(\eta; \sigma_\eta^2\right) d\eta \\ \text{Prob}(Y_i = 2) = \int \left[\dfrac{e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}} - \dfrac{e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}} \right] f\left(\eta; \sigma_\eta^2\right) d\eta \\ \text{Prob}(Y_i = 3) = \int \left[\dfrac{e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}} - \dfrac{e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}} \right] f\left(\eta; \sigma_\eta^2\right) d\eta \\ \text{Prob}(Y_i = 4) = \int \left[1 - \dfrac{e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}} \right] f\left(\eta; \sigma_\eta^2\right) d\eta \end{cases} \tag{4.4}$$

where f is the probability density function (PDF) of a normal distribution with mean 0 and variance σ_η^2.

The log-likelihood function comprising the resulting integrated probabilities for all observations can be obtained and is then maximized with parameters being estimated as a result.

There are two ways to calculate mean WTP. First, estimate intercepts α_j and the slope coefficient ρ in (4.2) by setting $\lambda' = 0$ so that α_j / ρ becomes the mean WTP for cultivar j (Hanemann et al. 1991). This mean WTP also serves as the base value for evaluating marginal effects. The marginal effect of an explanatory variable is essentially the difference between when the parameter estimate is added to the intercept (base) and when it is not:

$$\text{Marginal Effect of } \lambda_k = \frac{\alpha + \lambda_k}{\rho} - \frac{\alpha}{\rho} = \frac{\lambda_k}{\rho}. \tag{4.5}$$

Or alternatively, the ratio $\left(\alpha_j + \lambda' x\right)/\rho$ is derived from the random utility model as the mean WTP for cultivar *j* for a given value of the vector *x* (Kaneko and Chern, 2003; Lin et al. 2006; Qaim and Janvry, 2003), which implies that the utility level from consuming cultivar *j* is at least as much as what the monetary value would provide otherwise. This approach recognizes the influences of explanatory variables on the mean WTP. Taking the partial derivative of the above ratio with respect to an explanatory variable will result in the marginal effect of that variable (Lin, et al. 2006), which is λ_k/ρ. So from either method above, the marginal effect of an explanatory variable is shown to be the same.

III. Data

A cherry taste-testing survey was conducted at an outside public venue, the Portland Farmers' Market, in July 2005. Volunteers were recruited to taste cherry samples and complete questionnaires inquiring about information on the consumers' demographics and preferences, as well as WTP. In total, 81 respondents participated in the survey and their responses were recorded using ballots on computer tablets equipped with data collection software. Each respondent was instructed to taste five cultivars of cherries: Lapin, Bing, Skeena, Regina, and Sweetheart (not necessarily always in this order). Besides WTP questions, they were also asked to express their opinions on the individual cultivars and preferences among them all. Information on their demographics, shopping patterns and preferences for cherries were also collected in the last part of the survey.

Reading from Table 4.1, it is apparent that the majority of the respondents in the survey were female, accounting for 59.26% of the respondents. Women are over-represented in the experiment, but this is not a concern since a greater proportion of women do the household shopping. Among the seven age groups, ages 35 to 44 had the highest percentage of respondents (23.46%). Other age groups had a considerable share except for groups 18-24 and 65+, which only captured 9.88% and 6.17% of the respondents, respectively. This is comparable to the general population of Portland. Ten juniors under the age of 18 also took a short survey, but the WTP and most of the demographics questions were excluded in that version. Hence, these observations were discarded from the study. The mode annual household income level is greater than $75,000 (39.51%) while the percentage of the respondents descends as income level decreases except for the lowest income group (less than $10,000). The income responses are comparable to the general population of Portland.

Table 4.2 summarizes the respondents' answers to the shopping patterns and preferences questions. There is an overwhelming preference for cherries with the stems still on where 93.83% of respondents stated this preference. Furthermore, all respondents except for one were willing to pay the same or less for stemless cherries. In terms of the most frequent shopping place to obtain produce during the summer months, 32.10% of the respondents stated supermarkets and grocery stores, 56.79% stated farmers markets, produce stands, and farm direct or grow at home, and only 11.11% stated natural food stores and food COOPs. As for the organic constituent of fruit purchases, the 1 – 10% range had the highest percentage of respondents (18.52%), followed by 81 – 90%

(14.81%) and then 91 – 99% (13.58%). 100% had the least percentage of respondents (1.23%).

A glimpse of respondents' opinions on the cherries is presented in Table 4.3. Appearance wise, the highest percentage (27.16%) of the respondents liked Bing cherries the best and the lowest percentage (13.58%) liked Sweetheart the best. In terms of fruit size, Skeena was preferred by the highest percentage of the respondents (35.80%) and Sweetheart the lowest (9.88%). As to color, Bing and Skeena were equally preferred by the highest percentage of the respondents (23.46%) and Sweetheart the lowest (11.11%). Sweetheart has the highest mean overall liking (7.17) with the lowest standard deviation (1.89) on a 0-10 scale whereas Lapin has the lowest mean overall liking (5.73) with standard deviation being 2.25. Firmness, sweetness and tartness/sourness were being evaluated on a 1-5 "just about right" scale anchored with 3 "just about right," 1 "not nearly firm/sweet/tart/sour enough," and 5 "much too firm/sweet/tart/sour" among which "just about right" represents the optimum state. The means of firmness for all cultivars are closely scattered around 3 with Skeena and Regina being equally closest to 3. The means of sweetness are all below the optimum. The closest to 3 is the mean for Sweetheart (2.68). Same as sweetness, the means of tartness/sourness are all below 3. The means for Bing and Skeena (2.85) are equally closest to 3. When asked if they would buy cherries to eat fresh for $2.49 per pound, a majority of respondents answered yes to all cultivars except for Lapin.

The distribution statistics relating to responses to various premiums and discounts for all cherry cultivars are available in Tables 4.4 and 4.5. As the premium amount increases, the percentage of respondents saying yes to the premium price does not necessarily diminish, and as the discount increases, the percentage of respondents saying yes to the discounted price does not necessarily increase, which is slightly counterintuitive. This is possibly associated with the fact that fresh cherries have a very short season, which occasionally causes cherries to not act as a normal good.

The survey data is analyzed in the framework of the mixed logit model, and maximum likelihood estimates are obtained via an application of the maximum likelihood principle programmed in the Gauss programming language. Marginal effects of the explanatory variables are also calculated to evaluate the impact of each explanatory variable on WTP.

IV. Empirical Specification and Estimation Results

The respondents' demographic information gathered in the survey, namely gender, age and annual household income, are incorporated in the mixed logit model as explanatory variables, as well as percentage of regular fruit purchases that is organically grown. Other explanatory variables include firmness and sweetness that respondents evaluated for each individual cultivar. WTP for all cherry cultivars is examined through the model in (4.2), which can be written as follows:

$$\begin{aligned} WTP_{ij} &= \alpha_j - \rho B_{ij} + \lambda_1 Firmness_{ij} + \lambda_2 Sweetness_{ij} + \lambda_3 Organic_i + \lambda_4 Gender_i \\ &\quad + \lambda_5 Age_i + \lambda_6 Senior_i + \lambda_7 Income_i + \lambda_8 HighIncome_i + \eta_i + \varepsilon_{ij} \end{aligned} \tag{4.6}$$

where *Firmness* and *Sweetness* are both discrete variables coded as -2 for "not nearly firm/sweet enough" or "much too firm/sweet", 0 for "just about right", and -1 for in-between. *Organic* is a semi-continuous variable that takes the values of the midpoints of the percentage ranges of organic fruit purchases that the respondents claimed to make. *Gender* is an indicator variable that is 1 if it represents female and 0 if it is male. *Age* is a semi-continuous variable consisting of the midpoints of all age groups except for 65+, the latter being denoted by a dummy variable *Senior*, taking the value of 1 as falling into the category and 0 as not. *Income* is a semi-continuous variable corresponding to the scaled midpoints (divided by 10,000) of all income groups that are under \$75,000. *HighIncome* is an indicator variable representing observations that belong to the income group above \$75,000. It is 1 when the annual household income is greater than \$75,000 and 0 otherwise.

The parameter estimates and their standard errors, z-tests, and P-values are reported in Table 4.6. Marginal effects of the explanatory variables are calculated. The standard errors of the marginal effects are obtained from the asymptotic variance, calculated by following the delta method of deriving standard errors of nonlinear function parameter estimates (Greene 2003). The estimated marginal effects and their standard error and P-values are presented in Table 4.7. As shown in Table 4.6, σ_η^2 is statistically significant, which justifies the specification of incorporating such a random coefficient in the model. From the parameter estimates in Table 4.6 and the corresponding marginal effects in Table 4.7, it is apparent that the probability that consumers are willing to pay more for cherries significantly increases as firmness or sweetness approaches "just about right" on the scale and this is even more so for sweetness. This finding can be inferred as a generalization for sweet cherries since the different cultivars involved in the study provided a variety of sweet cherries with diverse characteristics in terms of appearance and taste.

