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Demand Elasticity of Organic Fruits and Vegetables by Income

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Introduction

Organic sales have been increasing over the years. Nielsen reported that the sales of organic products in quantity grew 13.1% between 2015 and 2016 (Nielsen, 2016). This trend continued in the following period 2016-2017, increasing 11.4% in volume (Nielsen, 2017). Fresh organic vegetables and fruits are leading the way, accounting 83.2% out of top 10 organic sales categories[1] in dollars(Nielsen, 2016). Despite increasing demand for organic products, studies on organic buying consumers have relatively received scant attention compared to conventional products in previous studies. It mainly resulted from the lack of data availability. With the increase of organic market size and better data accessibility, a few research have sought the differences in consumer responses between organic and conventional products. Lin, Yen, Huang, & Smith (2009) investigated differences of the demand elasticities in the consumption of conventional and organic fruits. Kasteridis & Yen (2012) conducted a similar research but on organic and conventional vegetables. The two studies concluded that consumers are more sensitive to changes in price of organic fruits and vegetables than conventional ones.

While these studies report important implications in organic buying behaviors, their information does not consider differences in socio-demographic characteristics of consumers which are expected to impact their buying behaviors. They only provide one elasticity of demand, assuming all consumers would show the same behaviors regardless of their income levels or other individual factors. However, the responsiveness to price changes might vary depending on individual's disposable funds to spend or one's preferences. For instance, high-income households

[1] Top 10 fresh organic categories: packaged salad, berries, apples, herbs, spices and seasonings, carrots, bananas, value-added vegetables, lettuce, chicken, beverages. They are UPC-coded only products (Nielsen, 2016) .

might consider organic products as a necessity while low-income households might consider them as luxury goods. However, even budget-sensitive consumers may place a priority on buying organic food according to one's belief or preferences. Therefore, accounting for varied consumption behaviors among consumers with only a single point of elasticity is likely an insufficient measure to explain demand responses to changes in price. This paper addresses the question of whether income affects the consumption of organic fruits and vegetables and if so how consumers' responses are different by income groups.

Recently, finding heterogeneity in the demand behaviors of consumers have been an interesting issue in other fields and products. Lusk & Tonsor (2016) presented different consumption patterns of meats by income groups using data from choice experiments. They found that high-income group is less sensitive to own-price changes for all types of meat than is low-income group. As an earlier study, Smith, Huang, & Lin (2009) estimated the probability of organic produce consumers being categorized as nonusers, casual, and devoted by utilizing socio-demographic characteristics. This study also shows that organic consumption is dependent of the income size. Similarly, Ferrier & Zhen (2017) sought to find the role of income in the consumption of preserved and fresh vegetables. They estimate demand elasticities by income quintile and consider the unevenness of income growth across income quintiles to explain differences in demand elasticity. More broadly, Lusk (2017) examined the heterogeneity in demand systems of food at home, away from home, and nonfood across 50 different groups of people clustered by similar demographic variables and consumption preferences.

This existing work strongly provides the reason to consider the differences in consumers' demand behaviors by income levels. Andreyeva, Long, & Brownell (2010) also mentioned that

heterogeneity in demand systems across distinct socio-demographic groups has not been fully examined. They reviewed 160 studies on the price elasticity of demand for food and summarized means and variations of price elasticities by food category. They found that only 9 studies evaluated price elasticity for low-income consumers. Smith, Huang, & Lin (2009) discussed about consumption behavior of organic fresh fruits and vegetables, but it focused on finding the general profile of organic consumers, therefore, heterogeneity in demand elasticity of organic fruits and vegetables remains unknown.

The purpose of this study is to examine the demand elasticity of both organic fruits and vegetables by income groups using Nielsen panel data through which individual households reveal their purchasing preferences at grocery markets. An Almost Ideal Demand System is used to test the hypothesis that groups with higher income are relatively less sensitive to price changes. As shown in previous studies, income is expected to be a big player, but other factors may influence consumers on organic produce purchases. This study contributes to the knowledge of existing literature on consumer behaviors while provides an updated information to organic produce industry in the response of its growing demand.

