

CONSUMER DEMAND FOR ORGANIC PRODUCE IN THE UNITED STATES:
EVIDENCE FROM ACNIELSEN HOMESCAN DATA

by

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(Under the Direction of James E. Epperson)

ABSTRACT

This dissertation addresses several important issues on consumer demand for fresh organic produce in the United States in recent years using scanner data. It consists of three studies encompassing organic produce consumption, the interrelationship between organic and conventional produce demand, and organic price premiums paid by U.S. households. The results of this research have implications for organic retailers in formulating organic produce marketing strategies and organic producers in making production decisions.

The first study is intended to identify important consumer demographic characteristics related to the growth of the fresh organic produce market with a generalized double hurdle model. Natural logarithm transformed consumption data were used to deal with the nonnormality problem usually associated with such data. Market participation and conditional/unconditional consumption elasticities were computed for the generalized double hurdle model.

The second study provides an overview of the organic fresh vegetable market by investigating market shares and price premiums of selected organic fresh vegetables and estimating the interrelationship between consumer demand for organic and conventional fresh vegetables. The linear Almost Ideal Demand System was found to fit the data best among

alternative demand models. Expenditure, own, and cross price elasticities were computed for both organic and conventional vegetables based on the best fitting model.

Using multivariate regression on data for prices with respect to produce characteristics, buyer demographics, and interactions, the third study investigates the organic price premiums U.S. consumers have paid for selected produce and identifies factors explaining variation in organic price premiums. The econometric problem, with each buyer having multiple records in the purchase data, is addressed in the model.

INDEX WORDS: Organic produce, Consumer demand, Scanner data, Hurdle model, Demand system, Price premium

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This dissertation is dedicated to my dear parents for their unwavering support of my studies and for their deep love and trust in me.

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CHAPTER 1

INTRODUCTION

1.1 Background

According to the Organic Trend Tracker survey in 2005 commissioned by Whole Foods Market, the largest U.S natural and organic food retailer, Americans are buying organic foods and beverages for a variety of reasons. The top three are avoidance of pesticides (70.3%), freshness (68.3%), and health and nutrition (67.1%). More than half (55.0%) buy organic to avoid genetically modified foods. Also, more than half of all respondents agree that organic foods and beverages are "better for my health" (52.8%) and better for the environment (52.4%).

As more Americans are choosing organic foods as part of a lifestyle aimed at wellness, the U.S. Organic foods industry has grown considerably over the last decade. The Nutrition Business Journal (NBJ) estimates U.S. sales of organic foods at nearly \$10.4 billion in 2003, or about 1.8% of total U.S. retail sales of food, up from \$3.5 billion in 1997 (NBJ, 2004). Annual growth rates over the period are around 20% (table 1). Growth rate estimates through 2010 range from 9 to 16% annually, with growth slowing in the later years. By 2010, sales of organic foods are estimated to increase to \$23.8 billion, or 3.5% of total retail food sales in the United States (NBJ, 2004).

In order to standardize organic food products, Congress passed the Organic Foods Product Act of 1990 to establish national standards for organically produced commodities, and the USDA promulgated final rules for implementing this legislation in December 2000, with an 18 month transition period. As of October 2002, all agricultural

Table 1.1. Consumer Sales and Growth Rates of Organic Foods, 1997-2003

Year	Sale	Growth Rate
	\$ billion	%
1997	3.6	
1998	4.3	19.7
1999	5.0	18.2
2000	6.1	21.0
2001	7.4	20.7
2002	8.6	17.3
2003	10.4	20.2

Source: Nutrition Business Journal, 2004.

products that are sold, labeled, or represented as organic are to be in compliance with the regulations. They require that organic growers and handlers (including food processors and distributors) be certified by State or private agencies/organizations under uniform standards developed by the USDA, unless farmers and handlers sell less than \$5,000 a year in organic agricultural products. Retail food establishments that sell organically produced agricultural products, but do not process them, are also exempt from certification.

According to USDA standards, organic production is defined as “A production system that is managed in accordance with the Act [Organic Foods Production] and regulations in this part to respond to site-specific conditions by integrating cultural, biological and mechanical practices that foster cycling of resources, promote ecological balance and conserve biodiversity” (National Organic Program, 2002).

Effective October 2002, all farms and agricultural products with organic claims must be guaranteed by a USDA-approved independent agency as meeting the following guidelines:

- Abstain from the application of prohibited materials (including synthetic fertilizers, pesticides, and sewage sludge) for three years prior to certification and then continually throughout the organic license period.
- Prohibit the use of genetically modified organisms and irradiation.
- Employ positive soil building, conservation, manure management, and crop rotation practices.
- Provide outdoor access and pasture for livestock.
- Refrain from antibiotic and hormone use in animals.
- Sustain animals on 100% organic feed.
- Avoid contamination during the processing of organic products.
- Keep records of all operations.

For final food products on the market, there are four levels of claims covered by the National Organic Program (NOP): “100% Organic”, “Organic” (at least 95% Organic), “Made with Organic Ingredients”(at least 70%) and “Some Organic Ingredients”(less than 70%, the organic items can be listed individually in the ingredients list on the side panel). The first two categories can use the NOP seal on the front of the food package as shown here.



The focus of this study is on organic fresh produce, one category with the highest market share and market penetration ratio among various organic foods. Organic produce is important in the organic sector because produce items are “gateway” products, or the first organic products purchased by consumers, which often steer consumers toward other organic products, such as cereal, snacks, and meat and poultry, and are perceived as important frontline commodities for the industry.

Although organic food sales make up a small portion (1.8%) of total food retail sales in the United States, some organic fruit and vegetable categories have higher market penetration rates than others. For example, in 2002, organic fresh fruit and vegetable sales accounted for 4.5% of total fresh fruit and vegetable sales (NBJ, 2003). Nutrition Business Journal (NBJ) reported \$4.3 billion in U.S. sales of organic produce in 2003, or 42% of total U.S. sales of organic foods. Of this amount, fresh produce accounted for the largest share (93%). NBJ estimates that sales of organic fruits and vegetables in 2010 could reach \$8.5 billion, an increase of more than 300% over sales in 2000.

1.2 Problem Statement

Despite the projected high growth in consumption of fresh organic produce, consumer characteristics contributing to its growth are not well understood. Most previous studies of organic produce have measured attitudes regarding the purchase of organic produce rather than actual purchase choices or behaviors. As an indication of such attitudes, these studies typically elicit willingness to pay for organic produce and the likelihood of consumption of organic relative to its conventional counterpart. Additionally, results from previous studies using surveys are often fragmentary and sometimes inconsistent. Thompson (1998) summarized studies prior to 1997 pertaining to

the impact of demographic characteristics on the likelihood of consumption of organic foods. His study revealed some contradictory findings about the effect of income, age, and educational attainment on the likelihood of consuming organic. More recent survey studies also had different conclusions regarding the impact of income on consumption of organic food. A survey conducted by the Hartman Group in 2002 showed that over half of those who frequently bought organic foods in the United States had incomes below \$30,000, and African-Americans, Asian-Americans, and Hispanics used more organic products than Caucasians. Results of the Hartman Group survey are interesting, given that a USDA, ERS study found that low-income households eat less fresh fruits and vegetables than higher-income households (Blisard, et al., 2004). Thus, additional research on who buys organic foods is needed (Oberholtzer, et al., 2005).

In response to the growing popularity of organic products, conventional supermarkets and mass market merchandisers have added organic fruits and vegetables to their shelves. In 2000, for the first time, more organic food was purchased in conventional supermarkets than in any other venue. In 2003, 47% of organic foods were sold through conventional channels, 44% were sold through natural food stores, and 9% were sold through direct and other marketing channels, e.g., farmers' markets, restaurants, exports (Organic Trade Association, 2004). Organic foods are now taking market share from conventional foods.

Even though the implementation of organic standards and increasing public awareness of organic food is helpful in promoting organic fresh produce sales, more affordable prices are also important for long-term growth of the organic market. Consumers are expected to purchase more organic produce as the price premium for organic is reduced. On the other hand, farmers expect a sufficient premium to warrant

production of organic produce as such production usually involves relatively high costs. In the Organic Farming Research Foundation (OFRF) 2001 survey of organic farmers (Walz, 2004), 41% of respondents reported receiving price premiums for all items sold, and 71% received a premium for at least half of items sold. When asked about the circumstances that made it difficult to receive price premiums, limited local demand for organic items in some areas (e.g., rural areas) and price competition from conventional items (e.g., corn and strawberries) were some often cited reasons. Investigation into organic price premiums at retail level for fresh produce and the interrelationship between consumer demands for organic and conventional fresh produce can provide insight into relative changes in the demand for and the supply of organic and a clearer sense of the degree of market maturity and the likelihood of further growth.

In addition, at the retail level, different buyer groups may be willing to pay different prices for organic based on preference. For marketing purposes, it is important for retailers and producers to know which market segments are willing to pay higher prices for organically grown produce items based on consumer demographics and marketing season. In this sense, this study adds to the body of knowledge from previous studies on motivation for consuming organic produce and willingness to pay based on attitudes and lifestyle characteristics.

1.3 Objectives

This research analyzes consumer behavior with respect to organic consumption using retail-level data. The intent is to depict the fresh organic produce market from the consumer side. The research results should have important implications for retailers and producers in the fresh organic produce market to identify market opportunities and

formulate effective marketing and supply decisions. Specifically, the research objectives to be investigated are

1. To identify important consumer demographic characteristics that are associated with fresh organic produce consumption, both in terms of probability and consumption level, and investigate effects on consumption.
2. To study market trends within the fresh produce market and understand interrelationships between consumer demands for fresh organic produce and conventional counterparts.
3. To investigate the magnitude of organic premiums consumers actually paid for selected organic produce items and identify household-level demographic factors and seasonal variables which explain variation in organic price premiums.

1.4 Organization

The dissertation consists of six chapters. Chapter 2 is a literature review of consumer demand for organic produce and organic foods in general. In this chapter, relevant previous studies are summarized and limitations are pointed out, followed by the possible contribution of this research to the extant literature. Chapters 3, 4, and 5 constitute the main body of this dissertation, each focusing on a subject as outlined in the research objectives. Chapter 3 analyzes consumer demographic characteristics related to the probability and level of organic produce consumption with a generalized double hurdle model. Using a general differential demand system that nests several of the most commonly used functional forms in demand analyses, Chapter 4 investigates the interrelationships between consumer demands for selected organic and conventional produce items with the most appropriate specific demand model and time series data. In

Chapter 5, organic price premiums for the top organic produce items are investigated; and factors which explain variation in organic price premiums, such as consumer demographic characteristics and seasonal variables, are identified.

CHAPTER 2

LITERATURE REVIEW OF CONSUMER DEMAND FOR ORGANIC

2.1 Motivations and Consumer Characteristics Related to Organic Consumption

Consumers purchase organic foods for a variety of reasons. Using data collected from a mail survey of Georgia residents in 1989, Huang (1996) found that consumers who are nutritionally conscious and concerned about the use of pesticides, wanting produce tested for freedom from residues, have a higher propensity to prefer organically grown produce. Respondents to a nationwide survey cited health and nutrition (66%), taste (38%), food safety (30%), and the environment (26%) as motivating factors behind organic food purchases (Hartman Group, 2002). In another survey, consumers cited the environment (58%), health (54%), food quality (42%), and support for small and local farmers (57%) as influences (Whole Foods, 2004).

Buying organic may represent a lifestyle choice. Using survey data collected from 10 major supermarkets in the Boston area that sell organic or conventional fresh produce, Williams and Hammitt (2000) found that organic buyers have somewhat different lifestyle patterns and behaviors than conventional buyers. For example, organic buyers were more likely than conventional buyers to be vegetarians, grow their own fruits and vegetables, recycle, and purchase “environmentally friendly” products.

However, previous research failed to reach a consensus regarding the impact of consumer demographic characteristics on organic consumption decisions. Thompson (1998) summarized studies prior to 1997 concerning the impact of demographic

characteristics on the likelihood of consumption of organic foods. His study revealed some contradictory findings about the effects of income, age, and educational attainment on likelihood of consuming organic foods. Using survey data at two retail outlets in Arizona, Thompson and Kidwell (1998) found that consumers with advanced degrees are less likely to buy organic produce and households with children under age 18 are more likely to purchase organic produce. Such results are somewhat inconsistent with those of Lourieo and Hine (2002) who concluded that wealthy and well-educated consumers are willing to pay more for organic potatoes, while the presence of children in the household has a negative effect on willingness to pay for the organic potatoes.

More recent studies also had different conclusions regarding the impact of income on consumption of organic food. A survey conducted by the Hartman Group in 2002 showed that over half of those who frequently buy organic foods in the United States have incomes below \$30,000; and African-Americans, Asian-Americans, and Hispanics use more organic products than Caucasians. Results of the Hartman Group survey are interesting, given that a USDA, ERS study found that low-income households eat less fresh fruits and vegetables than high-income households (Blisard, et al., 2004).

Inconsistent results from various surveys may stem from the limitations of data collection methods, especially for surveys conducted at local or regional stores. As Williams and Hammitt (2000) pointed out, sampling of organic versus conventional food stores based on geographic location and average household income may result in a relatively homogenous sample which makes it difficult to assess potentially important demographic differences between buyers of organic and conventional fresh produce. For surveys using the contingent valuation method, even though they provided useful information on consumer motivations in buying organically grown produce and

willingness to pay, it remains unclear as to whether consumer attitudes can translate into actual purchases of organic produce.

2.2 Interrelationships between Demands for Organic and Conventional Food

The price premium for organic produce, percent increase over the conventional price, is an important measure to assess the market growth potential of organic produce. Part of the price premium is compensation for higher production and distribution costs on the supply side. The other part is from the demand side, which reflects greater willingness to pay for organic produce.

Existing studies (Oberholtzer et. al., 2005; Sok and Glaser, 2001) on price premiums for organic produce, limited by data, mainly focused on price premiums at farmgate and wholesale levels using average prices reported to regional trade associations (mainly for Boston and San Francisco markets). Using wholesale prices in the Boston area during 2000 to 2001, Sok and Glaser (2001) found that organic premiums averaged 130% of conventional prices for broccoli, 125% for carrots, and only 10% for mesclun (a mixture of small, young salad greens, herbs and edible flowers). Oberholtzer (2005) recorded a similar pattern for the same three organic produce items using 2000 to 2004 data. However, as Sok and Glaser (2001) pointed out, the conclusions do not necessarily reflect the entire industry as the results are based only on price movements for three vegetables in one wholesale market. If and when more organic produce moves through terminal markets, the data may provide a better indication of industry trends. Since consumers are the final link in the marketing channel, knowing the trend of price premiums for the main organic produce items at retail level can enable a better understanding of the degree of maturity of the organic market.

To date, only a few studies have focused on the interrelationship between demand for organic food and conventional food. Using U.S. monthly supermarket ACNielsen scanner data for the period from September 1990 to December 1996, Glaser and Thompson (1998) found own-price elasticities for selected frozen organic vegetables (broccoli, green beans, green peas, and sweet corn) ranging from -1.63 to -2.27, indicating that small changes in price elicit large changes in quantity purchased. Response to price change is two to three times as sensitive as for conventional counterparts. Despite low statistical significance of estimated elasticities as a result of large standard errors, there appears to be a tendency toward asymmetry in cross-price responses: changes in organic quantity as conventional prices change are larger than changes in conventional quantity as organic prices change.

Using monthly data from 1988 to 1999, Thompson and Glaser (2001) studied the demand for organic and conventional baby food. Their results suggest that reductions in organic price elicit limited substitution away from conventional products. Their results, however, also show that as market share grows over time, the substitution effect can be expected to increase. Any increase in conventional baby food price tends to boost purchases of organic baby food by a relatively larger amount. Surprisingly, the expenditure elasticities for both organic and conventional baby food items displayed erratic variation from -4.78 to 5.44, but none were significantly different from zero.

2.3 Willingness to Pay a Premium for Organic

Weaver, Evans, and Luloff (1992) reported that 56% of consumers indicated a willingness to pay at least a 10% premium to obtain pesticide-free tomatoes. Only 19% of the sample indicated that they were unwilling to pay any premium at all. Similarly,

Huang (1993) reported that the majority of consumers indicated a willingness to pay of up to 10% more for organically grown produce. A gender difference, which showed females to be more likely than males to pay a premium for organic produce, also was found. Huang noted that females and households with children were more likely to have higher risk aversions toward pesticide residues than males and households without children. Groff, Kreider, and Toensmeyer (1993) also reported that females were more likely than males to place a higher value on organic produce than conventionally grown produce.

With a consumer survey at various grocery retail establishments in New Jersey, Govindasamy and Italia (1999) found that young, high income females who usually or always purchase organic produce are more likely to pay a premium for organic produce. Their results also indicated that the likelihood of paying a premium is inversely related to the number of individuals living in the household and educational level.

Sanjuan et al. (2003) investigated consumer willingness to pay for organic produce in Spain for different groups (likely consumers, organic consumers, and unlikely consumers) segmented by lifestyle characteristics including various factors on preference for natural food, balanced life, concerns for health and social improvement. Their results confirmed that willingness to pay differs among consumer segments, products, and cities. The highest premiums that the most concerned consumers in large cities were willing to pay for organic products ranged from 22 to 37% for vegetables other than potatoes. However, for potatoes specifically, this range fell to 13-17%.

There is one study explicitly modeling the magnitude of willingness to pay for organic produce with consumer demographics. Using consumer survey data collected in supermarkets at different locations of the state of Colorado on potato purchases, Loureiro

and Hine (2002) studied consumer willingness to pay for organic potatoes and found that the age of the consumer seems to have a negative effect on willingness to pay and that wealthy, well educated consumers, on average, are willing to pay over \$0.02 per pound extra for organic.

CHAPTER 3

MODELING FRESH ORGANIC PRODUCE CONSUMPTION WITH SCANNER DATA: A GENERALIZED DOUBLE HURDLE MODEL APPROACH

3.1. Introduction

Concerns over health and environmental degradation have motivated U.S. consumers to purchase more organic produce over recent years. U.S. sales of organic foods were nearly \$10.4 billion in 2003, or about 1.8% of total U.S. retail food sales, up from \$3.5 billion in 1997 (NBJ, 2004). In response to the growing popularity of organic items, conventional supermarkets and mass market merchandisers have added shelf space for organic fruits and vegetables. In 2000, for the first time, more organic food was purchased in conventional supermarkets than in any other venue.

Among various organic foods, fresh fruits and vegetables have much higher market penetration rates than others. For example, in 2002, organic fresh fruit and vegetable sales accounted for 4.5% of total fresh fruit and vegetable sales (NBJ, 2003). The *Natural Foods Merchandiser* reported that sales of packaged fresh produce had the highest growth rate among sales of all organic products during 2002-2003, expanding 26% annually on average to \$364 million.

