An Economic Analysis of Fresh Fruit and Vegetable Consumption: Implications for Overweight and Obesity among Higher- and Lower-Income Consumers

Eugene Jones
The Ohio State University
Jones.73@osu.edu

Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Long Beach, California, July 23-26, 2006

An Economic Analysis of Fresh Fruit and Vegetable Consumption: Implications for Overweight and Obesity among Higher- and Lower-Income Consumers

Introduction

A large body of literature has emerged on the causes and consequences of overweight and obesity in the United States (Balusu, 2006; Sisson, 2002; Nestle and Jacobson, 2000; The Surgeon General Report, 2001). Some of the noted causes are: (1) excessive involvement of children in video games; (2) an inordinate amount of television viewing by both children and adults; (3) insufficient physical activity; and (4) poor diets. Some dire consequences are: (1) a rapid acceleration in some of the leading causes of death – heart disease, strokes and cancer; (2) an annual total of some 360,000 premature deaths; (3) a ballooning of the number of obese children to some 9 million; (4) a shorten lifespan for children; and (5) an enormous increase in health care costs. And while these causes and consequences apply to all Americans, studies further show that the highest rates of obesity occur among population groups with the highest poverty rates and the least education (Drewnowski and Specter, 2004). Yet, Drewnowski and Darmon (2005) surveyed the literature and concluded that no study has been able to link high consumption of fresh fruits and vegetables with obesity. Thus, a motivating factor for this research is to try and ascertain whether higher- and lower-income consumers exhibit major differences in their purchases and consumption of fresh fruits and vegetables.

This research uses scanner data for six supermarkets in the Columbus, Ohio area to examine produce composition diets of higher- and lower-income consumers. Data are taken from three stores in higher-income areas and from three stores in lower-income areas. These data cover 69 weeks, from January 2001 through April 2002. All fresh fruits and vegetables sold in these supermarkets comprise the data set and a key objective of this research is to compare and contrast the purchasing behaviors of the two income groups for these commodities. Many studies have hypothesized that cost is a major determinant of fruit and vegetable consumption and therefore another objective of this research is to determine if prices are more constraining on the purchasing behavior of lower-income consumers. That is, do higher- and lower-income consumers have different price elasticities of demand? To the extent that constraints are identified and they lead to poor diets and subsequent costs that are borne by all of society, then these findings could have important policy implications.

Data and Demographic Information

Data used in this study were obtained from a national supermarket chain in the Columbus, Ohio Metropolitan Area. These data were collected at the store level and obviously there are shoppers with varying levels of income at every store at any time period. To try and control for income variation, two sets of stores were selected: (1) three stores from inner-city locations where the majority of surrounding residents have low to moderate incomes; and (2) three stores from suburban locations where the majority of surrounding residents have moderate to high incomes. And since studies suggest that people shop within close proximity of their residence, it seems reasonable to conclude that these stores represent two distinct income groups.

Some specific characteristics of the six stores that segment them into two income groups are: (1) twelve percent of the households within a three-mile radius of the three inner-city stores have incomes below $10,000, as compared to 4.2 percent of the households within a three-mile radius of the suburban stores; and (2) just 12 percent of the households within a three-mile radius of the three inner-city stores have incomes above $75,000 as compared to 34.1 percent of the households within a three-mile radius of the suburban stores. Further, given the usual positive correlation between income and education, educational levels also support the identification of two distinct income groups. The data show that just 10 percent of the prospective shoppers within close proximity of the inner-city stores are college graduates, as compared to 38 percent of those within close proximity of the suburban stores.

Analyses conducted in this study employ the standard classification used by USDA and the produce industry. Fruit is segmented into 8 sub-categories: apples, bananas, berries, citrus, fresh-cut fruit, grapes, melons and soft fruit (Table 1 and Graph 1). Vegetables are segmented into 6 sub-categories: Chinese vegetables, collars and other greens, fresh-cut salads (bagged), major vegetables (corn, potatoes and tomatoes), salad vegetables (cucumbers, lettuce, etc.) and yellow vegetables (Table 1 and Graph 2). Quantity shares of both fresh-cut fruit and yellow vegetables are below 1% of total produce sales and these sub-categories are likely to be merged with other sub-categories in subsequent analyses of these data (Graphs 1 and 2). Even after fresh-cut fruit is compared to all fruit, its percentage remains below 1 percent, although yellow vegetables represents 1.4 percent of all vegetables (Graphs 3 and 4). Berries and fresh-cut fruit are the most expensive fruit; fresh-cut salads and Chinese vegetables are the most expensive vegetables (Graphs 5 and 6).