Percentage of organic purchases has a positive impact on WTP, i.e. the higher the proportion that consumers buy fruit that is organic the more likely they are willing to pay more for the cherries. This is probably because people who prefer organic fruits are likely to place more value on fruits, such as cherries, that are packed with healthy nutrients.

Age is statistically significant at a 0.10 level and *Senior* is significant at a 0.05 level with a higher marginal effect, which implies that the older the consumers, the more likely they are willing to pay more, and this trend is even more predominant for consumers over 65 as opposed to those under 65. It is an open research question whether older consumers are generally less willing to pay a premium for high quality in food. It has been reported that post-baby boom generations demand healthier and more sophisticated foods and are willing to pay for it (Ellison, 2004).

At a 0.10 significance level, annual household income level has a negative effect on the probability of paying more when under $75,000 such that the higher the income levels the lower the probability of consumers paying more. However, this income effect is no longer significant for income level higher than $75,000. Consumers' gender does not appear to be a significant factor to WTP.

V. Conclusions and Discussion

The current study is an attempt to discover influential factors that contribute to consumers' WTP for different cultivars of cherries. Such findings are valuable to the cherry industry as they provide insight into target consumers and their preferences, and will facilitate market and quality development.

Five different cultivars of cherries were involved in the study. The difference in appearance and taste offered a variety with which consumers could reveal their preferences in cherries. Due to the survey design, an extension of the double-bounded model, a mixed logit model, was implemented to accommodate the correlation between evaluations on different cherries from the same respondent. The inclusion of the random coefficient accounting for same-person correlation proved to be needed as it turned out to be statistically significant.

In order for survey objects to be more responsive, the external and internal attributes were represented by more direct measures such as size, color, firmness, sweetness, and tartness/sourness. In view of the importance of internal attributes in sustaining consumers' perception and repeated purchases, firmness and sweetness were chosen as the representative sensory attributes to be examined. As is shown in the results, both of the sensory attributes significantly affect consumers WTP for cherries, and sweetness has a larger impact than firmness. Essentially, consumers are likely to pay a premium for cherries once they find the levels of their firmness and sweetness satisfactory based on their own post-taste judgments.

The influences of demographics on consumers' WTP for cherries were also investigated. The relative amount of organic fruit purchase is significantly associated with the probability of consumers being willing to pay more, although the impact is fairly minor. This relationship most likely stems from consumers' preference for healthy foods. For those who are more conscious about health issues and what they eat, it is expected that they would be willing to pay more for fruits that are full of nutrients, in this case cherries. Age affects WTP in a similar way to the percentage of organic fruit purchase, and the rationale for that is similar to the one for the percentage of organic fruit purchase as well. The older people become the more aware they become of healthy foods and they are more willing to pay more for them. This postulation is more evident for consumers who are over 65 years old. The income effect on WTP is only significant when annual household income level is under $75,000. For consumers falling in this group, the more income they have the less likely they would be willing to pay more for cherries.

A message that can be delivered to the cherry industry is that cherries sell better among people who are more aware of the health benefits that cherries provide. As far as marketing strategies, programs of promoting awareness of the benefits should be arranged to "spread the word" and attract more customers.

The sample contained in this study was only collected from people who went to the Portland Saturday farmers' market and volunteered to participate in the survey, which is subject to self-selection bias. A more general study would be desirable where random participants from a larger population would be recruited.

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Table 4.1: Summary Statistics of Respondents' Demographics:

Variable	Description and Coding	Distribution
Gender	1: Female	59.26%
	2: Male	40.74%
Age	1: 12-17	0.00%
	2: 18-24	9.88%
	3: 25-34	20.99%
	4: 35-44	23.46%
	5: 45-54	20.99%
	6: 55-64	18.52%
	7: 65+	6.17%
Annual Household Income	1: Less than $10,000	9.88%
	2: $10,000-14,999	4.94%
	3: $15,000-24,999	4.94%
	4: $25,000-34,999	11.11%
	5: $35,000-49,999	13.58%
	6: $50,000-74,999	16.05%
	7: Greater than $75,000	39.51%

Table 4.2: Summary Statistics of Respondents' Preferences:

Variable	Description and Coding		Distribution
Stem Preference	Buy Cherries with the Stems Still on		93.83%
	Buy Cherries that are Stemless		6.17%
Purchase Intent for Stemless	Pay More for Stemless Cherries		1.23%
	Pay the Same for Stemless Cherries		70.37%
	Pay Less for Stemless Cherries		28.40%
Where Most of the Produce is Obtained during the Summer Months	Supermarkets, Grocery Stores	Most Frequent	32.10%
		In the Middle	39.51%
		Least Frequent	28.40%
	Farmers Markets, Produce Stands, Farm Direct or Grow at Home	Most Frequent	56.79%
		In the Middle	30.86%
		Least Frequent	12.35%
	Natural Food Stores, Food COOPs	Most Frequent	11.11%
		In the Middle	29.63%
		Least Frequent	59.26%
% of Regular Fruit Purchases that is Organically Grown	1: 0%		2.47%
	2: 1-10%		18.52%
	3: 11-20%		9.88%
	4: 21-30%		7.41%
	5: 31-40%		8.64%
	6: 41-50%		9.88%
	7: 51-60%		6.17%
	8: 61-70%		2.47%
	9: 71-80%		4.94%
	10: 81-90%		14.81%
	11: 91-99%		13.58%
	12: 100%		1.23%

Table 4.3: Summary Statistics for Consumer Responses over the Cherry Cultivars

Variable	Description and Coding		Distribution				
			Bing	Lapin	Skeena	Regina	Sweetheart
Appearance	Like Best for Overall Appearance Among All Cultivars		27.16%	16.05%	23.46%	19.75%	13.58%
Size	Like Best for Size Among All Cultivars		17.28%	20.99%	35.80%	16.05%	9.88%
Color	Like Best for Color Among All Cultivars		23.46%	19.75%	23.46%	22.22%	11.11%
Liking	Overall Liking for Individual Cultivars on a 0-10 Line Scale		Mean=7.09 Std.=2.05	Mean=5.73 Std.=2.25	Mean=6.74 Std.=1.93	Mean=6.00 Std.=2.40	Mean=7.17 Std.=1.89
Firmness	Firmness for Individual Cultivars on a 1-5 Just about Right Scale		Mean=2.85 Std.=0.48	Mean=3.09 Std.=0.71	Mean=3.05 Std.=0.42	Mean=3.05 Std.=0.65	Mean=3.28 Std.=0.62
Sweetness	Sweetness for Individual Cultivars on a 1-5 Just about Right Scale		Mean=2.59 Std.=0.75	Mean=2.10 Std.=0.89	Mean=2.41 Std.=0.74	Mean=2.63 Std.=1.03	Mean=2.68 Std.=0.77
Tartness/ Sourness	Tartness for Individual Cultivars on a 1-5 Just about Right Scale		Mean=2.85 Std.=0.74	Mean=2.74 Std.=0.80	Mean=2.85 Std.=0.74	Mean=2.46 Std.=0.82	Mean=2.77 Std.=0.60
Purchase Intent	Buy for $2.49 per pound	1: No	32.10%	53.09%	43.21%	46.91%	32.10%
		2: Yes	67.90%	46.91%	56.79%	53.09%	67.90%

Table 4.4: Range and Distribution of Response Rates to the Randomly Assigned Premiums

	Premium Prices	Bing	Lapin	Skeena	Regina	Sweetheart
Yes to Premium	$2.99	9.88%	2.47%	11.11%	9.88%	11.11%
	$3.49	7.41%	2.47%	6.17%	4.94%	6.17%
	$3.99	11.11%	4.94%	11.11%	4.94%	6.17%
No to Premium		39.51%	37.04%	28.40%	33.33%	44.44%
Total		67.91%	46.92%	56.79%	53.09%	67.89%

Table 4.5: Range and Distribution of Response Rates to the Randomly Assigned Discounts