Despite the projected high growth in consumption of fresh organic produce, consumer characteristics contributing to its growth are not well understood. Most previous studies of organic produce have measured attitudes regarding the purchase of organic produce rather than actual purchase choices or behaviors (Jolly, 1991; Huang, 1996; Williams and Hammitt, 2000). As an indication of such attitudes, these studies

typically have elicited willingness to pay for organic produce and the likelihood of consumption relative to conventional counterparts. Additionally, results from previous studies using surveys are often fragmentary and sometimes inconsistent. Thompson (1998) summarized studies prior to 1997 regarding the impact of demographic characteristics on the likelihood of consumption of organic foods. His study revealed some contradictory findings about the effects of income, age, and educational attainment on likelihood of consuming organic foods. More recent survey studies also had different conclusions regarding the impact of income on consumption of organic food. A survey conducted by the Hartman Group in 2002 showed that over half of those who frequently buy organic foods in the United States have incomes below \$30,000 and that African-Americans, Asian-Americans, and Hispanics use more organic products than Caucasians. Results of the Hartman Group survey are interesting, given that a USDA-ERS study found that low-income households eat less fresh fruits and vegetables than higher-income households (Blisard, et al., 2004). Thus, additional research on who buys organic foods is needed (Oberholtzer, et al., 2005).

Our objective in this study is to identify important consumer demographic characteristics that are associated with fresh organic produce consumption and investigate their effects on consumption. To achieve this purpose, we utilize a generalized double hurdle model which allows for different parameterizations of the participation and consumption processes and the possible correlation between these two processes.

3.2. Model Specification

For most cross-sectional consumption data, zero consumption is a problem for any modeling effort to address. The Tobit model developed by Tobin (1958) has been

widely used to deal with censored observations. It attributes the censoring to a standard corner solution. However, this model is very restrictive. For example, the Tobit model has been shown to be inadequate to characterize the two processes in consumption: the participation process and consumption process. Any variable which increases the probability of non-zero consumption must also increase the mean of positive consumption, which is not always reasonable (Lin and Schmidt, 1984). Even though the impacts of explanatory variables on the probability of consumption and level of consumption may be in the same direction, the magnitudes and statistical significance levels for these two processes may be quite different. For example, advertising intended to solicit memberships may not be effective in increasing revenue. The Tobit model cannot accommodate such an outcome.

The double hurdle model, originally proposed by Cragg (1971), assumes that households make two decisions with respect to purchasing an item, each of which is determined by a different set of explanatory variables. In order to observe a positive level of expenditure, two separate hurdles must be passed. First, the household decides whether or not to purchase the good, and second, by overcoming inhibition factors in acquisition such as search, information, and transaction costs, the household determines what it wants and decides on how much to purchase. A different latent variable is used to model each decision process, with one part modeling discrete choice of whether to purchase organic with a specification similar to that of a Probit model and the other part modeling the positive amount of purchase using a specification similar to a censored regression. The double hurdle model has been used widely since its introduction. Newman, et al. (2003) applied the double hurdle model to study Irish household expenditures on prepared meals for home consumption. Yen and Jones (1997) used the procedure for

analysis of U.S. household consumption of cheese. Other studies have also applied the double hurdle model to examine U.S. food expenditures away from home (Jensen and Yen, 1996) and household demand for finfish (Yen and Huang, 1996). Most applications rejected the Tobit model in favor of Cragg's independent double hurdle model based on statistical tests.

Though Cragg's model is an improvement over the Tobit model, it is still limited in that it assumes that the shocks to the participation and consumption processes are independent, which is not always a realistic assumption. Hidden factors that inhibit potential organic consumers from making actual purchases, such as availability, may result in consumers being excluded from the organic market in the first place. Drawing on the idea of correlated processes from the sample selection model of Heckman (1979), the generalized double hurdle model extended Cragg's independent double hurdle model to deal with correlated residuals from the participation and consumption processes. Jones (1989 and 1992) first used the generalized double hurdle model in analyzing tobacco consumption in the UK. Yen (2005) applied the generalized approach to study cigarette consumption in the United States using maximum likelihood estimation allowing computation of conditional and unconditional elasticities of consumption. The specification of the generalized double hurdle model is as follows:

$$y = \begin{cases} x' \beta + v & \text{if } z' \alpha + u > 0 \text{ and } x' \beta + v > 0 \\ 0 & \text{otherwise} \end{cases} \quad (3.1)$$

$$\begin{bmatrix} u \\ v \end{bmatrix} = N \left\{ 0, \begin{bmatrix} 1 & \rho\sigma \\ \rho\sigma & \sigma^2 \end{bmatrix} \right\},$$

where y is the expenditure, in original or transformed scale if applicable; z and x are variables determining the participation and the consumption processes, respectively; u

and v are residual terms from the two processes, with a correlation coefficient ρ ; and α , β , ρ , and σ are parameters for estimation.

The likelihood function can be written as

$$L = \prod_{y=0} \{1 - \Psi(z' \alpha, x' \beta / \sigma; \rho)\} \times \prod_{y>0} \frac{1}{\sigma} \phi[(y - x' \beta) / \sigma] \Phi\left[\frac{z' \alpha + \rho(y - x' \beta) / \sigma}{(1 - \rho^2)^{1/2}}\right], \quad (3.2)$$

where $\phi(\cdot)$ is the PDF for the univariate standard normal distribution which gives the probability for each positive purchase; $\Phi(\cdot)$ is the CDF for the conditional normal distribution for u given $v = y - x' \beta$ with a positive y (refer to Appendix 1 for derivation); and $\Psi(\cdot)$ is the bivariate standard normal CDF with three arguments, bivariate means and the error-term correlation. It represents the probability when both hurdles are cleared and a positive purchase is observed. When $\rho = 0$, the above model reduces to Cragg's independent hurdle model (1971, equations 5 and 6). In this analysis, we use one set of explanatory variables for both processes, $x = z$, as these variables represent all of the relevant demographic information available in the data which may be related to both processes. The importance of consumer demographic characteristics in different decisions is reflected in the statistical significance of the two sets of parameter vectors, α and β .

3. 3. Data and Variables

ACNielsen Homescan for 2003 is the data source of this study. ACNielsen Homescan is unique in that each panelist was supplied with a scanner device that he/she used at home to record grocery items purchased at any grocery or other type of store throughout a given time period. Each panelist represents a unique household, with each

household having 18 known demographic characteristics. By investigating the relationship between consumption of fresh organic produce and consumer characteristics, we can identify potential consumers of fresh organic produce.

In 2003, there were 8,833 households included in the ACNielsen consumer panel. The date, expenditure, and quantity of each purchase are recorded with the supplied scanner. To avoid the potential data problem of inadvertent recording by some households, we include only those households who made purchases of fresh produce for at least 10 months in 2003, which reduces the sample to 6,916 households. Total expenditures for organic fresh produce in 2003 were aggregated for each household, resulting in a final cross-sectional dataset containing organic expenditures and corresponding consumer demographic characteristics as described in table 3.1.

The validity of using two sets of parameters for the market participation decision and consumption level decision with a double hurdle model can be illustrated through descriptive statistics such as the percentage of organic buyers among all households and the mean expenditure on organic stratified by the main demographic characteristics of all households on the panel. Figures 3.1 - 3.5 show that the impacts of household demographic characteristics on the two decisions are not necessarily in the same direction, especially for household size and age of the household head. One-member households aside, larger households tend to be less likely to consume organic produce. However, no distinct relationship was identified between household size and consumption level. The evidence in figure 3.2 suggests that the age of the household head has differing impacts on organic market participation and consumption level. Households with older household heads tend to be more likely to consumer fresh organic produce.

However, among organic buyers, households with older household heads spend less on organic than younger ones on average.

The positive organic expenditure is specified via the following equation:

$$y = \ln C = \beta_0 + \beta_1 * HHSIZE + \beta_2 * INCOME + \beta_3 * AGE2 + \beta_4 * AGE3 + \beta_5 * EDUC2 + \beta_6 * EDUC3 + \beta_7 * CHIL6 + \beta_8 * EAST + \beta_9 * CENTRAL + \beta_{10} * WEST + \beta_{11} * URBAN + \beta_{12} * WHITE + \beta_{13} * BLACK + \beta_{14} * ORIENTAL \quad (3.3)$$

This functional form is applied for the consumption process expressed in equation (3.1).

The natural logarithm of the positive expenditure of fresh organic produce is modeled as a function of various consumer demographic variables.

As shown in table 3.1, the average amount of organic produce purchases for all households was \$6.51 in 2003. Among all households on the panel, about 42% actually purchased fresh organic produce with the average level of expenditure at \$15.33. A problem with the fresh organic produce expenditure variable is that the distribution of the values is highly skewed, with most consumers having small quantities purchased as shown in figure 3.6. This is a common problem with consumption data, as was the case for U.S. consumption of cheese (Yen and Jones, 1997) and finfish (Yen and Huang, 1996). However, for econometric models, whether double hurdle, Tobit, or OLS, they are only valid under the assumption that the normal distribution (or censored normal distribution) of the dependent variable is satisfied. If used directly as a response variable without transformation, consumption data may cause inconsistency of the estimators and nonnormality of the error terms (Newman, et al., 2003). In this study, following Wagner and Hanna (1983) and Newhouse (1987), we used the natural logarithm of positive fresh organic produce consumption in order to be able to handle positively skewed data and because of computational ease. Figure 3.6 shows the histograms of both original and transformed positive expenditures, which suggest that the natural logarithm of

consumption is more likely to be normally distributed. In addition, the natural logarithmic transformation of the response variable is more amenable to computing elasticities of organic consumption with respect to demographic variables than are other nonlinear transformations.

3.4. Elasticities

Elasticities of consumption probability and level (conditional and unconditional for the latter) are computed using Yen's (2005) formula. The probability of consumption (i.e., a positive observation) is

$$\Pr(y > 0) = \Psi(z' \alpha, x' \beta / \sigma; \rho), \quad (3.4)$$

which depends on both participation and consumption process parameters. The conditional and unconditional means of the dependent variable are given as follows:

$$\begin{aligned} E(y|y > 0) &= x' \beta + E(v|u > -z' \alpha, v > -x' \beta) \\ &= x' \beta + [\Psi(z' \alpha, x' \beta / \sigma; \rho)]^{-1} \sigma \times \{ \phi(x' \beta / \sigma) \Phi[(z' \alpha - \rho x' \beta / \sigma) / (1 - \rho^2)^{1/2}] \\ &\quad + \rho \phi(z' \alpha) \Phi[(x' \beta / \sigma - \rho z' \alpha) / (1 - \rho^2)^{1/2}] \}, \end{aligned} \quad (3.5)$$

$$E(y) = \Pr(y > 0) \times E(y|y > 0). \quad (3.6)$$

As the dependent variable is in natural logarithmic form for positive expenditures, the conditional and unconditional elasticities with respect to consumption level can be computed as $(\partial E(y|y > 0) / \partial x) * \bar{x}$ and $(\partial E(y) / \partial x) * \bar{x}$, respectively, for continuous variables, $\Delta E(y|y > 0)$ and $\Delta E(y)$ for discrete variables. Elasticities with respect to market participation probability were computed as $(\partial P(y > 0) / \partial x) * (\bar{x} / \bar{P})$ for continuous variables. However, for discrete variables, marginal effects with respect to market participation probabilities, $(\Delta P(y > 0))$, were reported since they are more meaningful in interpretation. Elasticities and marginal effects are evaluated for each

explanatory variable with all other variables held constant at mean levels. For statistical inference, standard errors for elasticities were calculated by first-order mathematical approximation (Davidson and Mackinnon, 2004), more commonly known as the *delta method*.

3.5. Estimation Results

Results of the maximum likelihood estimation for the generalized double hurdle model are presented in table 3.2. The correlation coefficient between residuals from the market participation and consumption processes is 0.8994 and highly significant, indicating the generalized double hurdle model is preferred to Cragg's independent double hurdle model in this study. Based on equations (3.4)-(3.6), the marginal probability effects (for discrete variables only) and conditional and unconditional elasticities for all demographic variables were calculated and reported in table 3.3.

Among consumer demographic variables, household income has a positive and significant effect for both processes. Higher income is associated with both a higher probability and higher level of fresh organic produce consumption. The unconditional income elasticity of consumption is about 0.37, which means an average household will increase organic fresh produce expenditures by 0.37% when household income rises by 1.00%. For organic buyers, however, a 1.00% increase in income will result in a 0.22% increase in organic expenditures on average.

The effect of household size suggests that the larger the household, the less likely is the consumption of fresh organic produce. Further, for current organic buyers, larger households do not necessarily spend more on fresh organic produce. The overall impact

of household size on consumption of fresh organic produce, as indicated by the small and insignificant unconditional elasticity with respect to consumption level, is negligible.

The role of the age of household head on expenditures for fresh organic produce is mixed with respect to market participation and consumption decisions. As shown in the results, among the three age groups, the older group is found to be significantly more likely to buy fresh organic produce. Of households that buy organic, those with older household heads spend less than those with younger ones. Overall, older consumers are important patrons of the fresh organic market, spending 28% more than younger ones holding other factors equal. Educational level is highly significant in explaining both market participation and consumption of fresh organic produce. The results seem to suggest that the higher the educational level of the household head, the more likely is the household to buy fresh organic produce. Of the households that are organic buyers, higher educational level of the household head is also associated with a higher level of consumption. Among all dummy variables, the post-college degree (EDUC3) elasticity is the highest with respect to both consumption probability and level. For an average household with the household head having a post-college degree, the household is 12% more likely to consume fresh organic produce and spends about 87% more on organic than an average household with the household head having only a high school education, holding all else equal.

The binary effects also show that, in 2003, *ceteris paribus*, urban households spent about 40% more on fresh organic produce than rural households. The main reason is that urban households are 6% more likely to be organic buyers than rural households. There was no significant difference between organic buyers regarding expenditures. A dummy variable for households with one or more children under six years of age was

included in the model to measure the possible impact of parental concern for the health of young children on organic expenditures. However, this variable is not significant in determining the likelihood of fresh organic purchases or level of consumption. This may be due to the many substitute organic foods available for children such as baby foods and dairy products.

Results for the U.S. geographic dummy variables indicate that the areas where households have the highest to lowest probability and level of fresh organic produce consumption are the East, followed by the West, then South, and finally the central United States in last position. The census regions are as indicated by ACNielsen (2006). These results echo the fact that the East has the highest percentage of certified organic acreage and the western area of the United States has the highest level of organic produce production. The certified organic acreage accounted for over 10% of the vegetable acreage in Vermont, New Hampshire, Maine, and Colorado in 2001 (Oberholtzer, et al., 2005), while California was the biggest organic vegetable producer in 2001, accounting for 41% of U.S. certified organic vegetable acreage. Therefore, people in both the East and West perhaps have broader access to or are more aware of fresh organic produce than people in other areas.

Among people of different races, Hispanics, as a group, are more likely to consume fresh organic produce than the baseline group, non-Hispanic white households. The same is true for households of other races (OTHER, mostly Orientals). In addition, among organic buyers, households of other races consume significantly higher levels of fresh organic produce than any other group on average. Overall, Hispanic households and households of other races are strong buyers of fresh organic produce. The probability and level of consumption for black households are higher but not significantly different than

those for white households. Thus, the results suggest that minority households may be heavier consumers than white households, all else being equal. These results are roughly consistent with those of the Hartman Group in 2002 which reported that African-Americans, Asian-Americans, and Hispanics used more organic products than Caucasians.

3.6. Conclusion

Previous studies from consumer surveys based on contingent valuation have given inconsistent or even contradictory results regarding the impact of certain consumer characteristics on organic food consumption. Using actual retail data, this study was intended to provide a more objective view of consumer characteristics which contribute to the viability of the fresh organic produce market.

By estimating the likelihood of market participation and estimating consumption levels simultaneously using maximum likelihood, the generalized double hurdle model distinguishes possible differential impacts of consumer demographic characteristics on organic consumption decisions. Consumption data in natural logarithm form were used in the model to avoid problems such as nonnormally distributed residuals.

The estimated results indicate that marketing strategies targeting higher income and higher educated consumers can be effective in both attracting new consumers and eliciting more sales from current consumers. Age of the household head has mixed effects regarding decisions for organic market participation and consumption levels. Minority households are an important segment of the fresh organic produce market which retailers can target effectively.

Table 3.1. Definition of Variables and Sample Statistics

Variables	Definition	Mean (SE)
ORGCOST (C) -full sample	Per household expenditure on organic fresh produce (in cents)-full sample	651 (2960)
ORGCOST (C) -organic buyers	Per household expenditure on organic fresh produce (in cents)-organic buyers	1533 (4389)
HHSIZE	Household size - number of people in a household	2.47 (1.34)
INCOME	Income (\$1000), midpoint of income category	52.87 (27.36)
Dummy variables (Yes = 1, no =0)		
AGE1	The higher age of the male and female household heads is less than 40	0.13
AGE2	The higher age of the male and female household heads is between 40 and 64	0.61
AGE3	The higher age of the male and female household heads is 65 and above	0.26
EDUC1	The higher education of the male and female household heads is high school	0.18
EDUC2	The higher education of the male and female household heads is college	0.65
EDUC3	The higher education of the male and female household heads is post college	0.17
CHILD6	Households with children under 6 years old	0.09
EAST	Residents in East region	0.21
CENTRAL	Residents in central region	0.19
SOUTH	Residents in South region	0.39
WEST	Residents in West region	0.21
URBAN	Residents in urban areas	0.87
RURAL	Residents in rural areas	0.13
WHITE	White households	0.76
BLACK	Black households	0.11
HISPANIC	Hispanic households	0.08
OTHER	Households of other races	0.04
Sample size		6,916

Source: Compiled from ACNielsen Homescan data 2003.

Table 3.2. Maximum Likelihood Estimates of the Generalized Double Hurdle Model

	Participation Process	Consumption Process
	Parameters (S.E.)	Parameters (S.E.)
CONSTANT	-.7028** (.0802)	3.8712** (0.1524)
HHSIZE	-0.0215* (0.0131)	-0.0099 (0.0237)
INCOME	0.0022** (0.0006)	0.0042** (0.0011)
AGE2	0.0475 (0.0490)	-0.1414 0.0882
AGE3	0.1647** (0.0559)	-0.0760 (0.1002)
EDUC2	0.1519** (0.0414)	0.2712** (0.0761)
EDUC3	0.3031** (0.0548)	0.6528** (0.0988)
CHILD6	-0.0240 (0.0630)	-0.0660 (0.1129)
EAST	0.2111** (0.0403)	0.4036** (0.0717)
CENTRAL	-0.0404 (0.0431)	-0.0395 (0.0793)
WEST	0.1680** (0.0403)	0.4067** (0.0718)
URBAN	0.1671** (0.0462)	0.2005** (0.0856)
BLACK	0.0326 (0.0479)	0.1240 (0.0871)
HISPANIC	0.3030** (0.0562)	0.3576** (0.0976)
OTHER	0.2380** (0.0737)	0.4467** (0.1273)
σ		1.7742** (0.0254)
ρ		0.8994** (0.0100)
Log Likelihood Value	-6825	
Likelihood Ratio Chi-square Test	<0.001	

Note: Double asterisks and single asterisk denote significance at 5 and 10%, respectively.