An Overview Discussion of Descriptive Statistics

Table 1 provides price and quantity data for the 14 sub-categories of fruit and vegetables for each store. These data are provided in cents per ounce and total ounces. This discussion is intended to share some insights on these data, as well as on other data omitted from this table. Relative to produce sales, store 1 is the largest, averaging $42,300 worth of produce sales per week. Store 3 averaged $37,800 per week; stores 2 and 4 averaged just over $28,000; and stores 5 and 6 averaged $21,400. With respect to sales alone, lower-income store 4 is comparable in size to high-income store 2, but the other two low-income stores are much smaller than a typical high-income store. These differences in size suggest a more limited number of produce items for lower-income stores. Quantity differences, as shown in Table 1, show similar size effects, but store 2 is now more comparable to store 5, than it is to store 4. This shift suggests entirely different purchasing patterns for higher- and lower-income shoppers. That is, if purchase bundles are similar, then comparable dollar sales should lead to comparable quantity sales. This expectation stems mainly from the fact that prices are identical across all stores.

Even though prices are identical across all stores, a quick glance at Table 1 shows that lower-income shoppers pay lower prices for all fruit and vegetables, except bananas and yellow vegetables. For these two sub-categories, lower-income shoppers pay either slightly higher or statistically identical prices. These price data suggest that lower-income shoppers make a special effort to purchase the lowest-priced commodities within a given sub-category. For example, a lower price can be realized for potatoes by purchasing pre-sorted bags of potatoes, instead of self-selecting potatoes from bulk bins. Similar tradeoffs can be made for commodities like apples and citrus. And while exact tradeoffs cannot be observed because the data are at a store level as opposed to an individual shopper level, observed differences in prices paid clearly suggest that lower-income consumers are careful shoppers. What is not clear is the extent to which income constraints dictate these shopping preferences.

Model Development

One of the key factors motivating this research is whether higher- and lower-income consumers have different demand responses to changes in prices for various sub-categories of fruit and vegetables. To address this issue, an error component model is specified and estimated. Since the data set is a cross-section of higher- and lower-income stores over a time period of sixty-nine weeks, an error component model as developed by Fuller and Battese (1974) is considered most appropriate for this study. The general form of this model is:

$$Y_{qr} = \sum_{s=1}^{v} X_{qrs}\beta_s + \mu_{qr} \qquad q = 1,2,...,N; \qquad r = 1,2,...,T$$

where N is the number of cross-sections, and T is the length of the time series for each cross-section.

Six cross-sections and 69 observations per cross-section are included in the specified model for this study. Fourteen equations are specified and estimated using the time series cross-section regression (TSCSREG) procedure in SAS. The equations and included variables are specified as follows:

$$Q_{ikt} = f(p_{ikt}, p_{jkt}s, p_{mkt}, SDUM_{kt}, TEXP_{kt}, Q_{ikt-1})$$

Where Q_{ikt} is total ounces of sub-category i for store k in week t; i = 1, …, 14; k = 1, …, 6; t = 1, …, 69; P_{ikt} is a weighted-average price of sub-category i for store k in week t; P_{jkt}s represents weighted-average prices for competing sub-categories for store k in week t; P_{mkt} is identical to P_{ikt} for lower-income stores 4, 5, and 6, but 0 for all other stores (it is intended to capture price elasticity differences for higher and lower income stores); $SDUM_{kt}$ are zero-one dummy variables intended to capture store differences; $TEXP_{kt}$ represents total expenditures on fruit and vegetables for store k in week t (intended as a proxy for consumer income); and Q_{ikt-1} is total ounces of sub-category i purchased in store k during the previous week. Descriptive statistics for dependent and independent variables are provided in Table 1.

Prices are determined by expressing each fruit or vegetable sale as a ratio of all fruit and vegetables sales within a given sub-category. Specifically, weighted prices for sub-category i in each time period is:

$$P_i = \sum_j W_{ij} p_{ij}, \text{where } W_{ij} = (P_{ij}Q_{ij}) / (\sum_j P_{ij}Q_{ij})$$

and *j* denotes the commodities in the same sub-category. Because each fruit or vegetable is a potential substitute for, or complement with, other fruit and vegetables, all sub-categories are included in each equation.

Since price elasticities of demand are a primary focus of this research, each equation is specified in its double logarithmic functional form to give direct demand elasticities. Given that economic theory suggests a link between income and demand responsiveness, it is hypothesized that lower-income consumers will show higher price elasticities than higher-income consumers. Stated differently, the variable P_{mkt} in equation 2 is expected to be negative and statistically significant.