	Discounted Prices	Bing	Lapin	Skeena	Regina	Sweetheart
Yes to Discount	$1.99	7.41%	13.58%	4.94%	8.64%	7.41%
	$1.49	9.88%	6.17%	12.35%	7.41%	8.64%
	$0.99	4.94%	9.88%	9.88%	9.88%	6.17%
No to Discount		9.88%	23.46%	16.05%	20.99%	9.88%
Total		32.11%	53.09%	43.22%	46.92%	32.10%

Table 4.6: Parameter Estimates for the Mixed Logit Model

Parameter	Variable Description	Estimate	Standard Error	z-test	P-value
$\tilde{\alpha}_1$	Intercept 1 (Cultivar Bing)	6.7956	0.6386	10.6420	0.0000
$\tilde{\alpha}_2$	Intercept 2(Cultivar Lapin)	6.4982	0.6551	9.9190	0.0000
$\tilde{\alpha}_3$	Intercept 3 (Cultivar Skeena)	6.6185	0.6424	10.3030	0.0000
$\tilde{\alpha}_4$	Intercept 4 (Cultivar Regina)	6.5657	0.6511	10.0840	0.0000
$\tilde{\alpha}_5$	Intercept 5 (Cultivar Sweetheart)	6.6262	0.6458	10.2600	0.0000
$\tilde{\rho}$	*Final Bid*	-2.1378	0.1183	-18.0710	0.0000
λ_1	*Firmness*	0.7535	0.2197	3.4290	0.0006
λ_2	*Sweetness*	1.8735	0.1785	10.4940	0.0000
λ_3	*Organic*	0.0102	0.0034	3.0170	0.0025
λ_4	*Gender*	0.1643	0.2215	0.7420	0.4583
λ_5	*Age*	0.0178	0.0101	1.7550	0.0792
λ_6	*Senior*	1.3255	0.6165	2.1500	0.0315
λ_7	*Income*	-0.1400	0.0759	-1.8450	0.0651
λ_8	*HighIncome*	-0.5153	0.3836	-1.3430	0.1791
σ_η^2	Variance of Random Variable η	0.7309	0.0635	11.5180	0.0000

Table 4.7: Marginal Effects of the Parameters

Parameter	Variable Description	Marginal Effect	Standard Error	P-value
$\tilde{\alpha}_1$	Intercept 1 (Cultivar Bing)			
$\tilde{\alpha}_2$	Intercept 2(Cultivar Lapin)			
$\tilde{\alpha}_3$	Intercept 3 (Cultivar Skeena)			
$\tilde{\alpha}_4$	Intercept 4 (Cultivar Regina)			
$\tilde{\alpha}_5$	Intercept 5 (Cultivar Sweetheart)			
$\tilde{\rho}$	*Final Bid*			
λ_1	*Firmness*	0.3525	0.1021	0.0006
λ_2	*Sweetness*	0.8764	0.0772	0.0000
λ_3	*Organic*	0.0048	0.0016	0.0024
λ_4	*Gender*	0.0769	0.1036	0.4581
λ_5	*Age*	0.0083	0.0047	0.0787
λ_6	*Senior*	0.6200	0.2876	0.0311
λ_7	*Income*	-0.0655	0.0355	0.0653
λ_8	*HighIncome*	-0.2410	0.1795	0.1792

CHAPTER 5

A COMPARISON BETWEEN PAYMENT CARD AND DOUBLE-BOUNDED DICHOTOMOUS CHOICE: ELICITATION FORMATS MAKE A DIFFERENCE

I. Introduction

The contingent valuation method (CVM) has been widely used to estimate monetary value of non-market goods or services evaluated by individuals without any actual purchasing involved. The hypothetical nature of such an elicitation approach originated its name and is the reason that CVM is referred to as a stated-preference method as opposed to a revealed-preference method where individuals' behaviors are observed and documented. Important information regarding the characteristics of demand for a commodity can be generated from such hypothetical exercises when the commodity is not being traded in a real market (Cameron and Huppert, 1991).

The core of a CV study lies in its elicitation technique as the quality of its findings largely depends on it. There are numerous different elicitation techniques among which the most extensively discussed in the literature are the (iterative) bidding game, open-ended (OE) questioning, payment-card (PC) method, and dichotomous choice (DC) or "take-it-or-leave-it" approach (Boyle and Bishop, 1988; Mitchell and Carson, 1989; O'Brien and Gafni, 1996; Reaves et al., 1999; Smith, 2000; Venkatachalam, 2004).

The bidding game is the oldest elicitation technique in CVM (Davis, 1964). The questioning process starts with a random monetary bid to which the individual can respond “yes” or “no” for a commodity, and then a higher or lower bid depending on the response follows for acceptance or rejection by the individual. This process continues until the maximum bid accepted by the individual is reached. The bidding game assists respondents by the simple and familiar nature of the choice making (Davis, 1964) as they only need to accept or reject the bid amount, which is what they face on a daily basis. The iterative process in the bidding game has the advantage of leading respondents to more thoroughly evaluate the value of, and their willingness to pay (WTP) for, the commodity (Hoehn and Randall, 1987). However, the disadvantages including starting point bias that stems from the initial bid affecting final bids accepted by respondents, and the costly necessity of interviewers present during the questioning process impair the usage of the bidding game (Boyle et al., 1985).

The OE questioning only engages respondents in stating the maximum amount that they are willing to pay for the commodity being evaluated. The simplicity of the format excludes the disadvantages of the bidding game mentioned above (Walsh et al., 1984). Then again, this format challenges respondents in that they need to decide a monetary value on the commodity and invites strategic overstatement, therefore it is unlikely to provide the most reliable valuations (NOAA, 1993). In addition, the fact that respondents are not familiar with the commodity being valued or not used to the OE questioning is subject to generating a large number of non-responses or protest zero responses (O’Brien and Gafni, 1996).

The PC method provides the respondents with a visual array of prices, ranging from $0 to some large amount, and the respondents select a price from the array. This preserves the properties of the OE while making it easier for the respondents to choose a price, thereby increasing response rates (Mitchell and Carson, 1989). Mitchell and Carson (1984) developed this method as an alternative to the bidding game to bypass the need of offering a single starting point to the respondent. In addition, it presents more of a context to the respondent than the OE method, although the disadvantage of the PC method is its tendency to cause range and centering biases (Mitchell and Carson, 1989). A study by Rowe et al. (1996), however, did not detect range and centering biases when using an exponential response scale on the payment card without truncating the range. The exponential response scale manages to cover a large range of responses without containing a cumbersome number of values.

The take-it-or-leave-it approach (or single-bounded DC approach), which was introduced by Bishop and Heberlein (1979), asks if the respondent is willing to pay a predetermined monetary amount for the commodity being valued and the respondent only needs to state 'yes' or 'no' to the bid. This approach resembles the bidding game in a way that simplifies the respondent's decision making, yet is free of the iterations in the bidding game (Mitchell and Carson, 1989). During the elicitation process different monetary amounts are assigned to respondents so that statistical models can be implemented to obtain point estimates and examine influential factors on WTP (Cameron and James, 1987). The take-it-or-leave-it approach suffers statistical inefficiency in that a large number of observations are required to identify the underlying distribution of WTP values (Reaves et al. 1999). To address this problem, the take-it-or-leave-it with a follow-up approach (or double-bounded DC approach, DBDC) has been developed where a second bid is proposed, higher if the first bid is accepted or lower if the first bid is turned down.[2] Although the double-bounded method causes bias when responses to the first and second bid are inconsistent, as Hanemann et al. (1991) concluded, the gain in efficiency largely prevails over the loss in bias, which, furthermore, tends to be moderate. Moreover, the DC method is incentive-compatible in that there is no strategic motive for the respondent to answer untruthfully (Hoehn and Randall, 1987; NOAA, 1993). Nevertheless, some respondents tend to be yes-sayers who would answer "yes" to a bid even if it is higher than their true WTP, which potentially causes upward bias (Mitchell and Carson, 1989; Ready et al. 1996). Like the bidding game, the DC method induces starting point bias since the respondent is asked to accept or reject a predetermined amount and if the respondent is unsure about the value of the commodity it is likely that the individual would base his WTP on the proposed amount (Mitchell and Carson, 1989).

It has long been recognized that different elicitation formats in the CVM can generate different WTP estimates (Carson et al. 2001; Welsh, 1998). Generally, DC formats are inclined to have higher WTP estimates than other elicitation formats (Carson et al. 2001). Brown et al. (1996) found that in majority of studies the estimates of WTP values derived from DC formats are greater than those from OE formats. More specifically, for the 11 studies listed, they calculated the ratios of DC to OE mean WTP,

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[2] Although DC approach with additional follow-ups such as triple-bounded or multiple-bounded DC designs have been explored (Langford et al. 1996; Welsh and Poe, 1998), one and two follow-ups have been the most commonly used and generally recommended (Mitchell and Carson, 1989).

which ranged from 1.12 to 4.78. A similar relation goes between DC estimates and PC estimates such that the estimates of DC values exceed those of PC values (Welsh, 1998).