Table 3.3. Marginal Effects and Elasticities of Demographic Variables

Variable	Probability Elasticity ^a / Marginal effect ^b	Conditional Level Elasticity	Unconditional Level Elasticity
<u>Continuous variable</u>			
INCOME	0.1036** (0.0302)	0.2194** (0.0595)	0.3684** (0.0977)
<u>Discrete variable</u>			
HHSIZE	-0.0085* (0.0051)	0.0132 (0.0186)	-0.0458 (0.0325)
AGE2	0.0185 (0.0190)	-0.1931** (0.0678)	0.0343 (0.1230)
AGE3	0.0648** (0.0219)	-0.2519** (0.0773)	0.2880** (0.1408)
EDUC2	0.0588** (0.0158)	0.1049* (0.0588)	0.3965** (0.0984)
EDUC3	0.1188** (0.0214)	0.3285** (0.0767)	0.8712** (0.1371)
CHILD6	-0.0094 (0.0247)	-0.0402 (0.0862)	-0.0745 (0.1561)
EAST	0.0833** (0.0159)	0.1798** (0.0552)	0.5877** (0.1022)
CENTRAL	-0.0156 (0.0166)	0.0050 (0.0612)	-0.0916 (0.1036)
WEST	0.0661** (0.0159)	0.2273** (0.0555)	0.5041** (0.1022)
URBAN	0.0649** (0.0176)	0.0182 (0.0665)	0.4020** (0.1112)
BLACK	0.0128 (0.0188)	0.0888 (0.0675)	0.1159 (0.1207)
HISPANIC	0.1203** (0.0223)	0.0443 (0.0754)	0.7535** (0.1450)
OTHER	0.0944** (0.0293)	0.1979** (0.0993)	0.6741** (0.1931)

Note: Double asterisk and single asterisk denote significance at 5 and 10%, respectively.

Standard errors are in parentheses.

^a Probability elasticity is used for continuous variables and interpreted as the percentage change in market participation probability in response to the percentage change in the continuous variable.

^b Probability marginal effect is reported for discrete variables and denotes absolute change in market participation probability in response to one level increase for the multilevel discrete variable (household size) or 0/1 change for the dummy variable.

Figure 3.1. Percentage of organic buyers and mean organic expenditures of current buyers stratified by household size

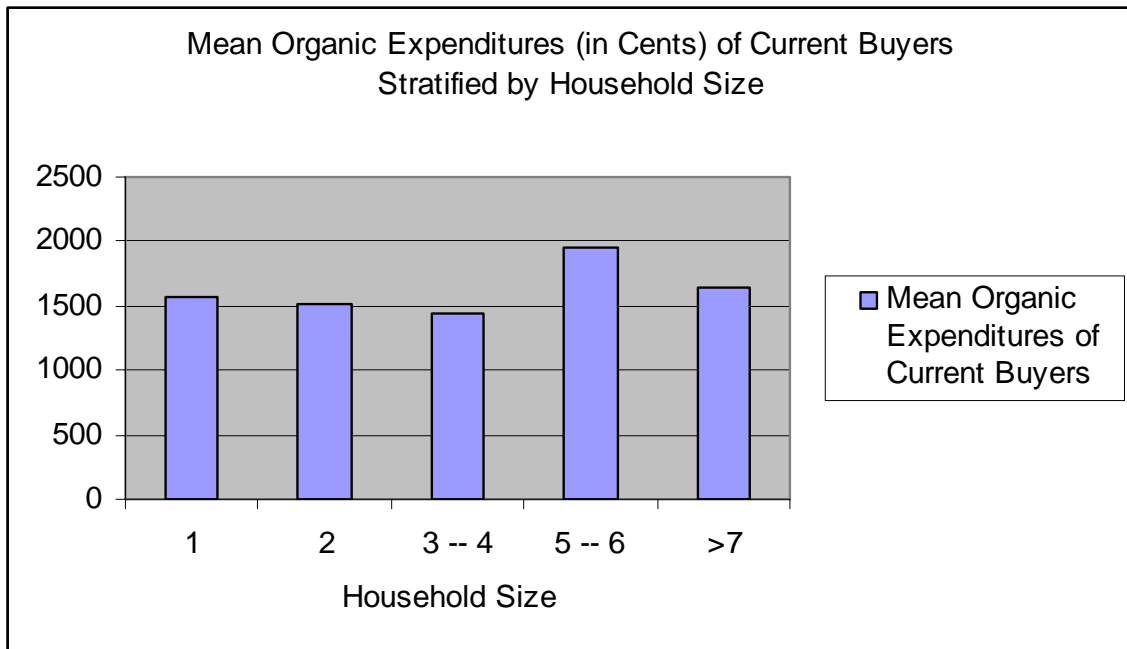
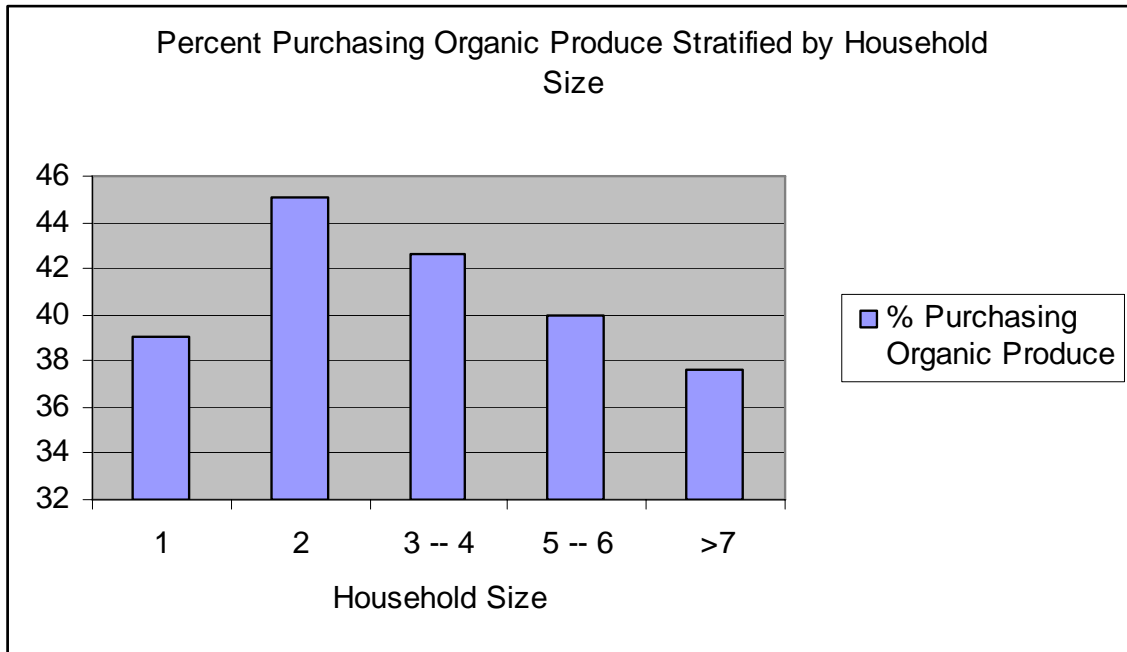


Figure 3.2. Percentage of organic buyers and mean organic expenditures of current buyers stratified by age group

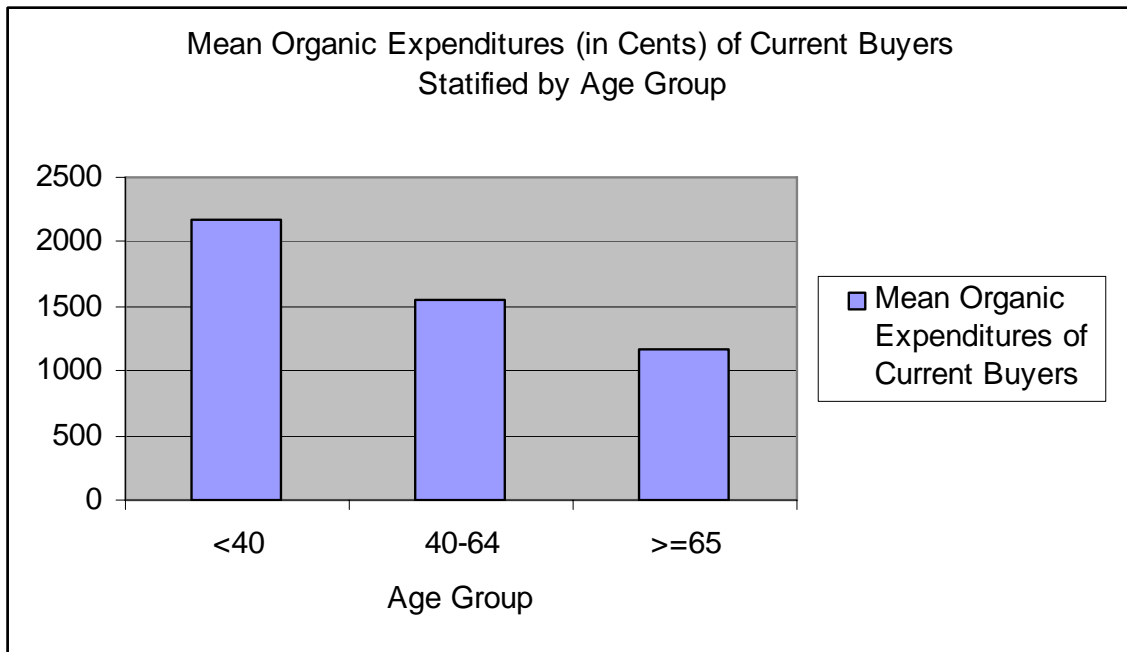
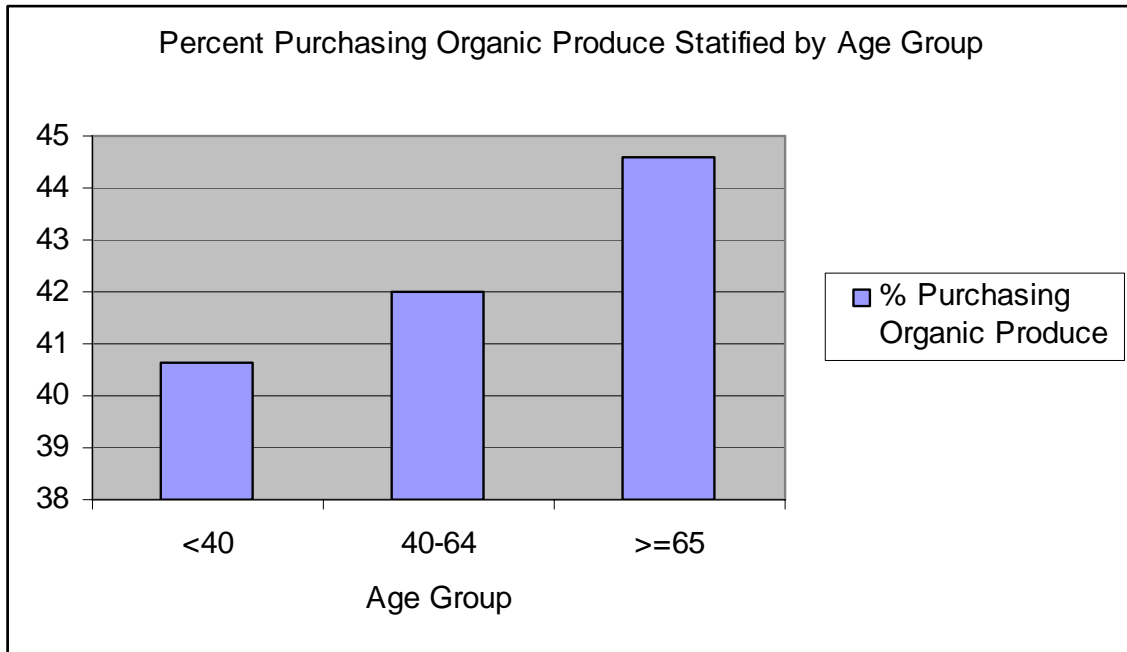


Figure 3.3. Percentage of organic buyers and mean organic expenditures of current buyers stratified by educational level

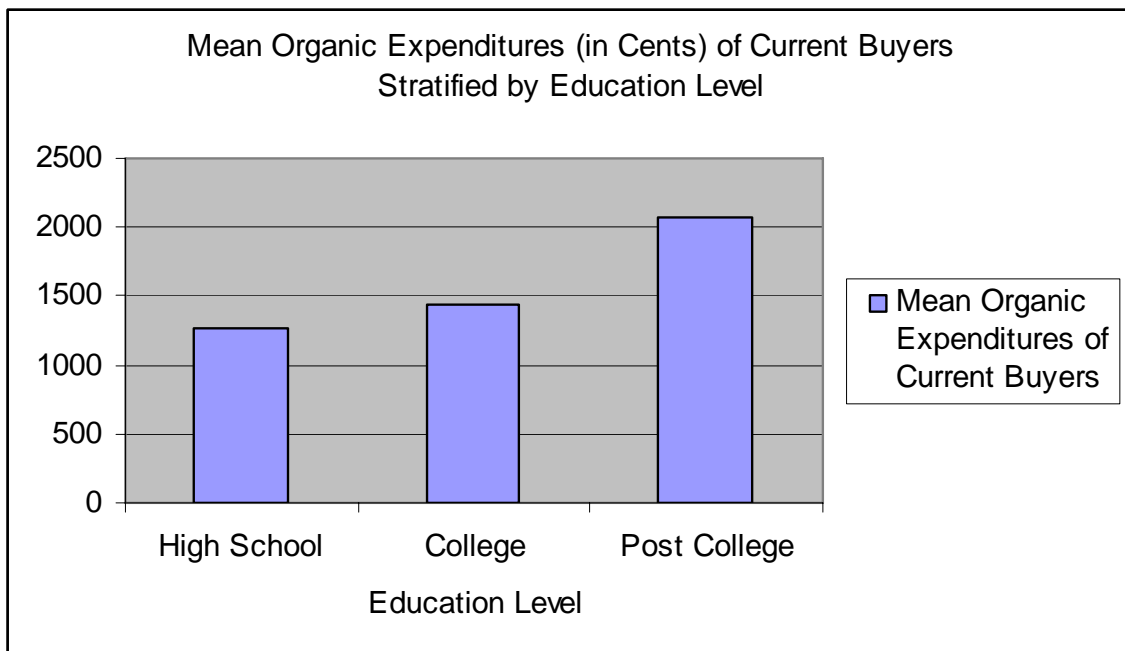
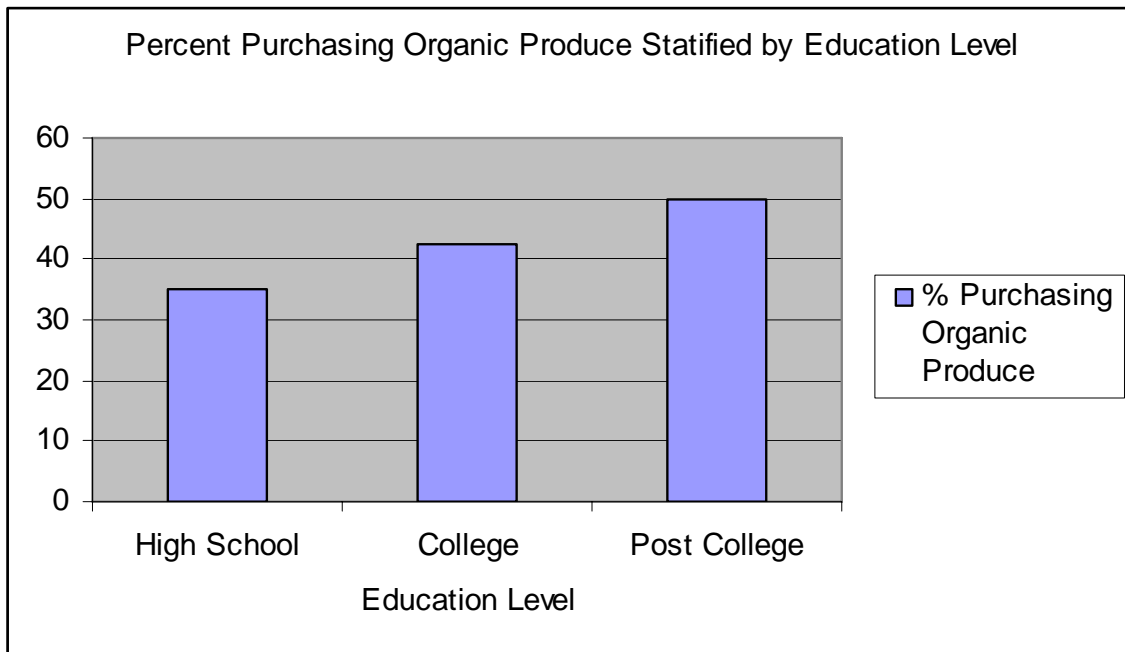


Figure 3.4. Percentage of organic buyers and mean organic expenditures of current buyers stratified by geographic region

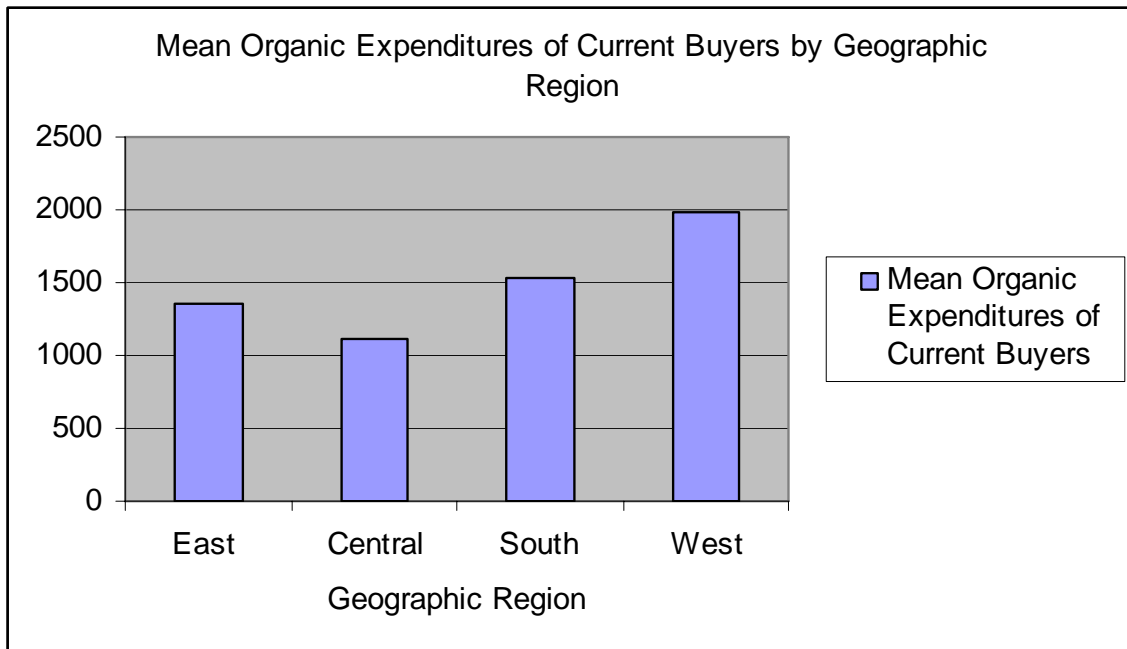
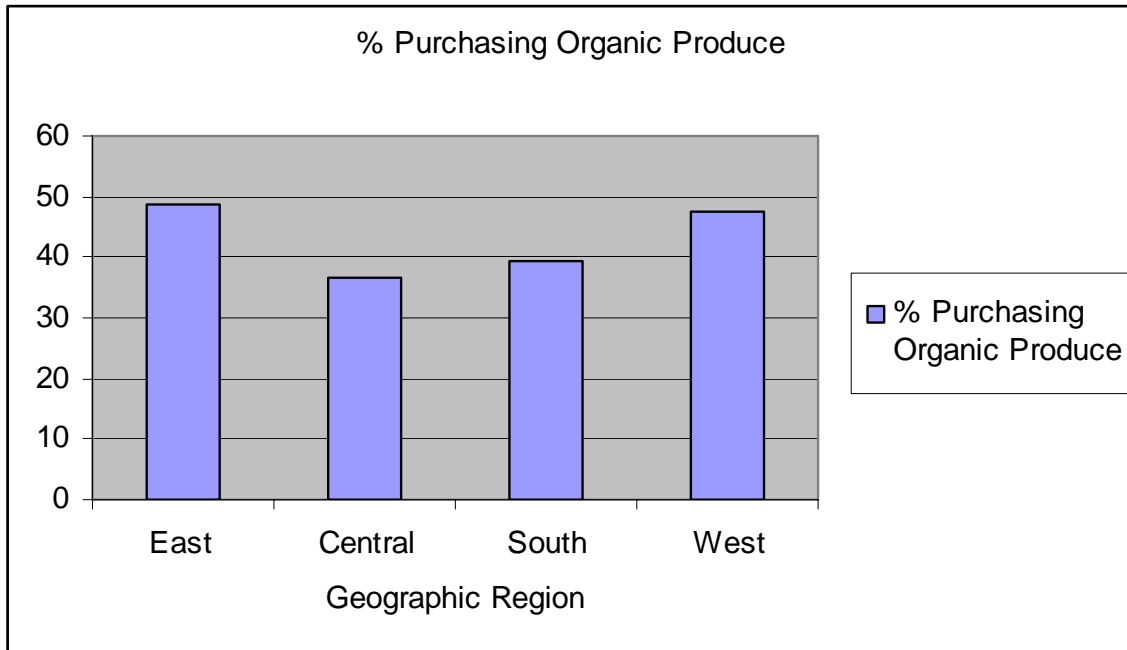