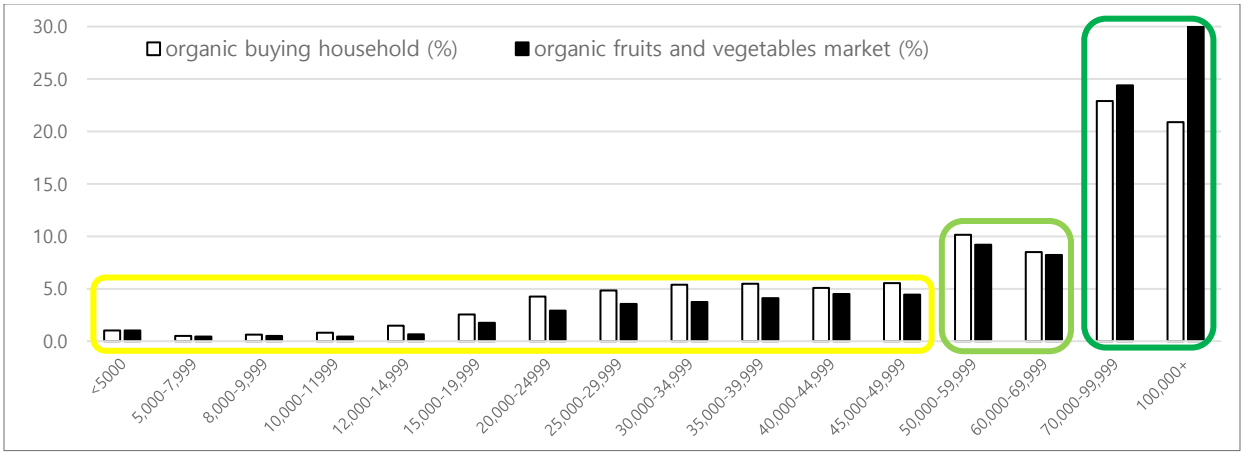
1. Data and Estimation Details

To identify the relationship between individual's income and organic fruits/vegetables consumption behavior, 2015-year Nielsen panel data is used. The data consists of approximately 61,380 U.S. representative households' demographic information and their food and non-food purchases record in 2015. Panelists uses their scanners to report all their purchases: when, where, and what they buy. Organic information can be identified from the organic claim code in the "Products Extra attributes" file.

97.5% of the panelists reported that they made fresh produce purchases, of which 56.7% was recorded organic ones, totaling 33,564 of households. The organic consuming households are divided into three income groups according to their similarity of organic fresh fruits and vegetables market shares (Figure 1). The expenditure shares of groups categorized as the low-income group vary from 0.4% to 4.5% of organic fresh produce, 8.2% to 9.2% for groups in the middle-income group, and 24.4% to 30.1% for groups in the high-income group.

Figure 1.

Household distribution and organic fruits and vegetables expenditure shares by income (%)



The high-income group comprised 43.8% of organic consumers and generated 54.5% of organic fruit and vegetable market consumption in 2015. The proportion of organic buying consumers at least one time in a year decreases as income levels do. 65.8% of the high-income group made at least a single organic fruits or vegetables purchases, meanwhile 47.5% of households in the low income did in 2015. The low-income group's organic market share (28.1%) is less than their population share (44.4%), while middle-income group's organic market share (17.4%) is relatively similar to their population portion (18.4%).

Table1.

Household distribution and organic fruits and vegetables consumption by income groups (%)

	US Census	Nielsen panel	Fresh produce consumers	Organic fresh produce consumers	Organic fresh produce consumption
Low income Under $49,999	44.8	44.8	44.4	37.6 (47.5)	28.1
Middle income $50,000 to $69,999	16.7*	18.3	18.4	18.6 (56.9)	17.4
High income $70,000 and over	38.5**	37.0	37.3	43.8 (65.8)	54.5
Total	125,819	61,380	59,858	33,564	$714,731

*income from 50,000 to 74,999
**income from 75,000 and over
( ) : % of households in each income group that made at least one-time organic fruits or vegetable purchase in the panel year of 2015.

Organic vegetable consumption takes account the majority organic fresh produce (vegetable and fruits) consumption by 67.7%. Fruits are categorized into 7 groups: apples, berries, oranges, lime and lemons, bananas, strawberry, and others. Berries (31%), strawberries (23%), and apples (22%) are the major organic fruits in dollars. With respect to organic vegetables, kales (60.5%), spinaches (9%), and carrots (7.7%) are the major commodities. Agricultural products are often purchased by random weights, not using standard UPC codes and they are classified as a "reference card" products in the Nielsen dataset. Reference card vegetables and fruits consist of 55.6% among the number of purchases observations. However, there is not enough information to figure out unit price per measurement unit. All reference card produce purchases are counted as one without any actual number of counts sold or weights per bag which prevents calculations of unit prices. Moreover, these products do not have organic seal information, so they are excluded in the demand system analysis.