The DC approach has been largely endorsed because the process of answering DC questions resembles the familiar choice making for consumers, which makes it easier to elicit true WTP. Like DC, the PC method does not consume much effort from respondents. In addition, it can generate direct estimates of WTP. Previous studies have attempted to compare DC with PC. The question of which one is more preferable is still unsettled but those comparisons certainly have brought a lot of insight to research on this topic. Holmes and Kramer (1995) surveyed independent samples with DC and PC questions, i.e. a split-sample design, and by comparing actual with predicted and simulated counterfactual responses they found that WTP distributions and mean WTP were different across these elicitations formats. Furthermore, they detected yea-saying and starting point bias in CV responses using a paired-comparison test.

Ready et al. (1996) reported that the DC format generated much higher WTP values than the PC format after comparing the two formats via a split-sample survey for food safety improvements. They concluded that the differences were mostly due to behavior differences that respondents had towards the two formats, not to the bias caused by distributional assumption made for the DC approach, and that yea-saying in DC might have contributed in part to the differences. Hackl and Pruckner (1999) compared the differences between PC and double-bounded DC (DBDC) answers through the welfare measures of models featuring different assumed probability distributions. Although they concluded that on average the PC welfare measures are below the closed-ended double-bounded measures, they suggested comparison between different question formats be conducted equally, i.e. according to the underlying evaluation models.

A study by Hammerschmidt et al. (2003) conducted two consecutive surveys in a time span of 2 – 4 months that collected first PC and then DC answers from the same sample. In addition to the finding that WTP estimates from the two elicitation formats were different, they discovered the pattern for unexpected yes/no DC answers such that respondents were more likely to say yes to DC questions than they did to PC questions at high bids whereas they were more likely to say no to DC questions than they did to PC questions at low bids, and overall the former outweighed the latter.

The current study focuses on the comparison between the estimates of a DBDC model and those of a PC model after incorporating a random variable in both models. This random variable is targeted to capture unobserved effects and the correlation among responses from the same respondent. The data used for analysis was collected during a taste-testing survey where the two elicitation formats were randomly applied to participants so as to investigate their WTP for cherries in the context of their perception and opinion of fruit quality as well as their demographics. Such a split-sample design is recommended by Ready et al. (1996). This direct comparison is aimed to empirically test the convergent validity of the two approaches that involve different answering behavior.

II. Econometric Models

Payment Card Model

During the survey, the WTP question in a PC format asked respondents to mark how much they would be willing to pay for cherries on a $0 – $5.99 scale in increments of $0.49 or $0.50. Each respondent that participated in the survey tasted and evaluated five different cultivars of cherries (Bing, Lapin, Skeena, Regina, and Sweetheart) in random orders. Correlation between evaluations of different cherries from the same respondent arises when a single model is estimated for all cultivars. Taking this into consideration, a random effect linear regression model is constructed as follows

$$Y_{ij} = \alpha + \lambda' x_{ij} + \delta_1 D_2 + \delta_2 D_3 + \delta_3 D_4 + \delta_4 D_5 + \eta_i + \varepsilon_{ij} \quad i = 1, 2, \ldots, n; j = 1, 2, \ldots, 5 \quad (5.1)$$

where response variable Y_{ij} is the dollar-value WTP, x_i is a vector of explanatory variables such as demographic information and consumption characteristics for individual i, D_2, D_3, D_4, and D_5 are dummy variables representing cultivars Lapin, Skeena, Regina, and Sweetheart, respectively, and α, λ', δ_1, δ_2, δ_3, and δ_4 are unknown parameters that need to be estimated. Note that from the way the model is constructed, coefficients δ_1, δ_2, δ_3, and δ_4 measure the differential effects of cultivars Lapin, Skeena, Regina, and Sweetheart, respectively, in comparison to that of cultivar Bing. η_i is the random coefficient that accounts for the correlations among the evaluations from the same respondent and is assumed to be normally distributed with mean 0 and variance σ_η^2 across all respondents. ε_{ij} is the random error term and is assumed to follow a normal distribution with mean 0 and variance σ_ε^2 across all observations. For five responses from each respondent, the variance and covariance matrix is

$$\Sigma = \begin{bmatrix} \sigma_\varepsilon^2 + \sigma_\eta^2 & \sigma_\eta^2 & \sigma_\eta^2 & \sigma_\eta^2 & \sigma_\eta^2 \\ \sigma_\eta^2 & \sigma_\varepsilon^2 + \sigma_\eta^2 & \sigma_\eta^2 & \sigma_\eta^2 & \sigma_\eta^2 \\ \sigma_\eta^2 & \sigma_\eta^2 & \sigma_\varepsilon^2 + \sigma_\eta^2 & \sigma_\eta^2 & \sigma_\eta^2 \\ \sigma_\eta^2 & \sigma_\eta^2 & \sigma_\eta^2 & \sigma_\varepsilon^2 + \sigma_\eta^2 & \sigma_\eta^2 \\ \sigma_\eta^2 & \sigma_\eta^2 & \sigma_\eta^2 & \sigma_\eta^2 & \sigma_\varepsilon^2 + \sigma_\eta^2 \end{bmatrix} \tag{5.2}$$

Since respondents are assumed to be independent of each other, the disturbance covariance matrix for all observations is

$$\Omega = \begin{bmatrix} \Sigma & \mathbf{0} & \mathbf{0} & \cdots & \mathbf{0} \\ \mathbf{0} & \Sigma & \mathbf{0} & \cdots & \mathbf{0} \\ & & & \vdots & \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \cdots & \Sigma \end{bmatrix}_{5n \times 5n} \tag{5.3}$$

where **0** denotes a 5×5 zero matrix.

A feasible generalized least squares (FGLS) procedure is employed in the Stata programming language to estimate the coefficients in the PC model.

Double-Bounded Model

The double-bounded format WTP questions in the survey engaged respondents in two bids. A second question associated with a higher or lower value is asked based on responses from the first question. There are four possible outcomes: (1) the respondent's willingness to pay is lower than the discount offered so she/he is not willing to buy the cherry at all, i.e. "no, no"; (2) the respondent's willingness to pay is between the lower bid price and the initial bid price, i.e. "no, yes"; (3) the respondent's willingness to pay is above the initial bid but lower that the premium offered, i.e. "yes, no"; (4) the respondent's willingness to pay is above the premium offered, i.e. "yes, yes."

The initial bid (B_0) equals zero and implies no price difference between the cherry the respondent just tasted and other cherries. The second bid is contingent upon the response to the first bid. It will be a discount bid (B_D), if the respondent answers she/he would not buy the cherries at their usual price. If the respondent answers that she/he would buy the cherries at their usual price, it becomes a premium bid (B_P). The sequence of questions isolates the range in which the respondent's true WTP for eating quality in cherries lies. The second bid, B_D *or* B_P, in conjunction with the response to the initial preference decision, allows an upper bound and a lower bound to be placed on the respondent's unobservable true WTP.

Let WTP_{ij} denote an individual's WTP (bid function) for the tasted cherry. The following discrete outcomes (D_g) of the bidding process are

Group

$$D_g = \begin{cases} 1 & WTP_{ij} \quad < B_D \\ 2 & B_D \leq \quad WTP_{ij} \quad < B_0 \\ 3 & B_0 \leq \quad WTP_{ij} < B_P \\ 4 & B_P \leq WTP_{ij} \end{cases} \tag{5.4}$$

Respondents who indicated they require no discount and would pay the premium price B_P fall into the fourth group (D_4). Those who indicated they require no discount and would pay a premium of less than B_P fall into the third group (D_3). Respondents who required a discount greater than or equal to B_D fall into the second group (D_2). Finally, the first group (D_1) contains respondents indicating the lowest WTP. Consumers in this group are not willing to purchase the tasted cherry at the discount offered.

As with the payment card model, correlation between responses on different cherries from the same respondent also occurs. To address this issue, a special case of the double-bounded model, a mixed logit model with a random coefficient is implemented. The WTP function for the tasted cherry cultivar *j* for individual *i* is specified as

$$WTP_{ij} = \alpha_j - \rho B_{ij} + \lambda' x_{ij} + \eta_i + \varepsilon_{ij} \qquad i = 1, 2, \ldots, n; j = 1, 2, \ldots, 5 \tag{5.5}$$

where α_j captures the differences in utility due to the different cherry cultivars being evaluated. B_{ij} denotes the final bid that was reached by individual *i* evaluating cultivar *j*.