Figure 3.5. Percentage of organic buyers and mean organic expenditures of current buyers stratified by race

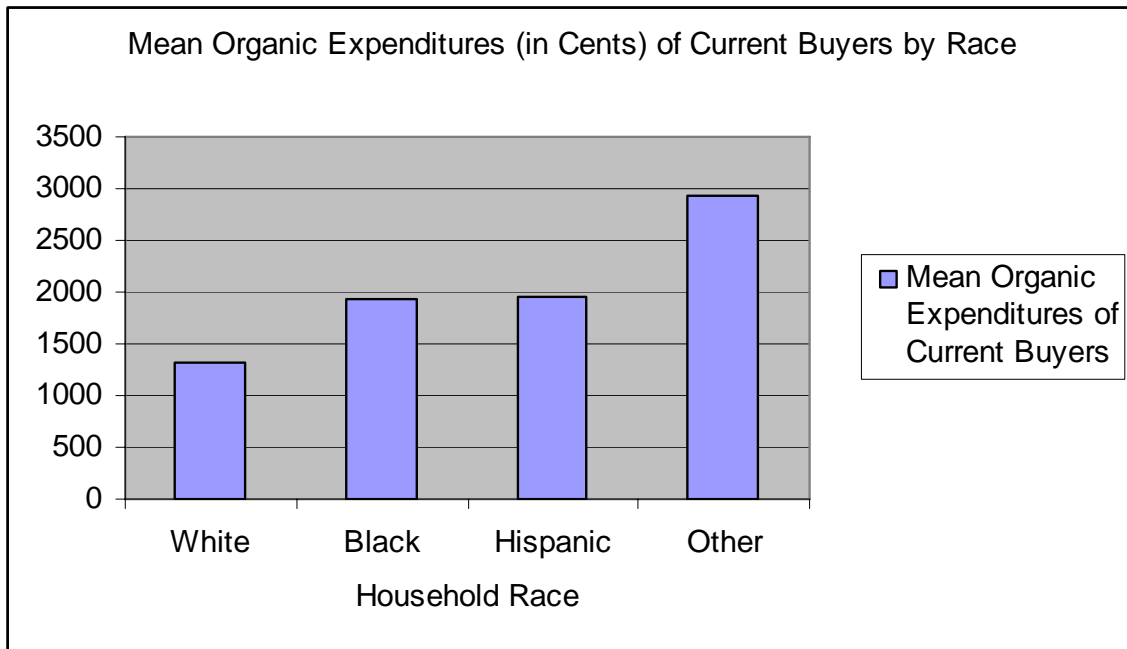
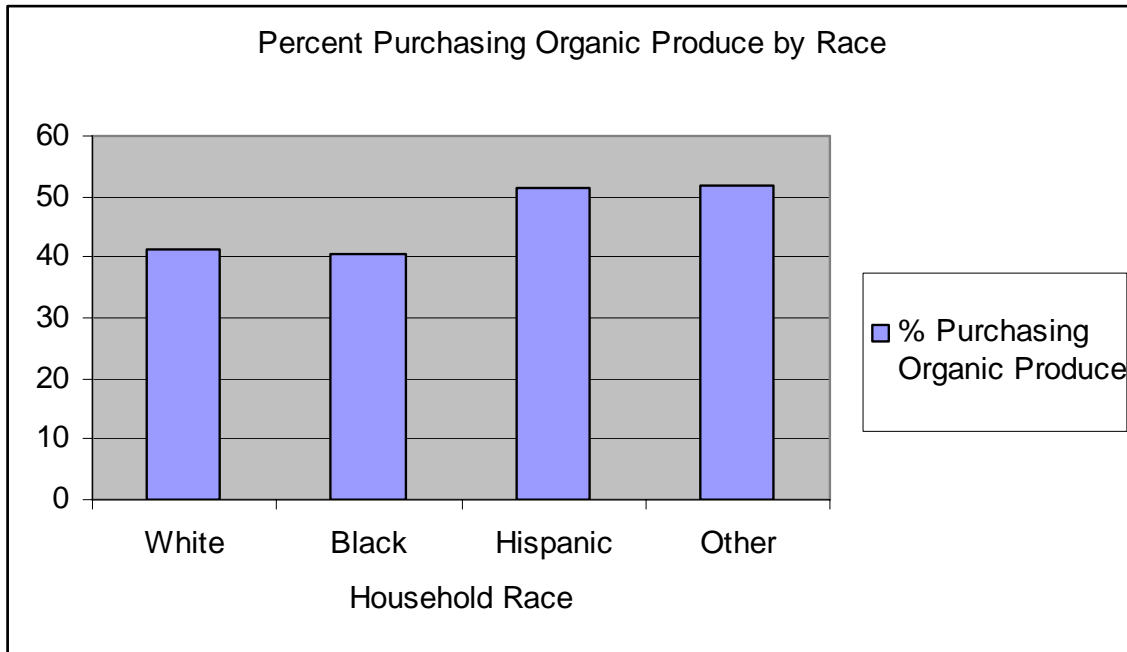
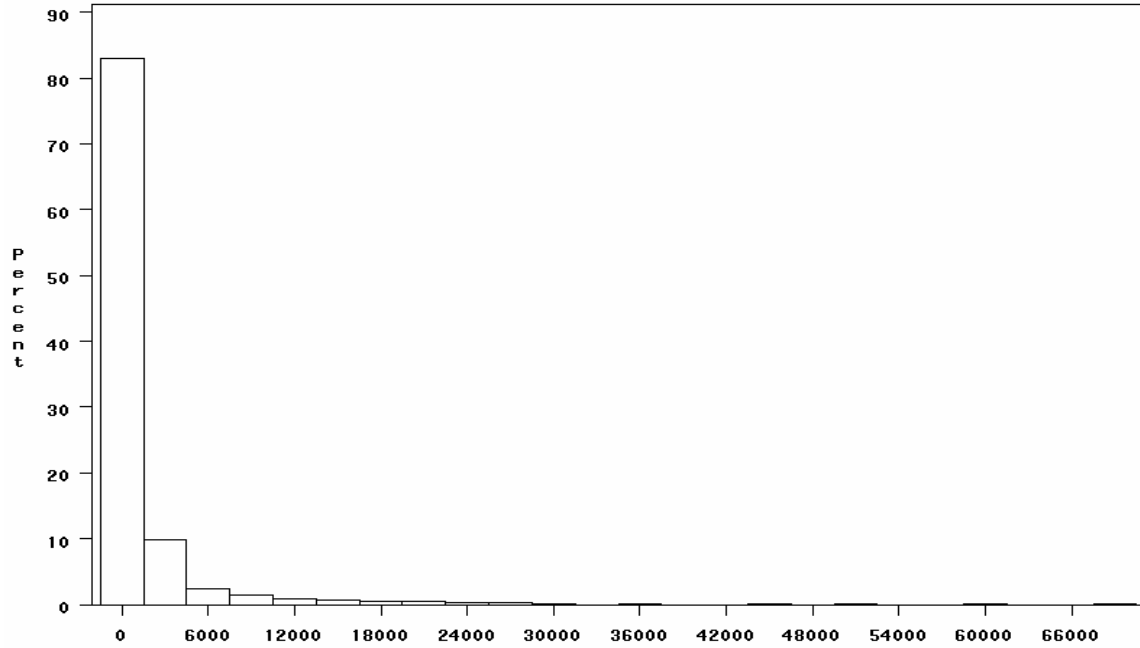
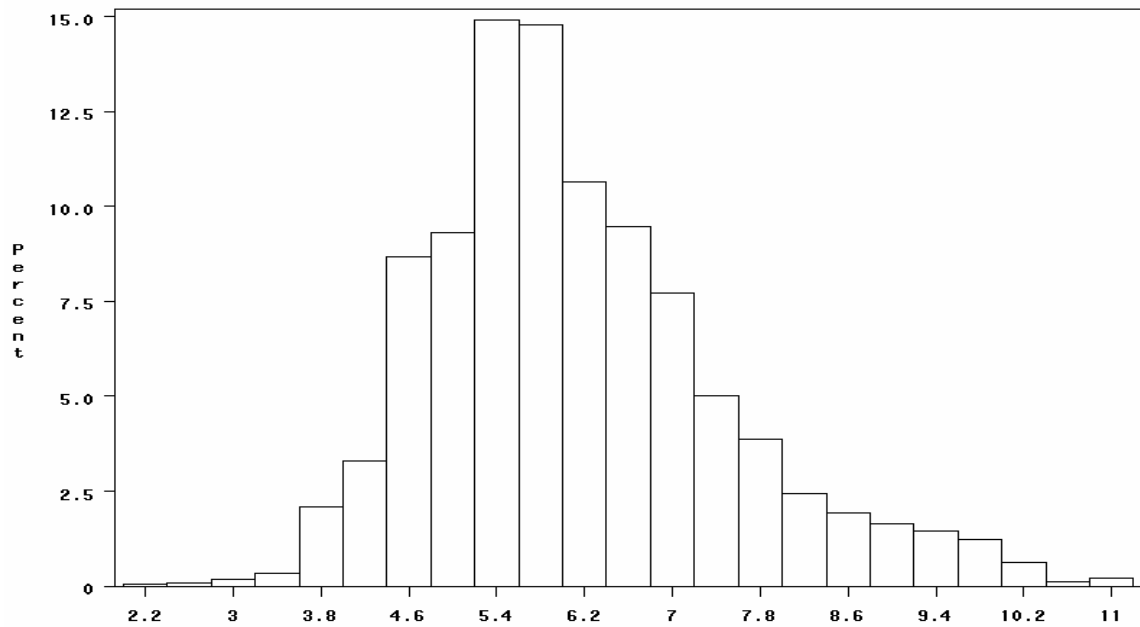


Figure 3.6. Distribution of fresh organic produce expenditures in original and natural logarithm scale (for positive consumption)

Expenditures in original scale (in cents)



Expenditures in natural logarithm scale



CHAPTER 4

NATIONAL DEMAND FOR FRESH ORGANIC AND CONVENTIONAL VEGETABLES: SCANNER DATA EVIDENCE

4.1. Introduction

Concerns over health and environmental degradation have motivated U.S. consumers to consume more organic produce in recent years. Sales of organic in natural food stores approached \$3.3 billion in 1998, compared with \$2.08 billion in 1995. In response to the growing popularity of organic, conventional supermarkets and mass market merchandisers have added shelf space for organic fruits and vegetables. In 2000, for the first time, more organic food was purchased in conventional supermarkets than in any other venue. In 2003, 47% of organic foods were sold through conventional channels, 44% were sold through natural food stores, and 9% were sold through direct and other marketing channels, e.g., farmers' markets, restaurants, exports (Organic Trade Association, 2004). Organic foods are now taking market share from conventional foods.

To facilitate the marketing of organic foods, Congress passed the Organic Foods Production Act of 1990 to establish national standards for organically grown commodities. However, final rules for systematic implementation of national organic standards had not come into force until recently. In October 2002, the new USDA standards for organic food were implemented with an 18-month transition period. According to USDA standards, organic production is defined as "A production system that is managed in accordance with the Act [Organic Foods Production] and regulations in this part to respond to site-specific conditions by integrating cultural, biological and

mechanical practices that foster cycling of resources, promote ecological balance and conserve biodiversity” (National Organic Program, 2002). The new USDA standards for organic food, by standardizing organic production and building consumer confidence in organic products, are expected to facilitate further growth in the organic foods industry.

Although organic food sales make up a small portion of total retail food sales in the United States, some organic fruit and vegetable categories have higher market penetration rates than others. For example, in 2002, organic fresh fruit and vegetable sales accounted for 4.5% of total fresh fruit and vegetable sales (NBJ, 2003). The *Natural Foods Merchandiser* reported that sales of packaged fresh produce had the highest growth rate among sales of all organic products during 2002-2003, expanding 26% to \$364 million. Conventional supermarkets accounted for three-fourths of this total. The number of new organic produce items introduced in retail markets has more than doubled over a decade, from 14 in 1993 to 30 in 2003 (USDA, ERS, 2005). In addition, organic produce has the highest market value among all organic foods. Produce accounted for 42% of U.S. organic food sales in 2000 according to the market research firm, Packaged Facts (2000).

Even though the implementation of organic standards and increasing public awareness of organic food is helpful in promoting organic fresh produce sales, more affordable prices are also important for long-term growth of the organic produce market. Consumers are expected to purchase more organic produce as the price premium for organic falls. On the other hand, farmers expect a sufficient premium to warrant the effort as organic production usually involves relatively high production costs. In a 2001 survey of organic farmers by the Organic Farming Research Foundation (OFRF), 41% of

respondents reported receiving price premiums on all items sold, and 71% received a premium on at least half of items sold (Walz, 2004). When asked about the circumstances that made it difficult to receive price premiums, limited local demand for organic items in some areas (e.g., rural areas) and price competition from conventional items (e.g., corn and strawberries) were some often cited reasons.

An analysis of trends in price premiums and price elasticities of demand can provide insight into relative changes in supply and demand for organic produce, a clearer sense of market maturity, and the likelihood of further growth. Results of this research can be valuable for farmers and retailers of fresh produce. If farmers know the price premiums of different produce items, they can allocate resources accordingly. If retailers know the target consumers and response to price, they can formulate more effective marketing strategies.

The main objective of this study is to shed light on trends in the fresh vegetable market and investigate consumer demand for fresh organic relative to conventional vegetables using ACNielsen Homescan data. The paper is organized as follows. The first section encompasses a review of the relevant literature on organic produce demand. In the second section, we introduce how different demand models can be nested and tested within a general differential demand system framework. The third section presents the economic theories of weak separability and the framework to test weak separability of consumer utility in consuming organic and conventional fresh vegetables. The formation of the time series data, organic shares and premiums, and trends are described in the fourth section. The fifth section reports the estimation results. The last section includes research implications.

4.2. Literature Review

The price premium of organic produce, percent increase over the conventional price, is an important measure to assess the market growth potential of organic produce. A part of the price premium is compensation for higher production and distribution costs on the supply side. The other part comes from the demand side, which reflects the additional amount consumers are willing to pay for organic produce.

Previous studies (Oberholtzer et. al., 2005; Sok and Glaser, 2001) on price premiums of organic produce, limited by data, mainly focused on price premiums at farmgate and wholesale levels using average prices reported to regional trade associations (mainly Boston and San Francisco markets). Using wholesale prices in the Boston area during 2000 to 2001, Sok and Glaser (2001) found that the organic premium averaged 130% over conventional prices for broccoli, 125% for carrots, and only 10% for mesclun (a mixture of small, young salad greens, herbs and edible flowers). Oberholtzer (2005) recorded a similar pattern for the same three organic produce items using 2000 to 2004 data. However, as Sok and Glaser (2001) pointed out, the conclusions do not necessarily reflect the entire industry as the price relationships between organic and conventional items were for only three vegetables in one particular wholesale market. If and when more organic produce moves through terminal markets, the data may provide a better indication of industry trends. Since consumers are the final link in the marketing channel, knowing the trend of price premiums for the main organic produce items at retail level can enable a better understanding of the degree of maturity of the organic market.

To date, only a few studies have focused on the interrelationship between demand for organic and conventional foods. Using U.S. monthly supermarket ACNielsen scanner

data for the period from September 1990 to December 1996, Glaser and Thompson (1998) found own-price elasticities for selected frozen organic vegetables (broccoli, green beans, green peas, and sweet corn) ranging from -1.63 to -2.27, indicating that small changes in price elicit large changes in quantity purchased. Response to price change is two to three times more sensitive than for conventional counterparts. Despite low statistical significance of estimated elasticities as a result of large standard errors, there appears to be a tendency toward asymmetry in cross-price responses: changes in organic quantity as conventional prices change are larger than changes in conventional quantity as organic prices change.

Using monthly data from 1988 to 1999, Thompson and Glaser (2001) studied the demand for organic and conventional baby food. Their results suggest that reductions in organic price elicit limited substitution away from conventional products. Their results, however, also show that as market share grows over time, the substitution effect can be expected to increase. Any increase in conventional baby food prices tends to boost purchases of organic by a relatively larger amount. Surprisingly, the expenditure elasticities for both organic and conventional baby food items displayed erratic variation from -4.78 to 5.44, but none were significantly different from zero.

In this study, we include several top fresh vegetables in the American diet in a demand system. The selected items account for the lion's share of U.S. vegetable consumption. Weak separability of the demand for these fresh vegetables is assumed in the demand analysis. In addition, various functional forms of the demand system are compared and tested so that the most appropriate form is used to obtain reliable estimated elasticities for economic interpretation.