Empirical Results for Fruit

Table 3 provides the estimated results for all sub-categories of fruit and vegetables. Store variables and other independent variables are included in this table, but this discussion will focus on own-price elasticities for the eight sub-categories of fruit. However, it should be noted that statistically significant differences are found among the stores for all sub-categories of produce. For example, store 1, a higher-income store, is used as the reference store and the results for citrus show that purchases of citrus for stores 2 and 3 are statistically insignificant from purchases in store 1. Lower-income stores, 4, 5 and 6, are shown to have citrus purchases that are different from those in store 1. That is, relative to store 1, the intercepts shift downward for stores 4, 5 and 6. Further, the variable produce sales, a proxy for income, shows that most fruit and vegetables have positive and statistically significant elasticities that are less than one, classifying these sub-categories as necessary goods, not luxury ones. Based on this classification criterion, berries, soft fruit, melons and grapes are shown to be luxury goods. Lagged quantities are positive and statistically significant for four sub-categories of fruit (bananas, fresh-cut, melons and soft), suggesting that current purchases are positively influenced by purchases during the previous week. For berries and grapes, lagged quantities are negative and statistically significant, suggesting an inverse relationship between current and past purchases.

With respect to own-price elasticities for sub-categories of fruit, all but one, fresh-cut fruit, is negative and statistically significant. Moreover, when demand elasticies for higher- and lower-income shoppers are compared for these remaining seven sub-categories, statistically significant differences are shown for all but one, berries. Specifically, relative differences in own-price elasticities for citrus are -2.12 versus -1.41 for lower- and higher-income shoppers respectively. Comparing this price elasticity difference with differences in prices paid as shown in Table 2 and Graph 5, this suggests that lower-income shoppers are quite sensitive to price changes for citrus. Yet, as a percentage of total fruit consumption, lower-income shoppers are shown to purchase a higher percent than higher-income shoppers (15.1% versus 12.6%). In essence, despite their sensitivity to price changes, lower-income shoppers find a way to add large amounts of citrus to their diets.

Differences in own-price elasticities for other fruit consumed by higher- and lower-income shoppers are not as great as that shown for citrus. For apples, the difference is -1.81 versus -1.54. This greater price sensitivity led lower-income shoppers to pay a lower price per pound for apples ($1.01 versus $1.18). Yet, as a share of both total produce consumption and total fruit consumption, lower-income shoppers are shown to lag far behind higher-income shoppers (Graphs 1 and 3). Of course, even more dramatic differences are shown for berries. Much of this difference is undoubtedly due to the high price of berries. Indeed berries are shown to be the highest-priced of all the sub-categories of fruit (Table 2 and Graph 5). Yet, the estimated results show statistically insignificant difference in price elasticities for higher- and lower-income shoppers. Of course, unlike oranges and apples, berries are offered in fewer alternative forms. Still, as shown in Table 2 and Graph 5, lower-income shoppers paid a much lower price per pound for berries ($2.87 versus $3.40). Given the high price of berries, it seems unreasonable to expect lower-income shoppers to increase their consumption significantly. Of course, there is always the possibility that a commodity like berries can be shown to have nutritional attributes that are critical to a healthy diet. Such attribute coupled with an effective educational program could lead to significant changes in consumption behavior.

While a statistically insignificant difference was shown in the purchase behavior of higher- and lower-income shoppers for berries, a statistically significant difference is shown for soft fruit. The magnitudes of these elasticities are -1.61 versus -1.25 for lower- and higher-income shoppers respectively. Also, just as lower-income shoppers used selective shopping behavior to pay lower prices for citrus, apples and berries, they used similar behavior to pay lower prices for soft fruit (Table 2 and Graph 5). As may have been expected, the magnitude of this price difference is not very large because soft fruit is also offered in fewer alternative forms than citrus and apples. Perhaps the best measure of the price impact is seen in the large differences in quantity shares as measured by a percentage of both total produce and total fruit. That is, higher-income shoppers are shown to have much higher percentages.

Bananas are an interesting sub-category of fruit because it is the least expensive of the eight sub-categories. Indeed it is the only category of fruit in which lower-income shoppers paid a slightly higher price than higher-income shoppers ($.55 vs $.49). Yet, lower-income shoppers are shown to have a more elastic demand for bananas (-.99 versus -.57). One possible explanation for the higher price paid by lower-income shoppers is the mix of bananas sold at the various stores. Specifically, plantains and red bananas were more prominent in the lower-income stores, although these varieties were a small share of total bananas sales in all stores. Further, the demographic data revealed that there is more diversity among residents surrounding the lower-income stores than there is among residents surrounding the higher-income stores. This would suggest a demand for more variety in bananas. Finally, it should be observed that bananas have the lowest own-price elasticity of all sub-categories of fruit. This result supports the finding of other studies that have shown consumers to be the least price sensitive to the lowest-priced product in a given product category (Lietag and Kaufman, 2003).