In order to be more effective in eliciting consumers' true WTP, different prices, higher or lower than the initial price depending on the first response, were offered to respondents. x_i represents the explanatory variables for individual *i* the same as for the PC model. η_i denotes the added random coefficient that accounts for the correlation between responses from the same respondent, as well as other unobserved effect on WTP. Note that if $\eta_i = 0$, (5.5) represents the WTP in a typical double-bounded model. It is assumed that η is normally distributed with mean 0 and variance σ_η^2 over respondents. ε is assumed to have an extreme value distribution i.i.d. over all observations. ρ, λ' are unknown parameters that need to be estimated, as well as the intercepts α's. As for ρ, it is natural to expect lower WTP associated with higher bids and higher WTP associated with lower bids, thus a negative relationship (i.e. the negative sign in front of ρ) is proposed.

The probabilities for the above WTP choice groups can be obtained for the mixed logit model. The conditional probabilities of WTP choices are expressed as

$$\begin{cases} \text{Prob}(Y_i = 1 \mid \eta) = \dfrac{e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}} \\ \text{Prob}(Y_i = 2 \mid \eta) = \dfrac{e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}} - \dfrac{e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}} \\ \text{Prob}(Y_i = 3 \mid \eta) = \dfrac{e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}} - \dfrac{e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}} \\ \text{Prob}(Y_i = 4 \mid \eta) = 1 - \dfrac{e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}} \end{cases} \tag{5.6}$$

Since η is unknown, to obtain the unconditional probabilities, the logit model needs be integrated over all values of η weighted by the density of η as follows

$$\begin{cases} \text{Prob}(Y_i = 1) = \int \left[\dfrac{e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}} \right] f\left(\eta; \sigma_\eta^2\right) d\eta \\ \text{Prob}(Y_i = 2) = \int \left[\dfrac{e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}} - \dfrac{e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^D + \lambda' x_{ij} + \eta_i}} \right] f\left(\eta; \sigma_\eta^2\right) d\eta \\ \text{Prob}(Y_i = 3) = \int \left[\dfrac{e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}} - \dfrac{e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^I + \lambda' x_{ij} + \eta_i}} \right] f\left(\eta; \sigma_\eta^2\right) d\eta \\ \text{Prob}(Y_i = 4) = \int \left[1 - \dfrac{e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}}{1 + e^{\alpha_j - \rho B_{ij}^P + \lambda' x_{ij} + \eta_i}} \right] f\left(\eta; \sigma_\eta^2\right) d\eta \end{cases} \tag{5.7}$$

where *f* is the probability density function (PDF) of a normal distribution with mean 0 and variance σ_η^2.

The log-likelihood function comprised of the resulting integrated probabilities for all observations can be obtained and is then maximized with parameters being estimated as a result.

There are two ways to calculate mean WTP. First, estimate intercepts α 's and the slope coefficient ρ in (5.5) by setting $\lambda' = 0$ so that α_j / ρ makes the mean WTP for cultivar *j* (Hanemann et al. 1991). This mean WTP also serves as the base value for evaluating marginal effects. The marginal effect of an explanatory variable is essentially the difference between when the parameter estimate is added to the intercept (base) and when it is not:

$$\text{Marginal Effect of } \lambda_k = \frac{\alpha + \lambda_k}{\rho} - \frac{\alpha}{\rho} = \frac{\lambda_k}{\rho}. \tag{5.8}$$

Or alternatively, the ratio $(\alpha_j + \lambda' x)/\rho$ is derived from the random utility model as the mean WTP for cultivar *j* for a given value of the vector *x* (Kaneko and Chern, 2003; Lin et al. 2006; Qaim and Janvry, 2003), which implies that the utility level from consuming cultivar *j* is at least as much as the monetary value would provide otherwise. This approach recognizes the influences of explanatory variables on the mean WTP, and hence is adopted in this study. Taking the partial derivative of the above ratio with respect to an explanatory variable will result in the marginal effect of that variable (Lin, et al. 2006), which is λ_k/ρ. So from either method above, the marginal effect of an explanatory variable is shown to be the same. The standard errors of the marginal effects can be obtained from the asymptotic variance, calculated by following the delta method of deriving standard errors of nonlinear function parameter estimates (Greene, 2003).

III. Survey Data

A cherry taste-testing survey was conducted at an outside public venue, the Portland Farmers' Market, in July 2005. Volunteers were recruited to taste cherry samples and complete questionnaires inquiring about information on the respondents' demographics and preferences, as well as WTP. The WTP questions were conveyed in two different formats, namely double-bounded DC and PC, which were randomly assigned to respondents. In total, 81 respondents completed the survey with the double-bounded DC questions and 87 completed the survey with the PC questions. Each respondent was instructed to taste five cultivars of cherries, Lapin, Bing, Skeena, Regina, and Sweetheart, not necessarily in this order. Besides WTP questions, they were also asked to express their opinions on the individual cultivars and preferences among them all. A few pieces of information on their demographics, shopping patterns and preferences for cherries were collected in the last part of the questionnaire. The responses were recorded using ballots on computer tablets, with which respondents could only proceed after they finished the previous question. Therefore, all questionnaires were complete.

Ten juniors under the age of 18 also took a short survey, but the WTP and most of the demographics questions were excluded in that version. Hence, these observations were discarded from the study.

The demographics of the respondents who participated in the survey with the DC questions are shown in Table 5.1. It is apparent that the majority of the respondents were female, accounting for 59.26% of the respondents. Women are over-represented in the experiment, but this is not a concern since a greater proportion of women do the household shopping. Among the seven age groups, ages 35 to 44 had the highest percentage of respondents (23.46%). Other age groups had a considerable share except for groups 18 – 24 and 65+, which only captured 9.88% and 6.17% of the respondents, respectively. This is comparable to the general population of Portland. The mode annual household income level is in the category greater than $75,000 (39.51%) while the percentage of the respondents descends as income level decreases except for the lowest income group (less than $10,000). The income responses are comparable to the general population of Portland.

The DC respondents' answers to the shopping place and preferences for stem/stemless cherries are summarized in Table 5.2. There is an overwhelming preference for cherries with the stems still on during purchasing among the respondents, 93.83% to be exact. Furthermore, all respondents except for one were willing to pay the same or less for stemless cherries. In terms of the most frequent shopping place to obtain produce during the summer months, 32.10% of the respondents stated supermarkets and grocery stores, 56.79% stated farmers markets, produce stands, and farm direct or grow at home, and only 11.11% stated natural food stores and food COOPs. As for organic constituent of regular fruit purchases, 1 – 10% had the highest percentage of respondents (18.52%), followed by 81 – 90% (14.81%) and then 91 – 99% (13.58%). 100% had the least percentage of respondents (1.23%).

A glimpse of DC respondents' opinions on the cherries is presented in Table 5.3. Appearance wise, the highest percentage of the respondents (27.16%) liked Bing cherries the best and the lowest percentage (13.58%) liked Sweetheart the best. In terms of fruit size, Skeena was preferred by the highest percentage of the respondents (35.80%) and Sweetheart the lowest (9.88%). As to color, Bing and Skeena were equally preferred by the highest percentage of the respondents (23.46%) and Sweetheart the lowest (11.11%). Sweetheart has the highest mean overall liking (7.17) with the lowest standard deviation (1.89) on a 0-10 scale whereas Lapin has the lowest mean overall liking (5.73) with standard deviation being 2.25. Firmness, sweetness and tartness/sourness were being evaluated on a 1-5 "just about right" scale anchored with 3 "just about right," 1 "not nearly firm/sweet/tart/sour enough," and 5 "much too firm/sweet/tart/sour" among which "just about right" represents the optimum state. The means of firmness for all cultivars are closely scattered around 3 with Skeena and Regina being equally closest to 3. The means of sweetness are all below the optimum. The closest to 3 is the mean for Sweetheart (2.68). Same as sweetness, the means of tartness/sourness are all below 3. The means for Bing and Skeena (2.85) are equally closest to 3. When asked if they would buy cherries to eat fresh for $2.49 per pound, a majority of respondents answered yes to all cultivars except for Lapin.

The distribution statistics of DC responses to various premiums and discounts for all cherry cultivars are available in Tables 5.4 and 5.5. As the premium amount increases, the percentage of respondents saying yes to the premium price does not necessarily diminish, and as the discount increases, the percentage of respondents saying yes to the discounted price does not necessarily increase, which is slightly counterintuitive. This is possibly associated with the fact that fresh cherries have a very short season, which occasionally causes cherries to not act as a normal good.