4.3. Differential Demand Systems

The Almost Ideal Demand System (Deaton and Muellbauer, 1980), the Rotterdam model (Barten, 1964; Theil, 1965), and their variants are probably the most commonly used functional forms in empirical demand analysis. The Rotterdam model is derived from a first-order approximation to arbitrary Marshallian demand functions. The Almost Ideal Demand System (AIDS) in its original formulation is derived from the maximization of an explicit indirect utility function or, equivalently, from the minimization of an explicit expenditure/cost function of price independent generalized logarithmic (PIGLOG) form. Since these functional forms cannot be nested within their original formulations, it is impossible to test one against the other. Therefore, in most demand analyses, it is often a practical matter for researchers to choose a specific functional form. Using a differential form of the linear AIDS model, Barten (1993) showed that the linear AIDS model, the Rotterdam model, and their variants can actually be nested in a general differential model which can be used to test the fit of different models.

The Rotterdam model, developed by Barten (1964) and Theil (1965), takes the following differential form:

$$w_i d \log q_i = \theta_i d \log Q + \sum_j \pi_{ij} d \log p_j \quad (4.1)$$

$i=1, 2, \dots, n,$

where $w_i = (w_{it} + w_{i,t-1})/2$ represents the average expenditure share for commodity i with subscript t standing for time; $d \log q_i = \log(q_{it} / q_{i,t-1})$ is the natural logarithmic change in the consumption level for commodity i ; and $d \log p_i = \log(p_{it} / p_{i,t-1})$ is the natural logarithmic change in the price for commodity i . The term $d \log Q$ is an index number (Divisia volume index) for the change in real income and can be written as

$$d \log Q = \sum_i w_i d \log q_i . \quad (4.2)$$

The time subscripts implied by the equations are omitted for convenience. The demand parameters θ_i and π_{ij} are given by

$$\theta_i = p_i(\partial q_i / \partial y), \quad \pi_{ij} = (p_i p_j / y) s_{ij}, \quad \text{and} \quad s_{ij} = \partial q_i / \partial p_j + q_j \partial q_i / \partial y, \quad (4.3)$$

where y is the total outlay or the budget and s_{ij} is the (i, j) th element of the Slutsky substitution matrix, parameter θ_i is the marginal budget share of commodity i , and π_{ij} is a compensated price effect. The constraints of demand theory can be directly applied to the Rotterdam parameters. In particular, we have

$$\text{Adding-up} \quad \sum_i \theta_i = 1, \quad \sum_i \pi_{ij} = 0, \quad (4.4)$$

$$\text{Homogeneity} \quad \sum_j \pi_{ij} = 0, \quad (4.5)$$

$$\text{Slutsky Symmetry} \quad \pi_{ij} = \pi_{ji}. \quad (4.6)$$

The Rotterdam model is a particular parameterization of a system of differential demand equations where demand parameters θ_i and π_{ij} are assumed to be constant. However, there is no strong *a priori* reason that θ_i and π_{ij} should be held constant. By relaxing the marginal budget share parameter to be variable, Keller and van Driel (1985) further proposed the CBS (Central Bureau of Statistics) model:

$$w_i d \log q_i = (\beta_i + w_i) d \log Q + \sum_j \pi_{ij} d \log p_j, \quad (4.7)$$

where β_i and π_{ij} are constant coefficients and $\beta_i + w_i$ is the marginal budget share.

In contrast to the Rotterdam model, the AIDS model, in its original formulation, is not a differential function. It is specified as

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log(y / P), \quad (4.8)$$

where P is a price index defined by

$$\log P = \alpha_0 + \sum \alpha_k \log p_k + 1/2 \sum_k \sum_l \log p_k \log p_l. \quad (4.9)$$

The adding-up restriction requires that $\sum_i \alpha_i = 1$, $\sum_i \beta_i = 0$, and $\sum_i \gamma_{ij} = 0$; homogeneity is satisfied when $\sum_i \gamma_{ji} = 0$; and symmetry is satisfied if $\gamma_{ij} = \gamma_{ji}$.

The differential form of equation (4.8), based on Deaton and Muellbauer's suggestion of substituting the Divisia Price index $\sum_i w_i d \log p_i = 0$ for $d \log P$, is

$$dw_i = \beta_i \log Q + \sum_j \gamma_{ij} d \log p_j \quad \text{or} \quad (4.10)$$

$$w_i d \log q_i = (\beta_i + w_i) d \log Q + \sum_j [\gamma_{ij} - w_i (\delta_{ij} - w_j)] d \log p_j, \quad (4.10a)$$

where δ_{ij} is the Kronecker delta equal to unity if $i = j$ and zero otherwise (Barten, 1993).

To derive (4.10a) from (4.10), one can use the relations

$$dw_i = w_i (d \log p_i + d \log q_i - d \log y) \quad \text{and} \quad d \log y = d \log P + d \log Q.$$

A fourth alternative, the National Bureau of Research (NBR) model (Neves, 1987), can be derived by substituting $\theta_i - w_i$ for β_i in (4.10a) so that it has the Rotterdam income coefficients but the AIDS price coefficients. Specifically, the NBR is

$$dw_i + w_i d \log Q = \theta_i \log Q + \sum_j \gamma_{ij} d \log p_j. \quad (4.11)$$

Similarly, equation (4.11) can be rewritten as

$$w_i d \log q_i = \theta_i d \log Q + \sum_j [\gamma_{ij} - w_i (\delta_{ij} - w_j)] d \log p_j. \quad (4.11a)$$

The four models [equations (4.1), (4.7), (4.10a), and (4.11a)] have the same left-hand side variable, $w_i d \log q_i$, and right-hand side variables, $d \log Q$ and $d \log p_i$.

These models can be considered as four different ways to parameterize a general model.

Marginal budget shares are assumed to be constant (i.e., θ_i) in the Rotterdam and NBR models but variable (i.e., $\beta_i + w_i$) in the AIDS and CBS. The Slutsky terms are considered to be constants (i.e., π_{ij}) in the Rotterdam and CBS and variable [i.e., $\gamma_{ij} - w_i(\delta_{ij} - w_j)$] in the AIDS and NBR. The CBS and NBR can be considered as income-response variants of the Rotterdam and AIDS, respectively.

These four models are not nested, but following Barten (1993), a general demand system can be developed which nests all four. The general system is

$$w_i d \log q_i = (d_i + \delta_1 w_i) d \log Q + \sum_j [e_{ij} - \delta_2 w_i (\delta_{ij} - w_j)] d \log p_j, \quad i = 1, 2, \dots, n, \quad (4.12)$$

where $d_i = \delta_1 \beta_i + (1 - \delta_1) \theta_i$ and $e_{ij} = \delta_2 \gamma_{ij} + (1 - \delta_2) \pi_{ij}$; δ_1 and δ_2 are two additional parameters to be estimated. Note that (4.12) becomes the Rotterdam when both δ_1 and δ_2 are restricted to be zero, the CBS when $\delta_1 = 1$ and $\delta_2 = 0$, the AIDS when $\delta_1 = 1$ and $\delta_2 = 1$, and NBR when $\delta_1 = 0$ and $\delta_2 = 1$. The demand restrictions on (4.12) are

$$\text{Adding-up} \quad \sum_i d_i = 1 - \delta_1, \quad \sum_i e_{ij} = 0, \quad (4.13)$$

$$\text{Homogeneity} \quad \sum_j e_{ij} = 0 \text{ and}$$

$$\text{Slutsky Symmetry} \quad e_{ij} = e_{ji}.$$

For application to discrete data, the specifications are approximated by replacing w_{it} by $(w_{it} + w_{it-1})/2$, $d \log q_{it}$ by $\log(q_{it} / q_{it-1})$ and $d \log p_{it}$ by $\log(p_{it} / p_{it-1})$, where subscript t indicates time. Since the four models have the same set of parameters and can be nested in the general demand system as four special cases, the magnitude of the maximum likelihood value can be used as a criterion to evaluate the goodness of fit of each nested model and the likelihood ratio test (LRT) can be used for model selection.

4.4. Weak Separability of Subgroups

Since the sample in this study includes organic and conventional fresh vegetables, it is natural to question whether the demand for organic fresh vegetables is independent of that for conventional counterparts. The concept of separability assumes that a set of commodities can be partitioned into some mutually exclusive and collectively exhaustive subsets and the commodities within each subset are assumed to possess some common characteristics. A rationale for incorporating such assumptions into the consumer allocation problem is that the consumption decision occurs in two stages. First, the consumer budgets income between subsets of commodities. The second stage involves within-subset or commodity group allocation decisions. Weak separability is a necessary and sufficient condition for the second stage of the two stage budgeting procedure (Deaton and Meullbauer, 1980).

Weak separability of consumer preferences implies the marginal rate of substitution between any two goods from within the same subset is independent of the quantities of the commodities consumed from other subsets which characterize an underlying weakly separable utility function. To review it briefly, let $\mathbf{q} = (q_1, \dots, q_n)$ denote the corresponding nominal price vector, and y denote total expenditures on the n goods. The set of indices for n goods is $I = \{1, \dots, n\}$, and these goods can be ordered in S separable groups defined by the mutually exclusive and exhaustive partition $\hat{I} = \{I_1, \dots, I_S\}$ of the set I . If $U(\mathbf{q})$ is the utility function, then $U(\mathbf{q})$ is directly symmetrically separable in the partition \hat{I} if it can be written as:

$$U(\mathbf{q}) = U^0[U^1(\mathbf{q}^1), U^2(\mathbf{q}^2), \dots, U^S(\mathbf{q}^S)], \quad (4.14)$$

where $U^S(\cdot)$ are subutility functions that depend on a subset \mathbf{q}^S of goods whose indices are in $I_s (s = 1, \dots, S)$. We assume $U^0(\cdot)$ and the subutility functions $U^S(\cdot)$ satisfy conditions typically required of a utility function (in particular, strong monotonicity, strictly quasi-concavity, and differentiability).

It is known that the separable structure in (4.14) imposes a number of restrictions on the substitution possibilities between goods in different groups. If $h_i(\mathbf{p}, u)$ denotes the i th Hicksian (compensated) demand function, where u is a reference utility level, $V(\mathbf{p}, y)$ is the indirect utility function dual to $U(\mathbf{q})$, and $q_i(\mathbf{p}, y)$ is the i th Marshallian (ordinary) demand function, Goldman and Uzawa (1964) showed that the elements in the Slutsky substitution matrix between two goods in different groups (s_{ik}) are proportional to the income effects of the two goods involved:

$$s_{ik} = \frac{\partial h_i(\mathbf{p}, V(\mathbf{p}, y))}{\partial p_k} = \mu_{gs}(\mathbf{p}, y) \frac{\partial q_i(\mathbf{p}, y)}{\partial y} \frac{\partial q_k(\mathbf{p}, y)}{\partial y} \quad (4.15)$$

for all $i \in I_g$ and $j \in I_s$, for all $g \neq s$. Note that the proportionality term $\mu_{gs}(\mathbf{p}, y)$ is the same for all goods in the two groups involved. It is important to emphasize that the restrictions in (4.15) are necessary and sufficient for the weakly separable structure in (4.14). Hence, (4.15) summarizes all the relevant restrictions of the separable structure in (4.14) and can be used to maintain this form of separability or to test it. If one multiplies both sides of equation (4.15) by $p_i p_k / y$, one obtains

$$\left(\frac{p_i p_k}{y} \right) s_{ik} = \pi_{ik} = \mu_{gs}(\mathbf{p}, y) \theta_i \theta_k, \quad (4.16)$$

where θ_i and θ_k are the marginal budget shares of commodity i and k , respectively, and π_{ik} are the Slutsky terms (compensated price terms).

Based on the above necessary and sufficient conditions of weak separability, Moschini, Moro, and Green (1994) derived the parametric restrictions required to implement the separability conditions for the AIDS and the Rotterdam demand systems. The number of nonredundant restrictions implied by the assumed separable structure is

$$n_R = \frac{1}{2} [n(n-1) - \sum_{s=1}^S n_s(n_s-1) - S(S-1)], \quad (4.17)$$

where n_s is the number of goods belonging to the s th group ($s = 1, \dots, S$).

For the Rotterdam model and linear AIDS models, the separability restrictions of (4.16) can be expressed as

$$\frac{\pi_{ik}}{\pi_{jm}} = \frac{\theta_i \theta_k}{\theta_j \theta_m} \quad \text{and} \quad (4.18)$$

$$\frac{\gamma_{ik} + w_i w_k}{\gamma_{jm} + w_j w_m} = \frac{(w_i + \beta_i)(w_k + \beta_k)}{(w_j + \beta_j)(w_m + \beta_m)} \quad (4.19)$$

for all $(i, j) \in I_g$ and $(k, m) \in I_s$, for all $g \neq s$. In contrast to the Rotterdam, where Slutsky terms and marginal budget shares are assumed to be constant, linear AIDS is characterized by variable marginal budget shares and Slutsky terms, thus weak separability restrictions for linear AIDS can be evaluated only at one point because of the inclusion of budget shares. Nevertheless, evaluation at mean levels of budget shares can be a good approximation for the weak separability test.

4.5. Data and Trends

Consumption data for organic and conventional fresh vegetables were drawn from ACNielsen Homescan panel data from 1999 to 2003. The panel is nationally representative of U.S. households and provides food purchase data for at-home

consumption. Each week, a panel household scanned either the Uniform Product Code (UPC) or a designated code (for random weight) for all purchases at retail outlets. The data include detailed product characteristics, quantity, expenditures, and promotion information as well as household income and demographic information. To avoid possible data problems resulting from careless or incomplete reporting, only those households which reported purchases for at least 10 months in a year were included. There were between 7,124 and 8,833 households on the consumer panel for each respective year during the five-year period. To study the trend in organic consumption with comparable data, we kept only 2,845 households – those which remained on the panel for all five years. Consumption data for the 2,845 households were aggregated by week to give 260 time-series observations.

Four popular vegetables in the consumer diet, potatoes, tomatoes, onions, and lettuce, which account for around 56% among all vegetables purchased by U.S. consumers in terms of quantity, are considered in the study.¹ Classified into organic and conventional, eight items in total are included in the demand system. Among these vegetables, tomatoes and lettuce are among the top organic vegetables purchased by U.S. consumers. According to a Fresh Trends 2002 survey, tomatoes (37% of the respondents) and leafy vegetables (18%, mostly lettuce) are the two most popular organic vegetables purchased (Shaffer, 2002).

The new USDA standards for organic food were implemented in October 2002, thus packaged organic vegetables with UPC codes in ACNielsen data for 2002 and after are explicitly labeled either “organic seal” (USDA certified organic) or “organic claim” (producer-claimed organic). In this study, vegetables with either one of the two organic

¹ The top eight vegetables in terms of quantity purchased in 1999 were potatoes, tomatoes, onions, sweet corn, green beans, carrots, lettuce, and green peas (Reed, 2004).

labels were regarded as organic. Organic vegetables sold random weight were identified by name, which is provided in the data.

The budget shares and premiums for the selected vegetables are shown in figure 4.1. Although the organic fresh produce market is growing fast, the organic vegetable share of consumer vegetable expenditures is still low compared with that of the conventional counterpart. Among the four vegetables, lettuce has the highest organic share which accounts for 3.76% of total lettuce sales on average during the five-year period. Tomatoes are a close second with 3.74% of tomato consumption devoted to organic. Organic onions and potatoes hold 1.50 and 1.10% of respective markets when measured in terms of value.

Growth patterns of the selected organic vegetables, lettuce and tomatoes in particular, are divergent during the years from 1999 to 2003. The organic share of lettuce went up steadily, while that of tomatoes decreased from 4.5 to 3.2%. There was not much change in the organic share for onions and potatoes. For the overall organic share of consumer expenditures on these four vegetables, the pattern suggests that after a slight decline over the first four years, it began to pick up in 2003.

Organic premiums vary by vegetable. The largest organic premium was found for potatoes, with organic prices about 75% higher than that for conventional potatoes and rising premiums over the five years. The same pattern was found for onions with the organic premium rising to 34% in 2003 from 11% in 1999. In contrast, for lettuce and tomatoes which have relatively higher organic market penetration, organic premiums appear to have declined for lettuce (from 36 to 26%) and remained unchanged for tomatoes (around 13%).

4.6. Estimation Results

As a result of the adding-up conditions, the full $n \times n$ matrices of all five demand systems are singular by construction (n is the number of goods). Therefore, the five demand systems were estimated by dropping the last equation, the equation for conventional lettuce. The parameter estimates are invariant to which equation is omitted. As the 2,845 households appearing in all five years are price takers in the market, prices in the demand system can be treated as exogenous. The models were estimated using maximum likelihood with homogeneity and symmetry conditions imposed.

The maximum likelihood values for the five demand systems are reported in table 4.1. The general demand system, of course, has the highest maximum likelihood value because the two parameters, δ_1 and δ_2 , are unrestricted. It has a statistically better fit to the data than any one of the nested models. Among the four nested demand systems, the linear AIDS model is found to have the highest maximum likelihood value. Because the four nested systems have the same set of parameters, the linear AIDS model, with the highest maximum likelihood value, is found to fit the data better than the Rotterdam, CBS, or NBR models and thus is selected as the best among the four nested models. Only results based on the linear AIDS model are reported and discussed in this section.

Elasticities

The income elasticity and compensated price elasticity of the linear AIDS were computed as follows:

$$\text{income elasticity, } \eta_i = \theta_i / w_i \text{ or } \eta_i = 1 + \beta_i / w_i, \text{ and} \quad (4.20)$$

$$\text{compensated price elasticity, } \eta_{ij} = \pi_{ij} / w_i \text{ or } \eta_{ij} = \gamma_{ij} / w_i - \delta_{ij} + w_j. \quad (4.21)$$

Since both expenditure and compensated price elasticities are functions of budget shares, they were computed at the sample means. The results are presented in table 4.2.

All income elasticities except that for organic lettuce are positive and significant at the 10% level. It is interesting to note that the income elasticities of all organic vegetables are higher than those of conventional counterparts. It implies that given an increase in the budget share for the four selected fresh vegetables, consumers will allocate a higher share of the budget to organic than to conventional vegetables. All own-price elasticities are negative and statistically significant. It is interesting to note that the magnitudes of own-price elasticities for the organic vegetables are not always higher than those for conventional ones. For potatoes and tomatoes, own-price elasticities for organic are found to be higher than those for conventional types in magnitude, whereas the opposite is found for onions and lettuce. The only commodity with an elastic own-price effect is organic potatoes. All other own-price elasticities are less than one in magnitude, implying inelastic consumption with respect to own-price change. The results are in contrast to those for frozen vegetables reported by Glaser and Thompson (1998) who found responsive own-price elasticities for all four frozen vegetables, broccoli, corn, green peas, and green beans. One should note that in the Glaser and Thompson (1998) study, demand for organic and conventional frozen vegetables was estimated with a three-good system (organic, conventional, and all else) for each vegetable, which may mask the substitution effect of other vegetables, especially fresh vegetables.

Among all cross-price elasticities between organic and conventional vegetables, only organic and conventional potatoes have a significant substitution relationship. Positive and significant cross-price elasticities imply that decreasing organic price premiums are likely to boost consumption of organic vegetables. The difference in

magnitude also suggests asymmetry in the substitution effect, implying that changes in the price of conventional potatoes tend to have a larger impact on consumption of organic potatoes than vice versa. This is consistent with findings of Glaser and Thompson (1998) and Thompson and Glaser (2001). Because the cross-price elasticities (η_{ij}) are computed as $\gamma_{ij} / w_i + w_j$ and γ_{ij} are symmetric, the asymmetry in cross-price elasticities between organic and conventional groups is not surprising, given such contrasting differences in budget shares of organic and conventional vegetables.