Melons are the second lowest-priced sub-category of fruit and lower-income shoppers are shown to purchase higher quantity shares as a percentage of both total produce and total fruit. Yet, lower-income shoppers are shown to have a higher own-price sensitivity (-2.26 versus -1.99) and to pay a lower price per pound ($.85 versus $.97). These outcomes suggest careful selections of the least expensive melons and they also suggest the role of price in influencing product selection from within a product group. As a share of both total produce and total fruit, bananas and melons are one and two for lower-income shoppers (Graphs 1 and 3). For higher-income shoppers, both apples and citrus exceed the share of melons. These differences in outcomes for the two income groups could reflect major differences in taste, but it is more tenable to conclude that they reflect the impact of income constraints on shopping behavior.

Grapes and soft fruit are similarly priced and differences in prices paid by higher- and lower-income shoppers are similar (Table 2 and Graph 5). As shown in Table 3, lower-income shoppers are more price sensitive than higher-income shoppers, with relative elasticities of -1.71 versus -1.39. As a quantity share of total fruit, grapes are shown to be fairly equal for both higher- and lower income consumers, but as a quantity share of total produce, grapes represent much higher percentage of produce consumption for higher-income shoppers (4.99% versus 3.83%). This disparity results from the fact that produce consumption is fairly evenly distributed between fruit and vegetables for higher-income consumers (50.7% vs 49.3%), but highly skewed toward vegetables for lower-income consumers (58.8% vs 41.2%). Since fruit is generally more expensive than vegetables, this disparity for the two groups support the premise that income serves to limit produce consumption bundles for lower-income consumers.

The final sub-category of fruit, fresh-cut fruit, provides empirical results that are inconsistent with consumption theory. The own-price elasticity is positive, but not statistically significant. Of course, fresh-cut fruit is less than 1% of total fruit consumption for both income groups and this small percentage is the likely explanation for the insignificance of the estimated parameters. Another factor surrounding fresh-cut fruit is that much of it is pre-ordered through deli departments and therefore does not scan as produce sales. But despite the insignificance of the own-price elasticity for fresh-cut fruit, prices paid by higher- and lower-income consumers show greater price sensitivity for lower-income consumers ($3.36 vs $2.61).

Empirical Results for Vegetables

As shown in Table 3, store differences exist for all sub-categories of vegetables, but the least difference is shown for major vegetables (corn, potatoes and tomatoes). This result is quite plausible, given that major vegetables represent the largest share of produce consumption for both higher- and lower-income consumers. With store 1 serving as the reference store, the results for greens show upward shifts in the intercepts for stores 3 through 6. Sales of greens in store 2 are shown to be statistically insignificant from those of store 1. Produce sales, the variable used as a proxy for income, are shown to have positive and statistically significant impacts on sales of all sub-categories of vegetables. All elasticity estimates are less than one and therefore all sub-categories of vegetables are what economists would describe as necessary goods. Mixed results are shown for the lagged dependent variable, suggesting that habit persistence is not a major determinant of vegetable consumption.

The estimated own-price elasticity for greens is highly inelastic (-.37) and statistically significant, but no price sensitivity difference is shown for higher- and lower-income consumers. For lower-income consumers, this was the least expensive of all vegetables and therefore greens fall into the same class as bananas as having the lowest price-elasticity among the six sub-categories of vegetables. Unlike bananas, greens do not represent the highest consumption sub-category of vegetables, as this distinction is reserved for major vegetables. Yet, despite the highly inelastic demand for greens, lower-income consumers paid an average of $.84 less per pound (Table 2 and Graph 5). This price disparity suggests entirely different purchasing bundles, perhaps determined as much by preferences as by price.

Lower-income consumers are shown to be more price sensitive in their purchases of fresh-cut salads (-1.11 vs -.91). For lower-income consumers, the share of fresh-cut salad vegetables is comparable to that of greens; for higher-income consumers, the share is almost three times that of greens. Given that fresh-cut salads are the highest-priced of all sub-categories of vegetables, disparities in consumption shares for the two income groups are to be expected if income constraints are binding for one group, but not for the other. Yet, lower-income consumers are shown to shop selectively within this sub-category as they paid an average of $2.65 per pound, compared to $3.67 paid by higher-income consumers. These price differences obviously reflect different purchase bundles, just as one would hypothesize given an inelastic demand for one group and an elastic demand for the other.