Demographics of the respondents who participated in the survey with the PC questions are shown in Table 5.1. As with the DC respondents, the majority were female, accounting for 59.77% of the respondents. Age group 25 – 34 had the highest percentage of respondents (29.89%), followed by age group 35 – 44 (24.14%). Other age groups had similar numbers of respondents except for age group 55 – 64, which had the lowest percentage of respondents (9.20%). Same with the DC case, the mode annual household income level is greater than $75,000 and income level $10,000 – 14,999 had the fewest respondents. Both age and income responses are comparable to the general population of Portland.

PC respondents' shopping place and stem/stemless preferences for cherries are presented in Table 5.2. Leaving the stem on during purchasing was preferred by all respondents except for three, which made 96.55%. Only three respondents would be willing to pay more for stemless cherries and the rest pay the same or less. In terms of the most frequent shopping place for produce in summer, the PC respondents showed a similar pattern as their DC counterparts, that is farmers markets, produce stands, and farm direct or grow at home had the majority of the respondents (56.32%), followed by supermarkets and grocery stores (35.63%), and natural food stores and food COOPs had the least share, 8.05%. Same with the DC case, the mode organic purchase is 1 – 10% of regular fruit purchases, accounting for 16.09% of the respondents. 11 – 20% and 31 – 40% had the second highest percentage of respondents, and 0% had the least.

Table 5.6 contains PC respondents' opinions on the cherries. Regarding appearance, the highest percentage of respondents (34.48%) liked Lapin the best. Like the DC respondents, the least percentage (14.94%) liked Sweetheart the best. About fruit size, PC respondents were in line with their DC counterparts, Skeena was preferred by the highest percentage of respondents (28.74%) and Sweetheart the lowest (11.49%). Color wise, Lapin was preferred by the highest percentage of respondents (28.74%) and Skeena the lowest (14.94%). Bing has the highest mean overall liking (6.55) with the lowest standard deviation (1.93) while Skeena has the lowest mean overall liking (6.01) with standard deviation 2.30. "Just about right" valuations from PC respondents on firmness, sweetness, and tartness/sourness resemble those from the DC respondents. The means of firmness for all cultivars are closely scattered around 3 with Regina (3.02) being the closest to 3. The means of sweetness and tartness/sourness are all below the optimum. The closest to 3 are the mean sweetness for Lapin (2.60) and the mean tartness/sourness for Sweetheart (2.77).

Table 5.7 shows the frequency that the WTP intervals were chosen by respondents on the PC for each cultivar. It appears that the peak of the frequency is either at interval \$1.99 – 2.49 or \$2.49 – 2.99 from which the frequency descends as interval values increase and decrease except for interval \$0 – 0.49 where some unusually high frequencies are present.

IV. Model Specification and Estimation Results

In addition to firmness and sweetness that respondents evaluated for each individual cultivar, respondents' demographic information such as gender, age and annual household income, as well as percentage of regular fruit purchases that is organically grown, are incorporated in both the mixed logit model and PC model as explanatory variables, namely *Firmness*, *Sweetness*, *Organic*, *Gender*, *Age*, *Income*, *HighIncome*. *Firmness* and *Sweetness* are both discrete variables coded as -2 for "not nearly firm/sweet enough" or "much too firm/sweet", 0 for "just about right", and -1 for in-between. *Organic* is a semi-continuous variable that takes the values of the midpoints of the percentage ranges of organic fruit purchases that the respondents claimed to make. *Gender* is an indicator variable that is 1 if it represents female and 0 if it is male. *Age* is a semi-continuous variable consisting of the midpoints of all age groups except for 65+, the latter being denoted by a dummy variable *Senior*, taking the value of 1 as falling into the category and 0 as not. *Income* is a semi-continuous variable corresponding to the scaled midpoints (divided by 10,000) of all income groups that are under $75,000. *HighIncome* is an indicator variable representing observations that belong to the income group above $75,000. It is 1 when the annual household income is greater than $75,000 and 0 otherwise.

The WTP function for the mixed logit model is specified as follows:

$$\begin{aligned} WTP_{ij} = {} & \alpha_j - \rho B_{ij} + \lambda_1 Firmness_{ij} + \lambda_2 Sweetness_{ij} + \lambda_3 Organic_i + \lambda_4 Gender_i \\ & + \lambda_5 Age_i + \lambda_6 Senior_i + \lambda_7 Income_i + \lambda_8 HighIncome_i + \eta_i + \varepsilon_{ij} \end{aligned} \quad (5.9)$$

The parameter estimates of the model and their standard errors, z-tests, and P-values are reported in Table 5.8. The estimated marginal effects and their standard error and P-values are presented in Table 5.9. It is apparent that the probability that consumers are willing to pay more for cherries significantly increases as firmness or sweetness approaches "just about right" on the scale and this is even more so for sweetness.

Percentage of organic purchases has a positive impact on WTP, i.e. the higher the proportion that consumers buy fruit that is organic the more likely they are willing to pay more for the cherries. Consumers' gender does not appear to be a significant factor to WTP. *Age* is statistically significant at a 0.10 level and *Senior* is significant at a 0.05 level with a higher marginal effect, which implies that the older the consumers, the more likely they are willing to pay more, and this trend is even more predominant for consumers over 65 as opposed to those under 65. At a 0.10 significance level, annual household income level has a negative effect on the probability of paying more when under \$75,000 such that the higher the income levels the lower the probability of consumers paying more. However, this income effect is no longer significant for income level higher than \$75,000. σ_η^2 is statistically significant, which justifies the specification of incorporating such a random coefficient in the model.

The linear PC model can be written as follows:

$$\begin{aligned} Y_{ij} &= \alpha + \lambda_1 Firmness_{ij} + \lambda_2 Sweetness_{ij} + \lambda_3 Organic_i + \lambda_4 Gender_i + \lambda_5 Age_i \\ &\quad + \lambda_6 Senior_i + \lambda_7 Income_i + \lambda_8 HighIncome_i + \delta_1 D_2 + \delta_2 D_3 + \delta_3 D_4 + \delta_4 D_5 \\ &\quad + \eta_i + \varepsilon_{ij} \end{aligned} \qquad (5.10)$$

The parameter estimates of the model and their standard errors, z-tests, and P-values are reported in Table 5.10. Note that the coefficients for the explanatory variables are also the marginal effects for these variables. Similarly to what was shown in the DC results, *firmness* and *sweetness* significantly affect WTP in a positive way, and sweetness does so more than firmness. Statistically significant at a 0.10 level, *Senior* negatively affects WTP, implying that consumers over 65 are less likely to pay more for cherries than younger people. This contradicts with the finding for the DC model. Moreover, while explanatory variables *Age*, *Organic*, and *Income* are statistically significant for the DC model, they are not for the PC model. Neither are *Gender* and *HighIncome*. Dummy variables D_2, D_3, D_4, and D_5 measure how much higher (or lower) the response WTP payments are for cultivars Lapin, Skeena, Regina and Sweetheart, respectively, compared to that for cultivar Bing. As seen from the table, dummies for Lapin, Skeena and Regina are highly significant as well as negative, which indicates that at any given levels of the explanatory variables the response WTP payments for Lapin, Skeena and Regina are less than that of Bing by $0.25, $0.23 and $0.24, respectively.

Mean WTP for DBDC and PC models and their ratios are calculated and shown in Table 5.11. Not surprisingly, mean WTP values for DBDC exceed those for PC, but the discrepancy between the two is relatively mild, ranging from 1.22 to 1.44. For both models, mean WTP for Bing is the largest, followed by mean WTP for Sweetheart. Mean WTP values for Lapin, Skeena, and Regina rank differently over the two models, but they are very close in magnitude within each model.

V. Conclusions and Discussion

Choosing among CV elicitation formats, especially between open-ended (e.g. OE and PC) and closed-ended (e.g. DC) formats, has long been an ongoing debate in the literature. Ready et al. (1996) mentioned a number of issues that need to be considered while weighing the choices: (1) cost of running surveys, (2) effort needed from respondents, (3) precision of the WTP estimates, and (4) incurred biases, whether statistical or behavioral. Concerning the first two issues, this study excludes the bidding game and OE from the comparison and compares only between PC and DBDC. The empirical findings of the current study are consistent with those of earlier studies in that the two elicitation formats in CVM generate different estimates and mean WTP values of DBDC exceed those of PC. Discussion of the discrepancy between the two formats is focused on the latter two issues and other relevant matters.