Positive cross-price elasticities are also found between organic and conventional onions, although not statistically significant. For tomatoes and broccoli, the cross-price elasticities are negative but not significantly different from zero. The cross-price elasticities between demands for organic and conventional fresh vegetables seem to suggest that demand for organic vegetables is not responsive to price changes in conventional vegetables except for some items with very low organic shares and high price premiums, such as potatoes.

Weak Separability Test

As the linear AIDS model was found to have the best goodness of fit among all four nested models, the test for weak separability between organic and conventional vegetable groups was applied using the linear AIDS model. From (4.14), the weakly separable utility function for organic and conventional vegetables can be written as

$$U = U^0 [U^N (q^{N1}, q^{N2}, q^{N3}, q^{N4}), U^O (q^{O1}, q^{O2}, q^{O3}, q^{O4})], \quad (4.22)$$

where N and O denote conventional and organic groups, respectively. Following the earlier discussion, it is verified that this structure entails 15 nonredundant restrictions

relative to the unrestricted utility function. For the preferred linear AIDS model, these nonredundant restrictions can be represented as:

$$\begin{aligned}
\frac{\gamma_{N1O1} + w_{N1}w_{O1}}{\gamma_{N1O2} + w_{N1}w_{O2}} &= \frac{(w_{O1} + \beta_{O1})}{(w_{O2} + \beta_{O2})}, & \frac{\gamma_{N1O1} + w_{N1}w_{O1}}{\gamma_{N1O3} + w_{N1}w_{O3}} &= \frac{(w_{O1} + \beta_{O1})}{(w_{O3} + \beta_{O3})}, & \frac{\gamma_{N1O1} + w_{N1}w_{O1}}{\gamma_{N1O4} + w_{N1}w_{O4}} &= \frac{(w_{O1} + \beta_{O1})}{(w_{O4} + \beta_{O4})}, \\
\frac{\gamma_{N2O1} + w_{N2}w_{O1}}{\gamma_{N2O2} + w_{N2}w_{O2}} &= \frac{(w_{O1} + \beta_{O1})}{(w_{O2} + \beta_{O2})}, & \frac{\gamma_{N2O1} + w_{N2}w_{O1}}{\gamma_{N2O3} + w_{N2}w_{O3}} &= \frac{(w_{O1} + \beta_{O1})}{(w_{O3} + \beta_{O3})}, & \frac{\gamma_{N2O1} + w_{N2}w_{O1}}{\gamma_{N2O4} + w_{N2}w_{O4}} &= \frac{(w_{O1} + \beta_{O1})}{(w_{O4} + \beta_{O4})}, \\
\frac{\gamma_{N3O1} + w_{N3}w_{O1}}{\gamma_{N3O2} + w_{N3}w_{O2}} &= \frac{(w_{O1} + \beta_{O1})}{(w_{O2} + \beta_{O2})}, & \frac{\gamma_{N3O1} + w_{N3}w_{O1}}{\gamma_{N3O3} + w_{N3}w_{O3}} &= \frac{(w_{O1} + \beta_{O1})}{(w_{O3} + \beta_{O3})}, & \frac{\gamma_{N3O1} + w_{N3}w_{O1}}{\gamma_{N3O4} + w_{N3}w_{O4}} &= \frac{(w_{O1} + \beta_{O1})}{(w_{O4} + \beta_{O4})}, \\
\frac{\gamma_{N4O1} + w_{N4}w_{O1}}{\gamma_{N4O2} + w_{N4}w_{O2}} &= \frac{(w_{O1} + \beta_{O1})}{(w_{O2} + \beta_{O2})}, & \frac{\gamma_{N4O1} + w_{N4}w_{O1}}{\gamma_{N4O3} + w_{N4}w_{O3}} &= \frac{(w_{O1} + \beta_{O1})}{(w_{O3} + \beta_{O3})}, & \frac{\gamma_{N4O1} + w_{N4}w_{O1}}{\gamma_{N4O4} + w_{N4}w_{O4}} &= \frac{(w_{O1} + \beta_{O1})}{(w_{O4} + \beta_{O4})}, \\
\frac{\gamma_{N1O1} + w_{N1}w_{O1}}{\gamma_{N2O1} + w_{N2}w_{O1}} &= \frac{(w_{N1} + \beta_{N1})}{(w_{N2} + \beta_{N2})}, & \frac{\gamma_{N1O1} + w_{N1}w_{O1}}{\gamma_{N3O1} + w_{N3}w_{O1}} &= \frac{(w_{N1} + \beta_{N1})}{(w_{N3} + \beta_{N3})}, & \frac{\gamma_{N1O1} + w_{N1}w_{O1}}{\gamma_{N4O1} + w_{N4}w_{O1}} &= \frac{(w_{N1} + \beta_{N1})}{(w_{N4} + \beta_{N4})}.
\end{aligned}
\tag{4.23}$$

The Wald test was used to test the validity of the above restrictions implied by weak separability. Unlike the likelihood ratio test, the Wald test is not invariant to different but algebraically equivalent nonlinear restrictions. However, since the restricted model here is too complicated to estimate, the likelihood ratio test is not executable. Instead, Wald tests with 15 restrictions in both multiplicative and divisible forms were applied to the unrestricted model. Using Monte Carlo simulation, Gregory and Veall (1985) showed that the Wald test can be statistically advantageous if restrictions with multiplicative forms rather than divisible forms are used. The Wald test statistics with 15 restrictions in multiplicative and divisible forms are 11.86 and 18.66, respectively, which are less than 25, the Chi-square distribution threshold value for 15 degrees of freedom at the 95% level of significance. Wald test results suggest that the null hypothesis that organic and conventional groups are weakly separable cannot be rejected, which implies

that consumer utility from consuming organic fresh vegetables tends to be self-contained and not likely to be affected by consumption levels of conventional vegetables.

4.7. Conclusion

Using ACNielsen scanner data on selected fresh vegetable sales from 1999 to 2003, this study analyzed consumption patterns and price premiums for organic fresh vegetables and selected the best model to investigate the interrelationship between consumption of organic and conventional fresh vegetables.

The general differential demand system which nests the linear AIDS, the Rotterdam model, and their variants can be very useful in selecting the best model. In this way the bias of parameter and elasticity estimates resulting from a suboptimal model can be avoided. In this study, the linear AIDS model was found to fit the fresh vegetable consumption data best among four nested models.

The results of the analysis have several implications for producers and retailers of fresh organic produce. Differences in organic premiums among alternative fresh vegetables are quite marked, with the highest relative organic premium (potatoes) more than five times higher than that for the lowest (tomatoes). If the difference cannot be fully explained by the difference in production costs for organic versus conventional farming, producers may be able to increase profit by allocating more resources to organic with higher profit margins.

Income elasticities for organic were found to be higher than those for conventional vegetables for all four vegetables included in the model, which suggests that if U.S. consumers were to increase expenditures on fresh vegetables, they would spend a larger portion of their budget on organic. With the exception of potatoes, all other

vegetables were found to have inelastic own-price effects and cross-price effects between organic and conventional vegetables, implying that a drop in the organic premium does not necessarily guarantee an increase in total organic revenues. Weak separability between organic and conventional vegetables also implies that consumption of organic is largely determined by preference for the “organic lifestyle.”

Most organic vegetables were about 10 to 30% higher in price than conventional counterparts except for some newly introduced organic vegetables with relatively thin market shares and high premiums. Room for price promotion of these organic vegetables is limited. Considering the fact that the fresh organic produce market is still thin (the highest organic share is less than 4% among the four vegetables in the study) but becoming more standardized and accessible to the public, we can expect that the market for organic will continue to grow in the foreseeable future while organic premiums are not likely to drop much except perhaps for some newly introduced items.

Table 4.1. Test Results for the Rotterdam Model, CBS, LA/AIDS, NBR, and General Model

Model	Restrictions	Log Likelihood	$-2[L(\theta^*) - L(\theta)]^a$
General Model	no	6224	
Rotterdam	$\delta_1 = 0, \delta_2 = 0$	6165	118
CBS	$\delta_1 = 1, \delta_2 = 0$	6190	68
Linear AIDS	$\delta_1 = 1, \delta_2 = 1$	6212	24
NRR	$\delta_1 = 0, \delta_2 = 1$	6186	76

^a $L(\theta^*)$ and $L(\theta)$ are restricted and unrestricted maximum likelihood values, respectively.

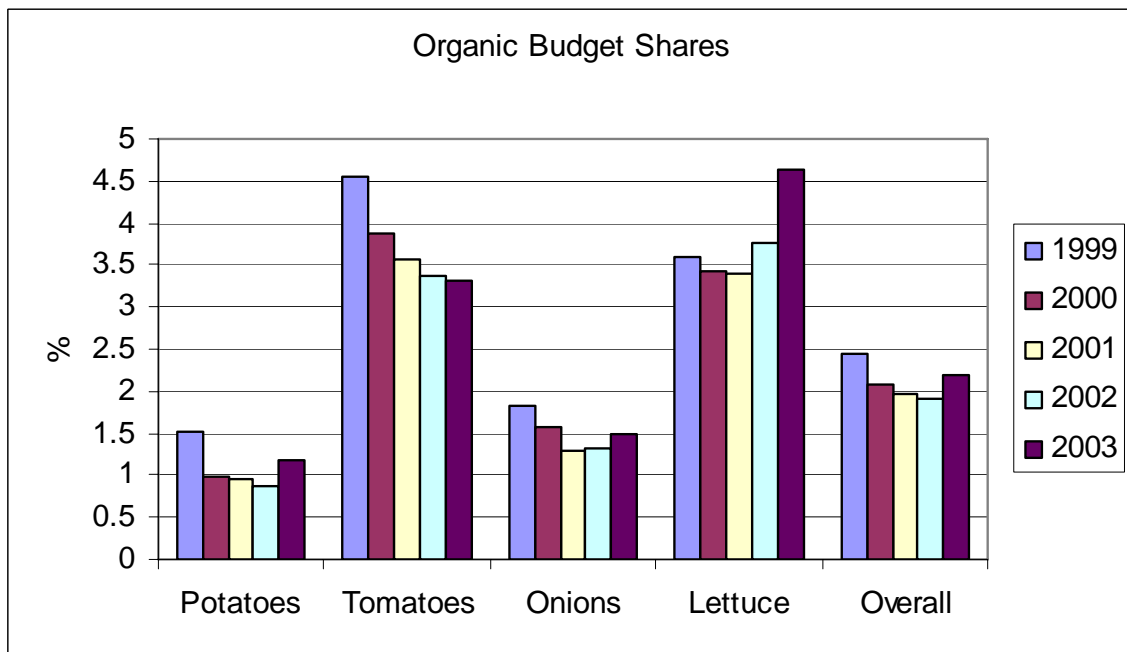
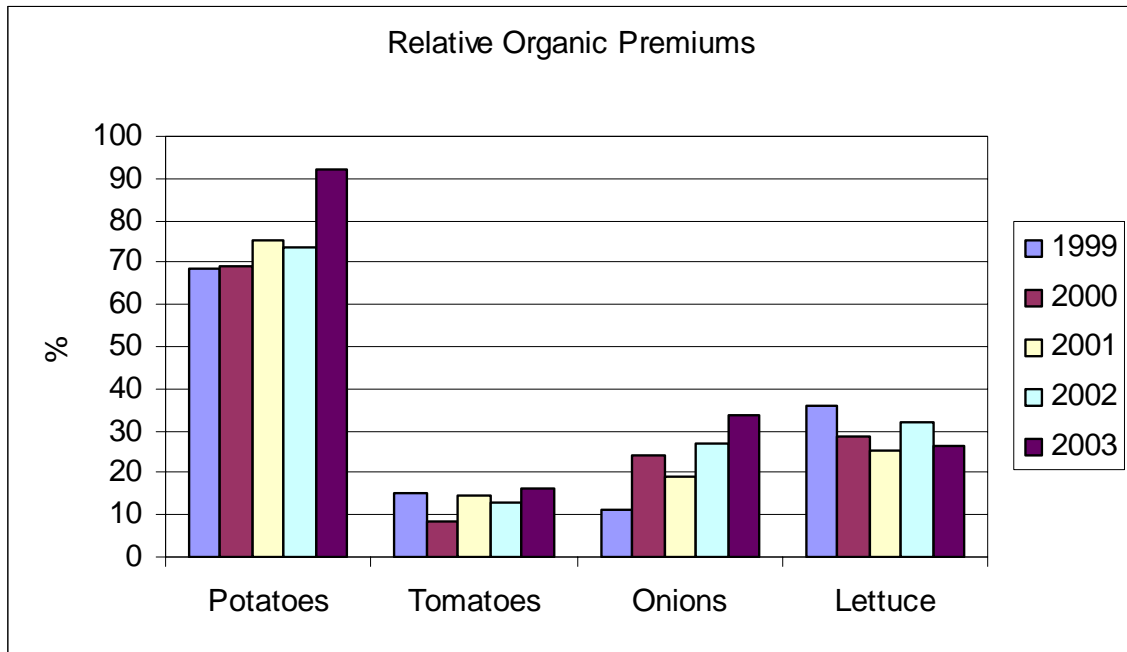
The table value for $\chi^2_{(2)} = 5.99$ at $\alpha = 0.05$ level.

Table 4.2. Compensated Price Elasticities and Income Elasticities Evaluated at Means of Budget Shares (LA-AIDS model) for both Organic and Conventional Vegetables

Commodity Group		Compensated Price Elasticities								Income Elasticities
		Potatoes		Tomatoes		Onions		Lettuce		
		Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	
Potatoes	Organic	-1.1136**	1.8686*	-0.3195	-1.8101**	0.0857	1.1026*	0.0135	0.1727	2.2619*
	Conventional	0.0211*	-0.5871**	0.0280	0.1841**	0.0041	0.1389**	0.0089	0.2021**	1.7653**
Tomatoes	Organic	-0.1015	0.7883	-0.7250**	-0.4872	-0.0922*	-0.0782	0.1006	0.5953	0.6153*
	Conventional	-0.0235**	0.2120**	-0.0199	-0.2726**	-0.0040	0.0064	0.0243**	0.0774	0.4744**
Onions	Organic	0.1258	0.5309	-0.4260*	-0.4483	-0.5312**	0.6886	-0.0032	0.0632	1.4787**
	Conventional	0.0269*	0.3007**	-0.0060	0.0120	0.0115	-0.6223**	-0.0439**	0.3212**	0.9808**
Lettuce	Organic	0.0073	0.4243	0.1709	1.0100**	-0.0012	-0.9716**	-0.5893**	-0.0505	0.4592
	Conventional	0.0036	0.3738**	0.0391	0.1244	0.0009	0.2744**	-0.0020	-0.8141**	0.4584**

Single and double asterisks indicate statistical significance levels at 10 and 5%, respectively.

Figure 4.1. Organic budget shares and premiums of selected vegetables for 1999-2003



CHAPTER 5
MODELING U.S. HOUSEHOLD ORGANIC PRICE PREMIUMS PAID FOR
SELECTED FRESH PRODUCE

5.1. Introduction

Voluminous studies have profiled organic consumers in terms of food safety attitudes and lifestyle characteristics. Consumer surveys have indicated that people believe organically grown foods are better than conventional counterparts in terms of personal safety, nutritional quality, taste, and adverse effects on the environment (Jolly, Schutz, Diaz-Knauf, and Johal, 1989; Davies, Titterington, and Cochrane, 1995; Hammitt, 1990). “Buying organic” may represent a lifestyle choice. Organic buyers have somewhat different lifestyle patterns and behaviors than conventional buyers (Williams and Hammitt, 2000). For example, Williams and Hammitt (2000) showed that organic buyers are more likely than conventional buyers to be vegetarians, grow their own fruits and vegetables, recycle, and purchase environmentally friendly products.

Using the contingent valuation approach with survey data at two large urban areas in Spain, Sanjuan et al. (2003) investigated consumer willingness to pay for organic produce for different groups (likely consumers, organic consumers, and unlikely consumers) segmented by lifestyle characteristics including various factors pertaining to preference for natural food, balanced life, concerns for health, and social improvement. Their results confirmed that willingness to pay differs among consumer segments,

products, and cities. The highest premiums that the most concerned consumers in large cities were willing to pay for organic products ranged from 22 to 37% for vegetables other than potatoes. However, for potatoes specifically, this range fell to 13-17%.

Given the fact that consumer information from organic retailing, other than transaction data, is usually limited to demographic characteristics of customers, previous research results on the relationship between organic consumption with respect to consumer attitudes and lifestyle characteristics are not of much practical use for retailers in formulating effective marketing strategies. If the gap can be bridged between consumer demographics and lifestyle characteristics and safety attitudes associated with preferences for organic, such relationships could be useful for retailers and producers in identifying potential consumer willingness to pay higher prices for organic produce.

There have been several studies investigating consumer demographic factors related to likelihood of consumer willingness to pay more for organic via surveys. Using data collected from mail surveys of Georgia consumers, Huang (1993) reported that the majority of consumers indicated a willingness to pay of up to 10% more for organically grown produce. A gender difference, which showed females to be more likely than males to pay a premium for organic produce, also was found. Huang noted that females and households with children were more likely to have a higher risk aversion toward pesticide residues than their counterparts. Groff, Kreider, and Toensmeyer (1993) also reported that females were more likely than males to place a higher value on organic than conventionally grown produce. With a consumer survey at various grocery retail establishments in New Jersey, Govindasamy and Italia (1999) found that females, those with higher annual incomes, younger individuals, and those who usually or always

purchase organic produce are all more likely to pay a premium for organic produce. Their results also indicated that the likelihood of paying a premium for organic produce decreases with the number of individuals living in the household and is also negatively related to educational level.

While surveys using contingent valuation provided useful information on consumer motivations in buying organically grown produce and likelihood of willingness to pay for organic items, it remains unclear as to whether consumer attitudes translate into real purchases of organic produce and at higher prices. Buzby and Skees (1994) reported that while over half of the respondents in a national survey indicated a preference for organically grown fresh fruits and vegetables, only 25% had actually purchased such produce on a regular basis. They suggested that price, availability, and cosmetic appearance are the major factors that account for the reported discrepancy between what consumers said they would prefer and what they actually purchased. Consumers who value the benefit associated with consuming organic food may not be willing to pay the higher prices.

There have been very few studies investigating the impact of potentially important demographic characteristics of consumers on price premiums that they are willing to pay or have paid for organic produce items. Using consumer survey data collected in supermarkets at different locations in the state of Colorado on potato purchases, Loureiro and Hine (2002) studied consumer willingness to pay for organic and found that the age of the consumer seems to have a negative effect on willingness to pay for organic and that consumers who are wealthy and well-educated, on average, are willing to pay about \$0.02 more per pound to obtain organic.

Given that organic fruits and vegetables usually cost more to produce than conventional items, it is important for retailers and producers to know how much the target consumers are willing to pay additionally for organically grown produce. Using multivariate regression on national-level retail data, this study complements previous studies by investigating the magnitude of organic premiums consumers actually paid for selected organic produce items and by identifying household demographic factors and seasonal indicators which explain variation in organic premiums. Based on the results of this study, organic retailers can know the best time and market segment to target to obtain desired levels of organic premiums.