Weekly prices per pound for each products are calculated from the panel purchases record. There are some fruits and vegetables on a count basis like pineapples, kiwis, watermelons, lettuce,

etc. with specific numbers sold provided. We utilized the USDA National Nutrient Database for Standard Reference, Release 28 to convert count measured items to a weight basis following prior studies (Ferrier & Zhen, 2017; Stewart, Hyman, Buzby, Frazão, & Carlson, 2011). The standard medium weights are used for the calculation of each unit prices. Average weekly prices of each product for three income groups are calculated by dividing total dollars spent by total volume purchased on each product for each week following the method of Reed, Frazão, Itskowitz, & Statess (2004). Prices are not identified in case of zero consumption and the average prices from whole group replace omitted prices for the week.

2. Theoretical Model

In this study, we estimate fruit and vegetable demand systems separately for three income groups, for 6 demand systems in total. It is assumed that fruit and vegetable consumption is separable from the demand of other goods in the household total expenditure. Almost Ideal Demand System, AIDS, (Deaton & Muellbauer, 1980) is chosen as it has been heavily used in analyzing such demand systems historically to investigate consumer behaviors in response to price changes (Glaser & Thompson, 1998; Huang & Lin, 2000; Lusk, 2017; Zhang, Huang, Lin, Epperson, & Hall, 2006). In the AIDS model, the budget shares of various products are the function of total expenditure and relative prices.

$$w_{it} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_{jt} + \beta_i \ln \frac{m_t}{P_t} + \mathrm{u_{it}} \quad (1)$$

w_{it} is the budget share of the product i at time t and p_{jt} is the price of good j at time t. m_t is total expenditure at time t and $\mathrm{P_t}$ is a translog price index identified as following.

$$\ln \mathrm{P_t} = \alpha_0 + \sum_i \alpha_i \ln p_{it} + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_{it} \ln p_{jt} \quad (2)$$

Restrictions on parameters α, β, γ are applied to represent theoretically desirable demand systems. The adding-up restriction is satisfied since the summation of all budget shares equals to one. The condition of homogeneous of degree zero in product prices and total expenditure ensures that the quantity demanded remains unchanged if both prices and income change by the same rate. Lastly, the symmetry condition follows.

$$\sum_i \ \alpha_i = 1; \ \sum_i \ \beta_i = 0; \ \sum_i \gamma_{ij} = 0 \quad \forall \, j \tag{3}$$

$$\sum_j \gamma_{ij} = 0 \ \forall \ j; \ \gamma_{ij} = \gamma_{ji} \ \ \forall \ i, j \tag{4}$$

Elasticities of the AIDS are given by followed Anderson & Blundell (1983). Compensated demand elasticities are derived by Slutsky equation.

Expenditure elasticity $\eta_{\mathrm{i}} = \frac{\partial x_i}{\partial m}\frac{m}{x_i} = 1 + \frac{\beta_i}{w_i}$ (5)

Marshallian price elasticity $\epsilon_{\mathrm{ij}}^{m} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \frac{\beta_i}{w_i}(\alpha_j + \sum_k \gamma_{kj} \ln p_k)$ (6)

Hicksian price elasticity $\epsilon_{\mathrm{ij}}^{h} = \epsilon_{\mathrm{ij}}^{m} + \eta_i w_j$ (7)

3. Results

3.1. Organic Fruits

Expenditure elasticity of demand shows that there exist significant variations in the responsiveness of demand to the expenditure (income) changes between groups, but in inconsistent ways. Berries and strawberries are found to be luxury goods across income groups while other fruits are necessity goods. Households with higher incomes are expected to be inelastic to the expenditure changes, but these tendencies are not found in demand for fruits. Instead all income groups show similar

responsiveness to expenditure changes. Middle income group less increase the consumption for apples, oranges, and lemon/limes, but more consume berries strawberries with income (expenditure) increase compared to other two groups.

Table 2. Expenditure elasticity of organic fruits

	Apples	Berries	Oranges	Bananas	Lemon-limes	Strawberries	Others
Low	0.9881	1.0288	0.5631	0.5323	0.7018	1.4022	0.7532
Middle	0.5346	1.4487	0.0972	0.5504	0.3363	1.6780	0.5811
High	0.6984	1.0917	0.8814	0.5971	0.7791	1.5017	0.6385

Regardless of their income levels, consumers are highly elastic to the change of prices of apples, berries, and strawberries. The quantity demanded is generally twice greater than the price change, meaning that there is high demand for organic fruits, but high prices act as a barrier. Unlike the expenditure elasticity, the behavior of consumers to own price changes are not all identical among income groups. The low income group has relatively high price elasticities in comparison with the high income group for all organic produce except bananas, meaning that consumers with low income are more responsive to price changes of organic products. The consumers in the middle income group were less responsive to price changes of bananas and strawberries, but more responsive to the changes of berries compared to the other groups.