PC method elicits additional information about WTP as well as making direct estimates of WTP compared to DC approach, however some have doubted the quality of its performance because the questioning places respondents in an unfamiliar market situation (Ready et al. 1996). Since DC questioning most resembles the real-life market situation where consumers only need to respond to listed prices, the familiarity and ease in the decision making process certainly has earned DC approach popularity among all CV elicitation formats for its ability to predict true WTP (Boyle and Bishop, 1988; Brown et al. 1996; NOAA, 1993; Smith, 2000). In addition, Brown et al. (1996) argued that having to state specific WTP values as being required in OE or PC creates cognitive difficulty might result in lower bids. The fundamental differences in the two elicitation formats cause behavior differences of respondents in responding to the two, which ultimately contributes to the differences in WTP estimates. Even though the matter of which method produces more precise estimates is still unresolved, advantages of DC emerge to outweigh those of PC.

The differences in resulting estimates could also be due to the biases associated with the two methods as mentioned before. Besides, these biases are prone to impair criterion validity, which refers to conformity of stated and revealed WTP values (Hammerschmidt et al. 2003). Nonetheless, the biases were expected to be considerably mitigated because cherries and cherry purchase were likely to be familiar to people who eat cherries, such as the respondents in the study who were attracted to participate in the taste test voluntarily. Familiarity with a good is considered as critical for respondents to provide reliable answers. Kealy and Turner (1993) noted that WTP values of OE and DC were different for the public good but not for the private good that was more familiar and tangible to respondents. Speculatively, the fact that cherries are a well-known good, and familiar to respondents might be connected to the mild difference in mean WTP for the two formats. This familiarity combined with the familiarity of DC questioning format is expected to yield more realistic results for the DC approach. In fact, considering the fact that the prices for cherries that were selling at the Saturday market and elsewhere during that time ranged around \$2.49 to \$3.49, and that \$2.49 was also the price that was instructed in the survey as the benchmark price for fresh cherries at the time, and also the fact that the ratings that respondents offered in terms of the overall liking, firmness, sweetness and tartness of the cherries were favorable, the mean WTP values of DC would strike as more sensible estimates of the true values for the data.

The random variable incorporated in both DC and PC models enabled utilizing the entire data as a whole, which reserved all available information and is certainly preferred (Chase et al. 1998). This random effect specification allows inferences made beyond the sample (Greene, 2003). And the information derived from the correlation among the multiple observations for the same individual is effective in generating efficient parameter estimates, which is more so for a DC model (Chase et al. 1998).

A quick check of consistency with economic theory on negative own-price elasticity (Carson et al. 2001) can be made with the DC estimates. As it turns out, WTP exhibits a negative relationship with the final bidding amount, indicating that the probability of WTP declines as the final bid increases, which agrees with economic theory. This advantage clearly lacks with PC estimates.

With the knowledge that many methodological problems are not yet unraveled (Diener et al. 1998), what elicitation format of CVM can derive better portrayals of the true WTP is still an open-answer question. Nevertheless, the empirical results of this study just might somewhat favor the mixed logit DBDC approach.

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Table 5.1: Summary Statistics of Respondents' Demographics for the DBDC and PC Surveys

Variable	Description and Coding	Distribution	
		DBDC	PC
Gender	1: Female	59.26%	59.77%
	2: Male	40.74%	40.23%
Age	1: 12-17	0.00%	0.00%
	2: 18-24	9.88%	11.49%
	3: 25-34	20.99%	29.89%
	4: 35-44	23.46%	24.14%
	5: 45-54	20.99%	12.64%
	6: 55-64	18.52%	9.20%
	7: 65+	6.17%	12.64%
Annual Household Income	1: Less than $10,000	9.88%	6.90%
	2: $10,000-14,999	4.94%	4.60%
	3: $15,000-24,999	4.94%	5.75%
	4: $25,000-34,999	11.11%	16.09%
	5: $35,000-49,999	13.58%	12.64%
	6: $50,000-74,999	16.05%	22.99%
	7: Greater than $75,000	39.51%	31.03%

Table 5.2: Summary Statistics of Respondents' Preferences for the DBDC and PC Surveys

Variable	Description and Coding		Distribution DBDC	Distribution PC
Stem Preference	Buy Cherries with the Stems Still on		93.83%	96.55%
	Buy Cherries that are Stemless		6.17%	3.45%
Purchase Intent for Stemless	Pay More for Stemless Cherries		1.23%	3.45%
	Pay the Same for Stemless Cherries		70.37%	50.57%
	Pay Less for Stemless Cherries		28.40%	45.98%
Where Most of the Produce is Obtained during the Summer Months	Supermarkets, Grocery Stores	Most Frequent	32.10%	35.63%
		In the Middle	39.51%	29.89%
		Least Frequent	28.40%	34.48%
	Farmers Markets, Produce Stands, Farm Direct or Grow at Home	Most Frequent	56.79%	56.32%
		In the Middle	30.86%	36.78%
		Least Frequent	12.35%	6.90%
	Natural Food Stores, Food COOPs	Most Frequent	11.11%	8.05%
		In the Middle	29.63%	33.33%
		Least Frequent	59.26%	58.62%
% of Regular Fruit Purchases that is Organically Grown	1: 0%		2.47%	2.30%
	2: 1-10%		18.52%	16.09%
	3: 11-20%		9.88%	13.79%
	4: 21-30%		7.41%	10.35%
	5: 31-40%		8.64%	13.79%
	6: 41-50%		9.88%	9.19%
	7: 51-60%		6.17%	6.90%
	8: 61-70%		2.47%	2.30%
	9: 71-80%		4.94%	8.05%
	10: 81-90%		14.81%	2.30%
	11: 91-99%		13.58%	11.49%
	12: 100%		1.23%	3.45%

Table 5.3: Summary Statistics for Consumer Responses over the Cherries for the DC Survey

Variable	Description and Coding		Distribution				
			Bing	Lapin	Skeena	Regina	Sweetheart
Appearance	Like Best for Overall Appearance Among All Cultivars		27.16%	16.05%	23.46%	19.75%	13.58%
Size	Like Best for Size Among All Cultivars		17.28%	20.99%	35.80%	16.05%	9.88%
Color	Like Best for Color Among All Cultivars		23.46%	19.75%	23.46%	22.22%	11.11%
Liking	Overall Liking for Individual Cultivars on a 0-10 Line Scale		Mean=7.09 Std.=2.05	Mean=5.73 Std.=2.25	Mean=6.74 Std.=1.93	Mean=6.00 Std.=2.40	Mean=7.17 Std.=1.89
Firmness	Firmness for Individual Cultivars on a 1-5 Just about Right Scale		Mean=2.85 Std.=0.48	Mean=3.09 Std.=0.71	Mean=3.05 Std.=0.42	Mean=3.05 Std.=0.65	Mean=3.28 Std.=0.62
Sweetness	Sweetness for Individual Cultivars on a 1-5 Just about Right Scale		Mean=2.59 Std.=0.75	Mean=2.10 Std.=0.89	Mean=2.41 Std.=0.74	Mean=2.63 Std.=1.03	Mean=2.68 Std.=0.77
Tartness/ Sourness	Tartness for Individual Cultivars on a 1-5 Just about Right Scale		Mean=2.85 Std.=0.74	Mean=2.74 Std.=0.80	Mean=2.85 Std.=0.74	Mean=2.46 Std.=0.82	Mean=2.77 Std.=0.60
Purchase Intent	Buy for $2.49 per pound	1: No	32.10%	53.09%	43.21%	46.91%	32.10%
		2: Yes	67.90%	46.91%	56.79%	53.09%	67.90%

Table 5.4: Range and Distribution of Response Rates to the Randomly Assigned Premiums for the DC Survey

	Premium Prices	Bing	Lapin	Skeena	Regina	Sweetheart
Yes to Premium	$2.99	9.88%	2.47%	11.11%	9.88%	11.11%
	$3.49	7.41%	2.47%	6.17%	4.94%	6.17%
	$3.99	11.11%	4.94%	11.11%	4.94%	6.17%
No to Premium		39.51%	37.04%	28.40%	33.33%	44.44%
Total		67.91%	46.92%	56.79%	53.09%	67.89%

Table 5.5: Range and Distribution of Response Rates to the Randomly Assigned Discounts for the DC Survey