5.2. Data and Variables

Observations used in this study are from ACNielsen Homescan data. To obtain both purchase records and corresponding household demographic information, ACNielsen provided a patented hand-held scanner to each household on its U.S. consumer panel which ACNielsen claims to be representative of all U.S. households. The hand-held scanner was used to record grocery items purchased at any store throughout a given time period. There are 18 known demographic characteristics for each household.

Data for 2003 were used as the latest available at the time of this study which corresponds to the first year after organic certification was implemented in October 2002. UPC-coded produce items in 2003 are explicitly labeled either with “organic seal” (USDA certified organic) or “organic claim” (producer-claimed organic). In this study, fruits and vegetables with either one of the two organic labels are regarded as organic. Organic produce items sold by random weight were identified by name. We limit our

investigation to organic premiums U.S. consumers paid for two fresh produce items in 2003, tomatoes and apples. They are among the most consumed organic vegetables and fruits, respectively.²

In 2003 there were 75,118 and 56,200 purchase records, made by 7,306 and 7,130 households, for fresh tomatoes and apples, respectively. One problem with the data is inaccuracy of some purchase records due to inadvertent recording or misestimated quantities (especially for some random weight items sold by count instead of weight). To eliminate inaccurate records, prices were calculated for each purchase record. Observations with zero or unreasonably high prices were deleted. A rule of thumb for outlier detection in statistics is to find measurements outside of three standard deviations from the mean (Anderson et. al., 2003). Using this criterion, prices that exceeded \$7.98/\$4.00 per pound for UPC-coded/random weight tomatoes and \$3.98/\$2.99 for UPC-coded/random weight apples were considered as unreasonable outliers and thus deleted. Lower end prices except values of zero were kept because they are within three standard deviations of mean prices and it is possible to have very low prices due to sales or promotions. It is acknowledged that deleting records with high outlier prices (organic and conventional) eliminates not only inaccurate data but also eliminates some accurate information.

To reasonably summarize purchase data (expenditure and quantity) of each household and exploit variables contained in the data, purchase data on tomatoes and apples in 2003 were aggregated at the household level within four dimensions as shown in table 5.1. As a result, seven additional dummy variables were created from the

² The top fresh organic fruits and vegetables purchased in the United States in 2002 were tomatoes, leafy vegetables, carrots, apples, potatoes, peaches, bananas, and squash (The Packer, 2002).

purchase data. Unit price was computed as aggregated expenditure divided by quantity. The unit price and seven dummy variables obtained from the purchase data were then merged with 18 household demographic variables, table 5.2. For each household, the number of observations ranges from 1 to 32 ($2*2*2*4$). The final data, with each household having multiple observations, may engender an econometric problem in linear regression because observations from the same household are not likely to be independent. The potential problem is addressed in the next section.

For households that bought tomatoes and apples in 2003, total expenditures on organic and conventional items were aggregated and organic market shares were calculated. The total expenditures and market shares are shown in figure 5.1. Since households on the ACNielsen consumer panel are representative of all U.S. consumers, the percentages, 4 and 3% for tomatoes and apples, respectively, can be considered indicators of national organic market shares for these two items.

Cross tabulation of the ORGANIC variable with the RW and SALE dummy variables using the original transaction-level data shows that organic items were more likely to be sold in loose form (random weight) than conventional ones for both tomatoes and apples. About 84% of purchases for organic tomatoes and 90% of purchases for organic apples were made in loose form. However, organic items were less likely to be put on sale, especially apples. Only 18% of purchases for organic apples were recorded as on sale, which is significantly less than the percentage for conventional apples, 27%.

5.3. Estimation Procedure

The primary purpose of the estimation is to model the organic premiums of the selected fresh produce items and identify factors which explain variation in organic price premiums. A multivariate linear regression model is proposed as follows:

$$\begin{aligned} PRICE_i = & \alpha + \beta_{1-3}(SEASON) + \beta_4(SALE) + \beta_5(RW) + \beta_{6-19}(DEMOGRAPHICS) \\ & + \beta_{20}(ORGANIC) + \beta_{21-23}(ORGANIC * SEASON) + \beta_{24}(ORGANIC * SALE) \\ & + \beta_{25}(ORGANIC * RW) + \beta_{26-39}(ORGANIC * DEMOGRAPHICS) + \varepsilon_i, \end{aligned} \quad (5.1)$$

where $PRICE_i$ is the price consumers paid for produce items, $SEASON$ includes three dummy variables to represent the four seasons of the year with spring as the baseline season, RW is the dummy variable for produce sold random weight, $DEMOGRAPHICS$ include 14 demographic variables described in table 5.2, and $ORGANIC$ is a dummy variable for organic produce. To account for possible differences in organic price premiums due to variation by season, package form, sales and promotion, and buyer demographics, interaction terms for $ORGANIC$ and these variables were added. Interaction variables, if statistically significant, can be considered as important factors explaining organic premiums.

For estimation of the above model, a possible data problem stemming from multiple observations for each household must be addressed. Because observations from the same household are not likely to be independent, Ordinary Least Square (OLS) estimation, which assumes independence among all observations, may produce results that appear too optimistic. In other words, for our data, OLS regression may overestimate statistical significance of explanatory variables because of smaller standard errors than would otherwise be the case for estimated parameters.

To address this problem, the standard errors of the estimators should be adjusted to account for possible dependence among household-level observations. Observations used in our study can be considered as data from a clustered sample design where the clusters are households with each having multiple purchases. For the regression with clustered observations, the estimated parameters are the same as those from OLS, but the variance-covariance matrix of $\hat{\beta}$ should be adjusted as follows:

$$\hat{V} = (X'X)^{-1} \left(\sum_{j=1}^G u_j' u_j \right) (X'X); \quad (5.2)$$

where X is the design matrix which includes all explanatory variables for all

observations; $u_j = \sum_{i=1}^{N_j} \varepsilon_i x_i$ with N_j being the number of observations in household j ,

ε_i as the residual for the i th observation, and x_i as a row vector of predictors including the constant; and G is the total number of households (clusters).

After parameters and robust standard errors were estimated, prices of the conventional produce items and organic premiums for different scenarios were calculated. Prices paid by consumers for conventional produce items (*CONPRICE*) were obtained by setting the dummy variable, *ORGANIC*, to zero which leads to the following equation:

$$CONPRICE_j = \hat{\alpha} + \hat{\beta}_{1-3}(SEASON) + \hat{\beta}_4(SALE) + \hat{\beta}_5(RW) + \hat{\beta}_{6-19}(DEMOGRAPHIC). \quad (5.3)$$

Representative levels of conventional prices can be obtained using equation (5.3) with right-hand-side variables set at mean levels.

Note that because interaction terms with *ORGANIC* were added to the model, the estimated parameter (β_{20}) for *ORGANIC* cannot be interpreted as the organic premium

directly. Instead, the premium consumers paid for organic (*ORGPREMIUM*) is a linear function of variables included in interaction terms. This linear function can be obtained simply by taking the first derivative of the dummy variable, *ORGANIC*, in equation (5.1):

$$\begin{aligned} ORGPREMIUM_j = \hat{\beta}_{20} + \hat{\beta}_{21-23}(SEASON) + \hat{\beta}_{24}(SALE) \\ + \hat{\beta}_{25}(RW) + \hat{\beta}_{26-39}(DEMOGRAPHICS) \end{aligned} \quad (5.4)$$

Representative levels of organic premiums can be obtained by calculating *ORGPREMIUM* with right-hand-side variables set at mean levels.

5.4. Estimation Results

For estimation, all variables (both produce characteristics and consumer demographics) were considered in the models. Those (with the exception of group dummy variables) significant at the 15% level were kept in the final models. The regression results for tomatoes and apples are presented in tables 5.3 and 5.4.

Tomato Prices

For tomatoes there were 7,306 households actually making purchases in 2003, with 33,779 observations after aggregation in four dimensions described in table 5.1. The R-square (0.30) indicates that the model fits the data reasonably well. The representative price of conventional tomatoes and the organic premium were calculated using equations (5.3) and (5.4), respectively, with all right-hand-side variables set at mean levels. The representative conventional tomato price, calculated with equation (5.3), is \$1.75 a pound, and the organic premium is \$0.38 a pound, calculated with equation (5.4). The relative organic premium (organic price premium divided by the price of conventional tomatoes) is 22%.

Seasonal variables, both alone and in interaction with *ORGANIC*, are statistically significant in the model. The price of conventional tomatoes is lowest in the summer and highest in the spring with a difference of about \$0.10 a pound. For organic tomatoes, however, the lowest price level was found in the fall, which is about \$0.23 a pound lower than the highest organic price level found in the spring. The seasonal variations in tomato prices and organic price premiums are illustrated in figure 5.3. The relative organic price premium for tomatoes is highest in the spring at 28%, followed by that in the summer and the winter, and drops to the lowest level at 16% in the fall.

Not surprisingly, the dummy variable for purchases on sale is negatively related to prices of conventional tomatoes and significantly more so for organic tomatoes. With organic tomatoes on sale, the average discount is around \$0.27 a pound (or 13% of the original price), which is more than the average discount for conventional tomatoes at \$0.19 a pound (or 11% of the original price). Even though organic tomatoes are less likely to be put on sale than conventional ones, the discount ratio is higher for organic tomatoes on sale. A similar effect was also found for the dummy variable for tomatoes sold random weight. On average, tomatoes sold random weight are \$0.90 a pound cheaper for the conventional type and \$1.12 a pound cheaper for organic than those sold in UPC-coded packages.

Only a couple of demographic variables were found to be significant in explaining variation in the organic premium. Even though age is a factor affecting price paid for conventional tomatoes, with older consumers paying less than younger ones, age is not an important factor in explaining the organic price premium for tomatoes. Households

with a child under 6 years of age, on average, paid \$0.06 a pound more for conventional tomatoes and \$0.15 a pound more for organic than households without young children. Wealthier households were found to have paid more for organic tomatoes than the less well off. Given an increase in annual household income by \$1,000, the household pays \$0.02 a pound more for organic tomatoes.

Apple Prices

For apples there were 7,130 households actually making purchases in 2003, with 25,927 observations after aggregation in four dimensions described in table 5.1. As with tomatoes, the representative price of conventional apples and the organic premium were calculated using equations (5.3) and (5.4), respectively, with all right-hand-side variables set at mean levels. The representative conventional apple price is \$1.00 a pound, and the organic premium is \$0.24 a pound, giving a relative organic premium of around 24%.

Slight seasonal variation was found only for conventional apples, with the lowest price found in the spring and the highest in the fall. Interaction terms between seasonal and organic dummy variables were found to be significant only for the fall, indicating that the organic price premium for apples is significantly higher in the fall than other seasons. The seasonal variations in apple prices and organic price premiums are illustrated in figure 5.3. The relative organic price premium for tomatoes is highest in the fall at 29%, followed by that in the winter and the spring, and drops to the lowest level at 21% in the summer.

As was similarly found for tomatoes, organic apples on sale tend to be \$0.27 a pound (or 22%) cheaper than those not on sale, which is more than the sale discount for

conventional apples at \$0.17 a pound (or 17%). Prices of conventional and organic apples were also found to be significantly different by form of sale (UPC-coded package or random weight). For conventional apples, UPC-coded packaging results in a \$0.23 a pound lower price. However, organic apples in UPC-coded packaging are \$0.42 a pound higher in price on average than those sold random weight.

Several demographic variables were found to be significant in explaining the organic price premium for apples. Household size is negatively related to the organic price premium. On average, households with one more member tend to pay \$0.05 a pound less. Income is positively related to the organic price premium at the 10% significance level, with \$0.014 a pound more paid for organic apples given an increase in per capita annual income by \$1,000. The age of consumers seems to be negatively related to the price premium paid for organic apples. Younger consumers paid \$0.11 a pound more than older consumers for organic apples, although statistically significant only at the 15% level. Interestingly, households in the East were found to have paid \$0.11 a pound less for organic apples than those in the West.

5.5. Conclusion and Discussion

Using multivariate regression on tomato and apple prices, paid by U.S. households in 2003, against household demographic variables and produce characteristics, we were able to estimate organic price premiums paid by U.S. households for the selected organic produce (tomatoes and apples) while controlling for heterogeneity in buyer demographic characteristics and seasonal factors. At the same time, interaction terms between the organic/conventional dummy variable and other

variables provided rich insight into the factors which explain variation in organic premiums paid by U.S. households for the selected fresh items.

The organic price premiums were 22 and 24% on average for tomatoes and apples, respectively, which are somewhat similar to the organic price premiums found for baby food of different flavors ranging from 16 to 27% in a study by Maguire, Owens, and Simon (2004) using retail data. For tomatoes, seasonal variation in the organic premium was significant with the spring showing the highest organic premium percentage and the fall the lowest. For apples, the organic price premium, in both absolute value and percentage, is highest in the fall.

For both tomatoes and apples, organic was less likely to be put on sale than conventional counterparts, but organic had a higher discount ratio if on sale. Even though organic was more likely to be sold random weight, organic tomatoes and apples sold in UPC-coded packages were found to be more expensive than those sold random weight. The price difference may perhaps stem from quality or cosmetic appearance.

Household demographic characteristics also are important factors in explaining organic price premiums, though to different extents for the different produce items. For both tomatoes and apples, total household income is positively associated with the organic price premium. For tomatoes, households with young children were found to have paid a significantly higher price for organic than households without young children. For apples, a different set of household demographic characteristics were found to be important regarding the organic price premium. Larger households tend to pay less for organic than smaller ones. And young households (with household heads under 40

years of age) were found to pay \$0.11 a pound more for organic apples than older households.

Generally, households with wealthy and young household heads, with young children, and small in size, are the desired market segments for organic produce retailers to target to achieve higher organic price premiums. These demographics perhaps reflect consumer risk attitudes and lifestyle preferences regarding food consumption.

Households with young children appear to be willing to pay higher prices for organic produce reportedly because of concern for the health of the children. Williams and Hammitt (2001) found that persons who are employed, female, and married with at least one child had greater concerns about pesticide residues on conventional produce than their counterparts. They found that many consumers perceive a significant reduction in pesticide-related risks associated with organic. Not surprisingly, wealthy and young household heads tend to care more about health and the environment and value more possible benefits associated with consuming organic. Such findings are consistent with those from a study on organic potatoes by Loureiro and Hine (2002). They found that age of the consumer seems to have a negative effect on willingness to pay for organic and that wealthy consumers, on average, are willing to pay more for organic. Govindasamy (1998) also found that households comprised of at least four individuals were 15% less likely to pay an organic premium.

Table 5.1. Variables for Produce Characteristics Created from Purchase Data

Dimensions of Aggregation for Purchase Data	Dummy Variables Created from Purchase Data (1= yes; 0 otherwise)
Organic/conventional	ORGANIC
Random weight/UPC coded items	RW
On sale/not on sale	SALE
Four seasons	SPRING, SUMMER, FALL, and WINTER

Table 5.2. Description of Demographic Variables for Consumer Panel Households, 2003

Variable	Definition	Mean (SE)
Hhsize	Household size	2.60 (1.39)
Income	Total income of the household in \$1,000 (midpoint of income category)	54.32 (27.16)
Dummy Variable (1= yes, 0 otherwise)		
Age1*	The higher age of the male and female household heads is less than 40	0.16
Age2	The higher age of the male and female household heads is between 40 and 64	0.62
Age3	The higher age of the male and female household heads is 65 and above	0.23
Educ1*	The higher education of the male and female household heads is high school	0.19
Educ2	The higher education of the male and female household heads is college	0.65
Educ3	The higher education of the male and female household heads is post college	0.16
Married	Head of the household is married	0.57
East	Residents in eastern region	0.21
Central	Residents in central region	0.18
South	Residents in southern region	0.40
West*	Residents in western region	0.21
Urban	Residents in urban areas	0.87
Rural	Residents in rural areas	0.13
White	White households	0.74
Black	Black households	0.13
Hispanic	Hispanic households	0.08
Oriental*	Oriental households	0.03
Sample size		8,833

Note: As baseline groups, variables marked with an asterisk are not entered in the model.

Table 5.3. Results of the Multivariate Regression on Tomato Prices

Parameter	Estimate	Standard Error	Pr > t
Intercept	2.3672	0.0521	<.0001
Summer	-0.0994	0.0095	<.0001
Fall	-0.0368	0.0103	0.0003
Winter	-0.0181	0.0109	0.0980
Sale	-0.1851	0.0103	<.0001
Rw	-0.9037	0.0144	<.0001
Hhsize	-0.0474	0.0058	<.0001
Income	0.0039	0.0003	<.0001
Age2	-0.0477	0.0215	0.0262
Age3	-0.1241	0.0248	<.0001
Educ2	0.0293	0.0176	0.0955
Educ3	0.0370	0.0238	0.1196
Child6	0.0606	0.0277	0.0286
Urban	0.0562	0.0198	0.0045
East	-0.1059	0.0213	<.0001
Central	-0.1702	0.0233	<.0001
South	-0.0946	0.0183	<.0001
White	0.1284	0.0347	0.0002
Black	-0.0327	0.0388	0.3993
Hispanic	-0.0923	0.0391	0.0182
Organic	0.5583	0.0981	<.0001
Organic*Summer	-0.1308	0.0557	0.0190
Organic*Fall	-0.2164	0.0573	0.0002
Organic*Winter	-0.1319	0.0645	0.0409
Organic*Sale	-0.0870	0.0447	0.0520
Organic*Rw	-0.2176	0.0655	0.0009
Organic*Income	0.0019	0.0008	0.0269
Organic*Child6	0.1502	0.0831	0.0708
Number of observations	33,779		
Number of households	7,306		
R-square	0.2968		

Table 5.4. Results of the Multivariate Regression on Apple Prices

Parameter	Estimate	Standard Error	Pr > t
Intercept	0.8102	0.0223	<.0001
Summer	0.0274	0.0044	<.0001
Fall	0.0702	0.0055	<.0001
Winter	0.0274	0.0054	<.0001
Sale	-0.1650	0.0051	<.0001
Rw	0.2272	0.0066	<.0001
Hhsize	-0.0168	0.0023	<.0001
Income	0.0015	0.0001	<.0001
Age2	-0.0414	0.0088	<.0001
Age3	-0.1016	0.0107	<.0001
Urban	0.0417	0.0084	<.0001
East	0.0059	0.0100	0.5558
Central	-0.0214	0.0108	0.0473
South	0.0164	0.0092	0.0731
White	0.0310	0.0163	0.0575
Black	0.0087	0.0183	0.6335
Hispanic	-0.0146	0.0195	0.4553
Organic	0.6913	0.1044	<.0001
Organic*Summer	-0.0105	0.0359	0.7693
Organic*Fall	0.0850	0.0491	0.0834
Organic*Winter	0.0189	0.0419	0.6520
Organic*Sale	-0.1045	0.0385	0.0067
Organic*Rw	-0.4196	0.0778	<.0001
Organic*Hhsize	-0.0508	0.0176	0.0040
Organic*Income	0.0014	0.0008	0.0600
Organic*Age2	-0.0386	0.0586	0.5096
Organic*Age3	-0.1083	0.0735	0.1403
Organic*East	-0.1131	0.0618	0.0676
Organic*Central	0.0483	0.0767	0.5290
Organic*South	-0.0347	0.0489	0.4777
Number of observations	25,927		
Number of households	7,130		
R-square	0.1688		