Table 3. Marshallian own price elasticity of organic fruits

	Apples	Berries	Oranges	Bananas	Lemon-limes	Strawberries	Others
Low	-2.3069	-1.7704	-2.0245	-0.2816	-1.8292	-2.3629	-0.2634
Middle	-2.1557	-2.0708	0.0301	-0.1788	-1.2636	-1.7414	-0.7253

High	-1.7839	-1.6524	-0.1514	-0.5141	0.2769	-2.2227	-0.1164

3.2. Organic Vegetables

Organic vegetables are generally considered as luxury goods acroos different income groups. Expenditure of elasticities of lettuce, mushrooms, tomatoes, and kales are relatively smaller in the magnitude of consumption changes in response to expenditure changes. As found in organic fruits consumption, the behaviors to price changes are not consistent with income increases. High income group is less sensitive to the expenditure changes in the consumption of celeries, onions, tomatoes, and potatoes than low income group, but low income group appears to be less senstivie in purchases of carrots, herbs, lettuce, mushrooms than high income group. Middle income groups also shows mixed results depending on commodities.

Table 4. Expenditure elasticity of Organic Vegetables

	Carrots	Celery	Herbs	Lettuce	Mushrooms	Onions	Spinach	Tomatoes	Kale	Potato	Others
Low	1.5097	4.3368	1.3747	0.4279	0.9464	1.1775	2.5414	2.2552	0.5117	1.8364	1.6016
Middle	2.0907	5.2401	2.3283	0.8590	0.4575	2.1629	1.2066	0.6492	0.5837	2.8939	1.4730
High	2.5776	2.7326	1.9131	0.6721	1.2967	-0.001	2.7685	0.75539	0.4155	-0.154	1.9653

The consumption of organic vegetables moves in opposite way with price changes, but the response are differenct according to income levels and commodities. High income group is less elastic to price changes compared to the low income groups in the consumption of celeries, herbs, onions, tomatoes, but the group is more responsive for carrots, spinaches, and potatoes. Middle income group is price elasticitic in the consumption of carrots, celeries, tomatoes compared to other two groups. Organic vegetables are generally less elastic to the own price changes compared

to organic fruits as they are used often in meal preparations while fruits can be consumed in additional way or in differenct form such as juice.

Table 5. Marshallian own price elasticity of Organic Vegetables

	Carrots	Celery	Herbs	Lettuce	Mush-rooms	Onions	Spinach	Tomatoes	Kale	Potatoes	Others
Low	-0.721	-0.523	-1.204	-1.688	-1.358	-2.077	-1.792	-0.699	-1.011	-0.664	-1.396
Middle	-1.610	-0.825	-0.893	-1.462	-1.188	-1.834	-1.387	-1.261	-1.012	-1.397	-1.324
High	-1.552	-0.138	-0.210	-1.459	-1.484	-1.193	-2.336	-0.037	-0.998	-2.028	-1.256

4. Discussion and Conclusions

In this study of organic fruit and vegetable purchases across 3 income groups, demand elasticity differed both between income groups and between types of produce. As expected, but not for all commodities, lower-income consumers are more sensitive to price changes, high-income consumers are more tolerant, while middle-income consumers vary behavior according to type of produce. It implies that income plays an important role in the consumption of some organic fruits and vegetables, however, the inconsistency of income effect proves the existence of other factors influncing consumers' organic choices. For example, even some low income households may place a high value on organic products for the benefits of enviornments and own health.

Lin et al. (2009) estimated organic and conventional fruits elasticity in one demand system. Our estimates of expenditure elasticities for organic fruits are found to be similar only for apples, but higher for strawberries, and lower for bananas and oranges. Fruits own price elasticities also have shown variations. Contrary to Lin et al. (2009), we found that the own price elasticity for apples and strawberries were higher whereas for bananas were lower. In terms of organic

vegetables, own prices elasticities of carrots and onions similarly follow the estimates of Kasteridis & Yen (2012), while these of tomatoes and potatoes are estimated lower in this study. These differences may come from the exclusion of conventional products in the demand system and the changes of fresh fruits and vegetables markets such as the increase of organic commodities leading to price reduction.

This preliminary result shows the variations of responsiveness to price changes by income groups, but further developments are required in several aspects such as estimating the whole fruits or vegetables demand systems including both organic and conventional produce in one system as conducted in previous studies(Kasteridis & Yen, 2012; Lin et al., 2009) and expanding datasets to other years to see consumers behavior changes over time.

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