	Discounted Prices	Bing	Lapin	Skeena	Regina	Sweetheart
Yes to Discount	$1.99	7.41%	13.58%	4.94%	8.64%	7.41%
	$1.49	9.88%	6.17%	12.35%	7.41%	8.64%
	$0.99	4.94%	9.88%	9.88%	9.88%	6.17%
No to Discount		9.88%	23.46%	16.05%	20.99%	9.88%
Total		32.11%	53.09%	43.22%	46.92%	32.10%

Table 5.6: Summary Statistics for Consumer Responses over the Cherries for the PC Survey

Variable	Description and Coding	Distribution				
		Bing	Lapin	Skeena	Regina	Sweetheart
Appearance	Like Best for Overall Appearance Among All Cultivars	16.09%	34.48%	16.09%	18.39%	14.94%
Size	Like Best for Size Among All Cultivars	18.39%	25.29%	28.74%	16.09%	11.49%
Color	Like Best for Color Among All Cultivars	17.24%	28.74%	14.94%	22.99%	16.09%
Liking	Overall Liking for Individual Cultivars on a 0-10 Line Scale	Mean=6.55 Std.=1.93	Mean=6.28 Std.=2.07	Mean=6.01 Std.=2.30	Mean=6.29 Std.=2.28	Mean=6.10 Std.=2.47
Firmness	Firmness for Individual Cultivars on a 1-5 Just about Right Scale	Mean=3.05 Std.=0.61	Mean=3.09 Std.=0.62	Mean=2.90 Std.=0.59	Mean=3.02 Std.=0.63	Mean=3.03 Std.=0.69
Sweetness	Sweetness for Individual Cultivars on a 1-5 Just about Right Scale	Mean=2.33 Std.=0.64	Mean=2.60 Std.=0.75	Mean=2.48 Std.=0.93	Mean=2.49 Std.=0.86	Mean=2.41 Std.=0.84
Tartness/ Sourness	Tartness for Individual Cultivars on a 1-5 Just about Right Scale	Mean=2.64 Std.=0.79	Mean=2.61 Std.=0.80	Mean=2.68 Std.=0.87	Mean=2.75 Std.=0.73	Mean=2.77 Std.=0.90

Table 5.7: Payment Card Intervals Marked by Respondents

Interval	Frequency				
	Bing (%)	Lapin (%)	Skeena (%)	Regina (%)	Sweetheart (%)
$0 – 0.49	1.15%	10.34%	10.34%	8.05%	6.90%
$0.49 – 0.99	2.30%	2.30%	2.30%	2.30%	0
$0.99 – 1.49	3.45%	5.75%	2.30%	6.90%	5.75%
$1.49 – 1.99	12.64%	17.24%	18.39%	17.24%	8.05%
$1.99 – 2.49	31.03%	31.03%	37.93%	29.89%	31.03%
$2.49 – 2.99	33.33%	20.69%	22.99%	24.14%	32.18%
$2.99 – 3.49	10.34%	11.49%	4.60%	9.20%	11.49%
$3.49 – 3.99	3.45%	1.15%	1.15%	2.30%	3.45%
$3.99 – 4.49	2.30%	0	0	0	1.15%
$4.49 – 4.99	0	0	0	0	0
$4.99 – 5.49	0	0	0	0	0
$5.49 – 5.99	0	0	0	0	0
Total	100%	100%	100%	100%	100%

Table 5.8: Parameter Estimates for the Mixed Logit Model

Parameter	Variable Description	Estimate	Standard Error	z-test	P-value
α_1	Intercept 1 (Cultivar Bing)	6.7956	0.6386	10.6420	0.0000
α_2	Intercept 2(Cultivar Lapin)	6.4982	0.6551	9.9190	0.0000
α_3	Intercept 3 (Cultivar Skeena)	6.6185	0.6424	10.3030	0.0000
α_4	Intercept 4 (Cultivar Regina)	6.5657	0.6511	10.0840	0.0000
α_5	Intercept 5 (Cultivar Sweetheart)	6.6262	0.6458	10.2600	0.0000
ρ	*Final Bid*	-2.1378	0.1183	-18.0710	0.0000
λ_1	*Firmness*	0.7535	0.2197	3.4290	0.0006
λ_2	*Sweetness*	1.8735	0.1785	10.4940	0.0000
λ_3	*Organic*	0.0102	0.0034	3.0170	0.0025
λ_4	*Gender*	0.1643	0.2215	0.7420	0.4583
λ_5	*Age*	0.0178	0.0101	1.7550	0.0792
λ_6	*Senior*	1.3255	0.6165	2.1500	0.0315
λ_7	*Income*	-0.1400	0.0759	-1.8450	0.0651
λ_8	*HighIncome*	-0.5153	0.3836	-1.3430	0.1791
σ_η^2	Variance of Random Variable η	0.7309	0.0635	11.5180	0.0000

Table 5.9: Marginal Effects of the Parameters for the Mixed Logit Model

Parameter	Variable Description	Marginal Effect	Standard Error	P-value
$\tilde{\alpha}_1$	Intercept 1 (Cultivar Bing)			
$\tilde{\alpha}_2$	Intercept 2(Cultivar Lapin)			
$\tilde{\alpha}_3$	Intercept 3 (Cultivar Skeena)			
$\tilde{\alpha}_4$	Intercept 4 (Cultivar Regina)			
$\tilde{\alpha}_5$	Intercept 5 (Cultivar Sweetheart)			
$\tilde{\rho}$	*Final Bid*			
λ_1	*Firmness*	0.3525	0.1021	0.0006
λ_2	*Sweetness*	0.8764	0.0772	0.0000
λ_3	*Organic*	0.0048	0.0016	0.0024
λ_4	*Gender*	0.0769	0.1036	0.4581
λ_5	*Age*	0.0083	0.0047	0.0787
λ_6	*Senior*	0.6200	0.2876	0.0311
λ_7	*Income*	-0.0655	0.0355	0.0653
λ_8	*HighIncome*	-0.2410	0.1795	0.1792

Table 5.10: Parameter Estimates for the PC Model

Parameter	Variable Description	Estimate	Standard Error	z-test	P-value
α	*Intercept*	2.9453	0.2372	12.4200	0.0000
λ_1	*Firmness*	0.3302	0.0522	6.3300	0.0000
λ_2	*Sweetness*	0.5141	0.0430	11.9600	0.0000
λ_3	*Organic*	-0.0028	0.0018	-1.6000	0.1100
λ_4	*Gender*	0.0226	0.1146	0.2000	0.8440
λ_5	*Age*	-0.0072	0.0057	-1.2700	0.2040
λ_6	*Senior*	-0.4876	0.2626	-1.8600	0.0630
λ_7	*Income*	0.0439	0.0361	1.2100	0.2250
λ_8	*HighIncome*	0.1442	0.1932	0.7500	0.4550
D_2	Dummy Variable for Lapin	-0.2519	0.0759	-3.3200	0.0010
D_3	Dummy Variable for Skeena	-0.2273	0.0764	-2.9700	0.0030
D_4	Dummy Variable for Regina	-0.2371	0.0755	-3.1400	0.0020
D_5	Dummy Variable for Sweetheart	-0.0624	0.0753	-0.8300	0.4080

Table 5.11: Comparison of the Mean WTP for Both Elicitation Methods

Cultivar	Mean WTP		DBDC/PC Ratio
	DBDC	PC	
Bing	2.8538	2.3483	1.22
Lapin	2.7147	1.9529	1.39
Skeena	2.7710	1.9230	1.44
Regina	2.7463	1.9943	1.38
Sweetheart	2.7746	2.2184	1.25

CHAPTER 6

CONCLUSIONS

This dissertation explores the effects of sensory attributes on WTP for two types of fruit: apples and cherries. It is evident from the estimation results that consumers' acceptance or satisfaction with firmness and sweetness significantly influence their WTP. An industry model of WTP for apples with physical measurements of firmness and sweetness was also estimated. Its outcome confirms that subjective variables of firmness and sweetness are more relevant to WTP than their physical counterparts. This lies in the subjective nature of WTP and its linkage to sensory contentment with the food product.

As concerns about health food and eating quality continue to grow, demand for food products clearly reflects this trend. Cherries are considered as a healthy food because they provide a substantial amount of antioxidants and other healthy nutrients. Therefore, it comes as no surprise when the estimation result reveals the positive relationship between WTP for cherries and the relative amount of organic fruit purchase, which implies that people who are more concerned about healthy food are more willing to pay a premium for fruits full of nutrients.

There has been a vast amount of research done to assess different CVM elicitation techniques, and the debate is ongoing over which generates more precise estimates. Chapter 5 examined this subject by comparing the empirical results from a

DBDC model and PC model. More thorough theoretical investigation should be undertaken before any unequivocal statement can be made on this issue.