Figure 5.1. Organic shares for tomatoes and apples

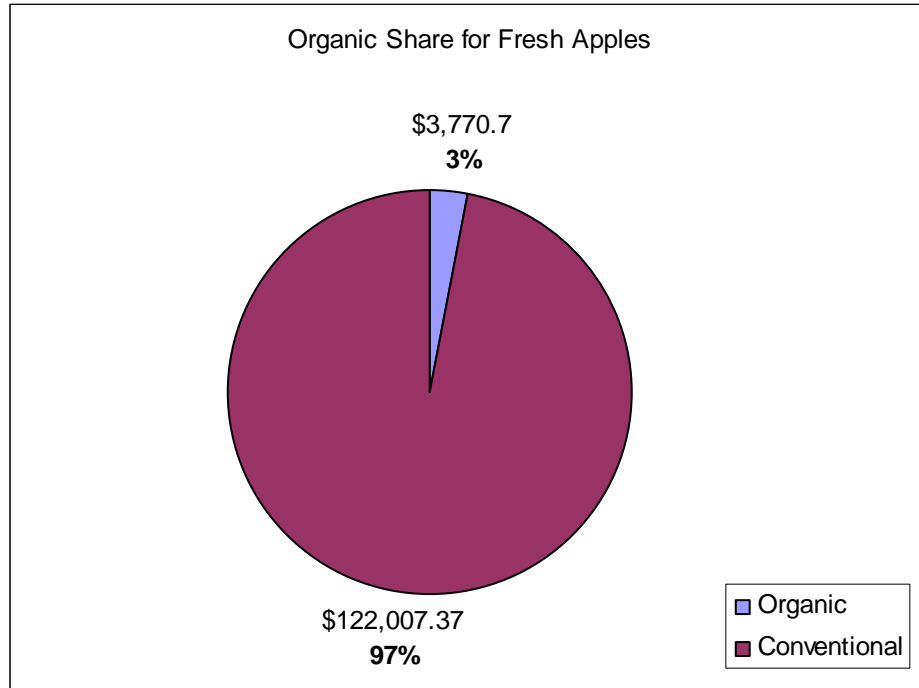
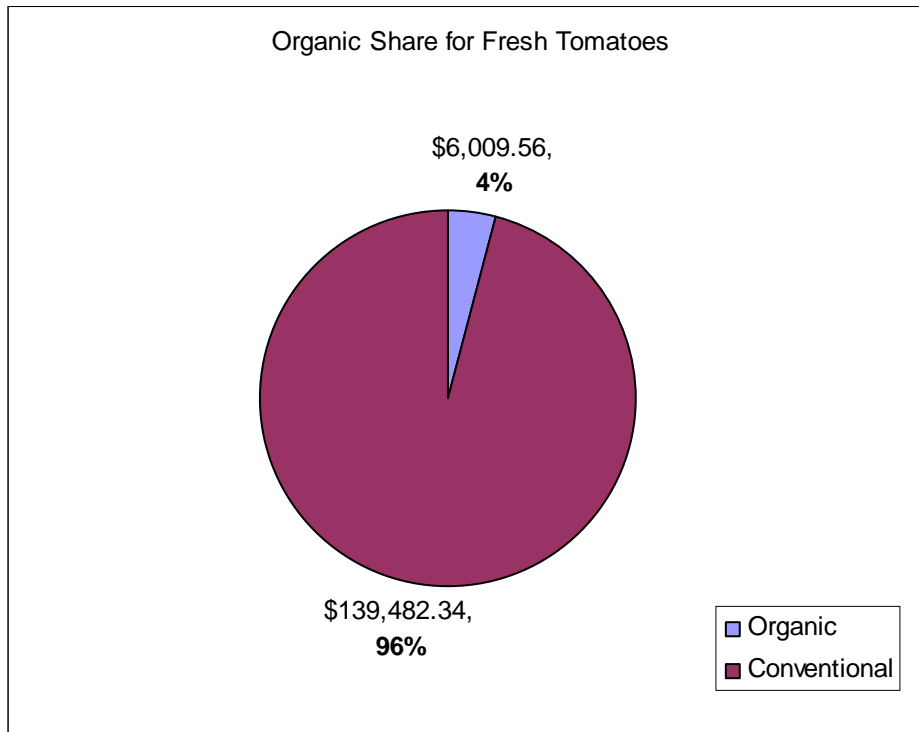


Figure 5.2. Percentages of random weight (RW) and on-sale purchases with respect to total purchases for organic and conventional tomatoes and apples

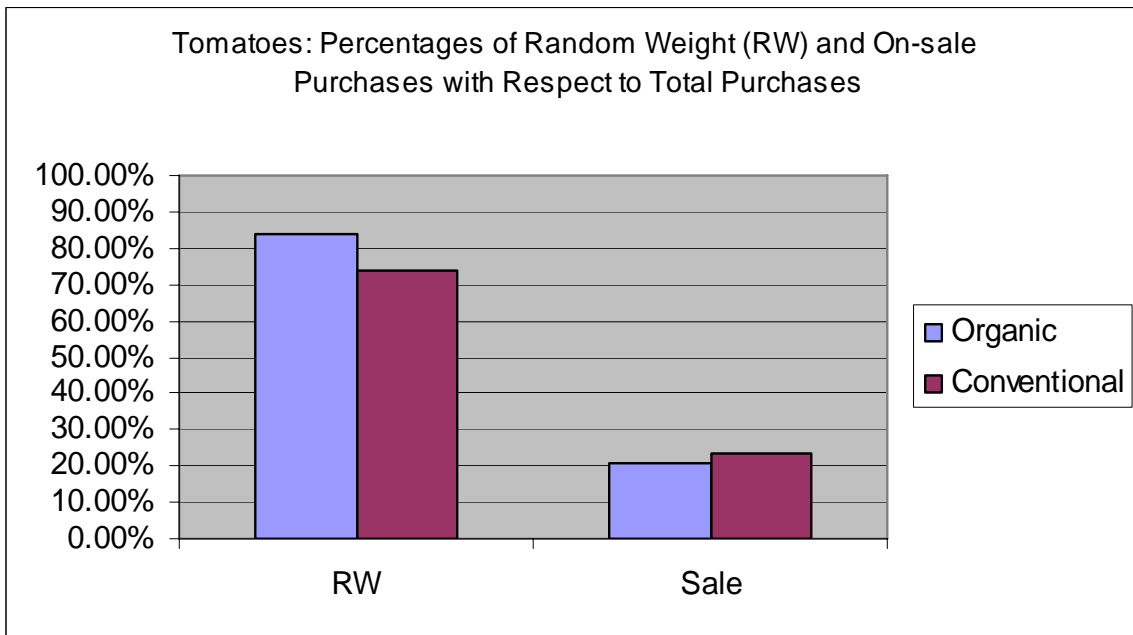
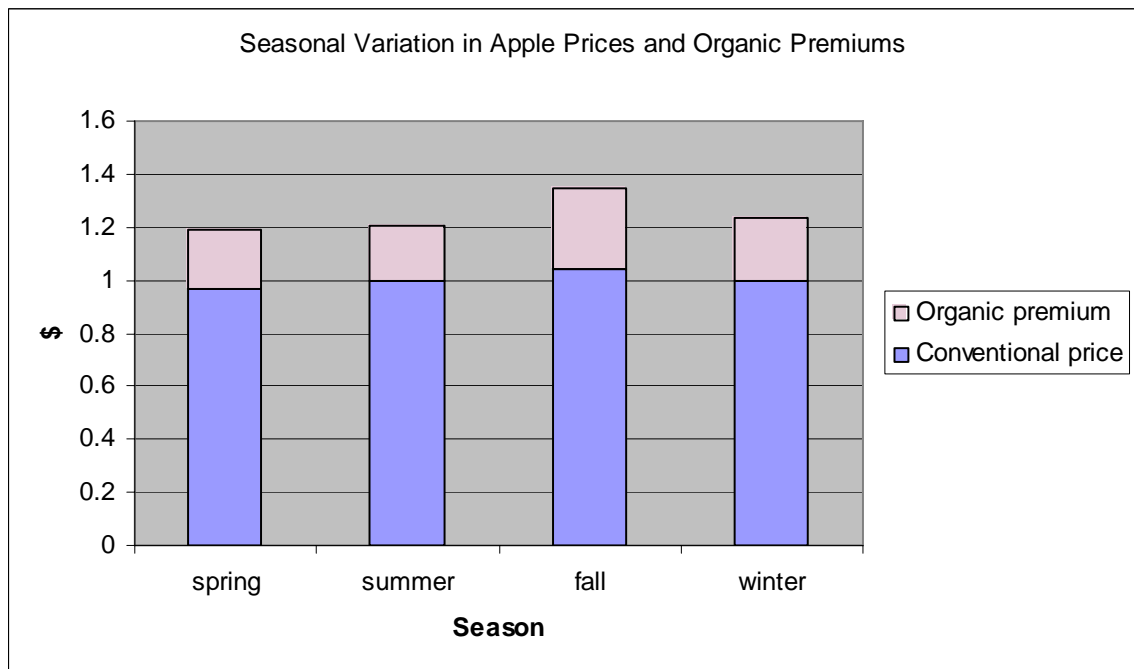
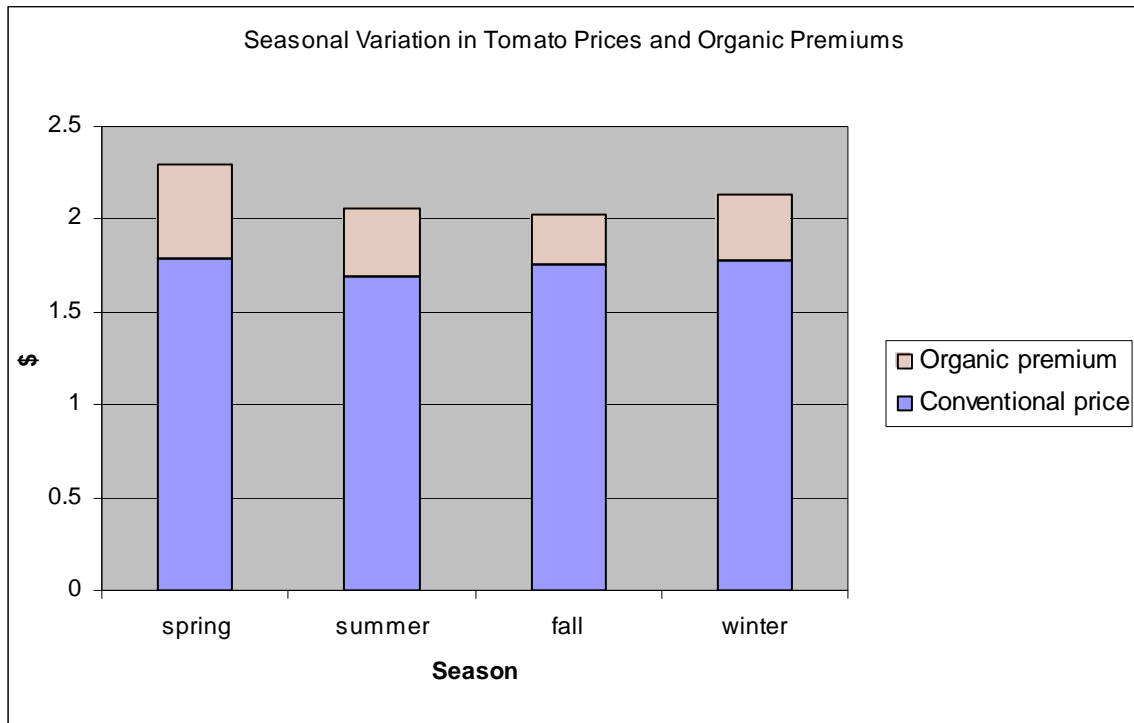


Figure 5.3. Seasonal variation in tomato and apple prices and relative organic premiums



CHAPTER 6
SUMMARY, CONCLUSION, AND IMPLICATIONS

6.1. Summary and Conclusion

Increased awareness of organic produce and its penetration into conventional markets has prompted research to document the dynamics of this emerging market. This dissertation provides analyses to understand how consumer decisions are made regarding organic produce consumption and how demands for organic and conventional produce are related. Understanding consumer behavior concerning organic purchases has important implications for retailers in formulating marketing strategies and for producers in making production decisions.

General results from this research suggest that for most common organic produce items, price promotion is not likely to be effective for market expansion because organic price premiums are limited and consumers are not responsive to price reductions except for a few newly introduced organic items. However, because of differences in consumer valuation of the benefits associated with organic consumption, market segmentation based on consumer demographic characteristics can be used to enhance market revenues. Further, the ongoing standardization of organic products and labeling is expected to foment expansion of the organic industry.

In contrast to most of the previous studies based on contingent valuation and consumer purchasing behavior surveys at local grocery stores, this research shows a more realistic picture of the national organic market with retail-level scanner data from a nationally representative consumer panel. This dissertation consists of three self-contained but related studies. The first study profiled organic consumers with associated demographic characteristics. It answered questions as to which demographic characteristics are important in determining the likelihood of organic consumption as well as the level of consumption. The second study described the current market trends for selected vegetables and investigated the interrelationship between consumer demands for conventional and organic produce. The results of the second study can be used to evaluate the effect of price changes on consumer demand for various organic vegetables and their market potential. The third study focused on identifying household demographic characteristics and produce attributes which explain variation in organic price premiums paid by U.S. households for selected fresh produce. The results can help organic retailers identify receptive market segments, advantageous marketing seasons, and favorable product attributes to command higher price premiums for various organic produce items.

Most organic vegetables were about 10 to 30% higher in price than conventional counterparts except for some newly introduced organic vegetables (potatoes for instance) with relatively thin market shares and high premiums. Room for price promotion of these organic vegetables is limited. Differences in organic premiums between common organic fresh vegetables (such as tomatoes and lettuce) and some newly introduced vegetables (such as potatoes) are quite marked, with the highest relative organic premium (potatoes) more than five times higher than that for the lowest (tomatoes). If the difference cannot

be fully explained by the difference in production costs for organic versus conventional farming, producers may be able to increase profit by allocating more resources to organic items with higher profit margins.

Income elasticities for organic vegetables were found to be higher than those for conventional vegetables for all four vegetables included in the model, which suggests that if U.S. consumers were to increase expenditures on fresh vegetables, they would spend a larger portion of their budget on organic. With the exception of potatoes, the vegetables were found to have inelastic own-price effects and inelastic cross-price effects between organic and conventional vegetables, implying that a drop in the organic premium does not necessarily guarantee an increase in total revenue for organic.

However, market segmentation with respect to consumer demographic characteristics can be used to enhance price premiums and market revenues for organic. To enhance market revenues, results from the first study indicate that marketing strategies targeting higher income and higher educated consumers can be effective in both attracting new consumers and eliciting increased sales from existing consumers. Age of the household head had mixed effects regarding the organic market participation decision and the level of consumption decision. Although households with older household heads are more likely to buy organic, households with older household heads already buying organic tend to purchase smaller amounts than younger ones. Minority households (especially Hispanics and Orientals) constitute an important segment of the fresh organic produce market which retailers cannot afford to neglect. With respect to geographical locations, households in the East and the West were found to be stronger buyers than those in other areas in term of both probability and level of consumption.

Generally, households smaller in size, households with wealthy and young household heads, and households with young children are the desired market segments for organic produce retailers to target to achieve higher organic price premiums. For both tomatoes and apples, total household income is positively associated with organic price premiums. For tomatoes, households with young children were found to pay a significantly higher price for organic than households without young children. For apples, a different set of household demographic characteristics were found to be important regarding the organic price premium. Larger households tend to pay less for organic than smaller ones. And younger households (with household heads under 40 years of age) were found to pay \$0.11 a pound more for organic than the households with older household heads. Results from the third study indicate that marketing season also affects organic price premiums. For tomatoes, seasonal variation in the organic premium was significant with the highest premium percentage in the spring and the lowest in the fall. For apples, the organic price premium, in both absolute value and percentage terms, was highest in the fall.

6.2. Limitations of the Study and Recommendations for Future Research

Scanner data provide excellent opportunities to analyze consumer demand for organic at the retail level. However, there are problems of which researchers should be aware when using such data. One problem is related to the way the data used in this study are collected. Since data are recorded by a member of the household, some records may not be accurate due to incomplete recording and misreporting. Inclusion of households

that do not make regular purchase recordings may lead to inaccurate estimates, especially for demand system modeling with aggregate time series data. To avoid such problems in this study, households that reported less than 10 months of purchase records were excluded from the dataset. Misreporting of purchase quantities or expenditures causes distortion of commodity prices. Inaccurate purchase records, with unreasonable prices, were eliminated from the analysis. Another difficulty with ACNielsen Homescan data is that consumption away from home is missing. Given that patterns of away from home food consumption may be different from those of consumption at home, caution should be taken in generalization of the results from this study to away-from-home food consumption.

As shown by the results from the demand system in this study, price promotion for common fresh organic produce items, such as tomatoes and lettuce, is not likely to be very effective due to inelastic price effects except for a few newly introduced organic items. However, the effect of standardization in organic products and labeling on market expansion should not be overlooked. With the organic produce market becoming more standardized and accessible to the general public following implementation of USDA standards and unified labeling, the organic market is expected to grow further. With more recent data, future research can incorporate the effect of this event in demand system modeling using time series data.

In addition, price premiums paid by consumers for organic reveal only one side of the story. To analyze the market growth potential for individual organic produce items, the additional cost incurred in production and distribution for organic should be understood as well. Cost differentials in organic and conventional farming of different

fruits and vegetables tend to be varied due to farming technologies for different produce items. Judgments regarding organic market growth potential and production decisions should involve consideration of both consumer and production data simultaneously.

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APPENDIX

Appendix A. Derivation of Conditional Normal Distribution CDF

For bivariate normally distributed variables (x_1, x_2) with

$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \sim N\left\{\begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix}, \begin{bmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{21} & \sigma_{22} \end{bmatrix}\right\}$, the conditional distribution $(x_1 | x_2 = a)$ is an univariate

normal denoted by $N(\bar{\mu}, \bar{\sigma})$, where the mean $\bar{\mu} = \mu_1 + \sigma_{12}\sigma_{22}^{-1}(a - \mu_2)$ and variance

$\bar{\sigma} = \sigma_{11} - \sigma_{12}\sigma_{22}^{-1}\sigma_{21}$. Then the conditional distribution $(u | v = y - x'\beta)$ in our model is

$N[\rho(y - x'\beta)/\sigma, (1 - \rho^2)]$. Therefore, the probability that $z'\alpha + u > 0$ given

$v = y - x'\beta$ is:

$$F(u > -z'\alpha | v = y - x'\beta) = \Phi\left[\frac{z'\alpha + \rho(y - x'\beta)/\sigma}{(1 - \rho^2)^{1/2}}\right].$$