Higher- and lower-income consumers are shown to have the same price sensitivity (-.94) for salad vegetables, but descriptive statistics of Table 2 show lower-income consumers paying prices that are statistically lower than those paid by higher-income consumers ($1.51 vs $1.33). A similar pattern is shown for major vegetables. No statistical difference is shown in the own-price elasticities of higher- and lower-income consumers, but lower-income consumers pay a much lower price ($1.13 vs $1.61). These price differences show considerable selectivity in purchase selections because lower-income consumers purchase a much higher percentage of their total produce within this sub-category (34.5% vs 22.3%). Indeed large purchases of major vegetables by lower-income consumers are what account for the disparity in overall fruit and vegetable purchases for this group (58.8% vegetables vs 41.2% fruit). The fact that lower-income consumers have own-price elasticities comparable to those of higher-income consumers and yet pay much lower prices would suggest that the two groups actually purchase entirely different bundles of commodities.

The own-price elasticity for Chinese vegetables is highly inelastic (-.43), but statistically identical for both income groups. Identical elasticities for the second highest-priced sub-category of vegetables are difficult to justify theoretically, but given the mix of vegetables within this category, it is likely that consumers further segment this sub-category. That is, price changes that influence the purchases of one group might be entirely irrelevant to another group. Such scenario could explain how identical price elasticities for Chinese vegetables would result in lower-income consumers paying an average of $1.04 less per pound for Chinese vegetables (Table 2).

Lower-income consumers are shown to have larger own-price elasticities than higher-income consumers for yellow vegetables and these differences are statistically significant (-1.66

vs -1.48). Theoretically these differences are difficult to explain because yellow vegetables are such a small share of total produce consumption for both groups. But given the limited selections and the near uniformity of yellow vegetables, the results suggest that both groups are responding to the same group of commodities and to the same set of prices. Indeed these factors result in both groups paying statistically identical prices.

Summary and Conclusions

A key objective of this study was to determine if higher- and lower-income consumers show similar or dissimilar own-price elasticities for fruit and vegetables. To accomplish this objective, a time series cross-section model was specified and estimated for 14 sub-categories of produce across 6 cross-sections and over 69 weeks. The results showed lower-income consumers to have a more elastic demand for six of eight sub-categories of fruit and two of six sub-categories of vegetables. Own-price elasticities were shown to be identical for all but one remaining sub-category, fresh-cut fruit. Price was not a statistically significant determinant of consumption for fresh-cut fruit and this finding is attributed to its relatively small share of total produce consumption. A contributing factor to its small share is the sale of specially ordered fruit trays through the deli department as opposed to the produce department. But even if all specially-ordered fresh-cut fruit were sold as produce, it is still possible that price would be an insignificant determinant of consumption because consumers are known to be less price-sensitive toward purchases made for special occasions.

A finding more revealing than the estimated differences in own-price elasticitiies was the observed differences in prices paid by the two income groups. Lower-income consumers almost invariably paid lower per unit prices. Perhaps product preferences played some role in effecting these outcomes, but it seems plausible to conclude that income constraints played a larger role in dictating these outcomes. To the extent that increased consumption of fresh fruit and vegetables is critical to a healthy and nutritious diet, it seems reasonable to conclude that lower-income consumers would have difficulty meeting such objective. Current purchasing patterns suggest that lower-income consumers are already stretching their limited budgets to purchase produce from each of the 14 sub-categories. And while efficient shopping is an admirable goal, the fact that lower-income shoppers realize lower prices for practically every sub-category would suggest that lower quality commodities are being purchased in at least some of these sub-categories. Increased consumption of lower-quality commodities would be better than no increase, but lower-quality commodities make it more difficult to reach a healthy and nutritious diet.

Table 1. Price and Quantity Comparisons across Stores

Variable	Store Type								Differences	
	HIGH INCOME STORES				LOW INCOME STORES					
	Mean Store 1	Mean Store 2	Mean Store 3	Mean AVG	Mean Store 4	Mean Store 5	Mean Store 6	Mean AVG	AVG DIFF	Z-tests
Price										
Citrus	0.080	0.080	0.084	0.081	0.070	0.068	0.067	0.069	0.013	7.698
Apples	0.076	0.074	0.071	0.074	0.065	0.062	0.063	0.063	0.010	10.309
Berries	0.210	0.211	0.216	0.212	0.181	0.170	0.187	0.179	0.033	5.348
Soft Fruit	0.109	0.103	0.103	0.105	0.099	0.092	0.106	0.099	0.006	3.076
Bananas	0.031	0.029	0.032	0.030	0.035	0.034	0.035	0.034	-0.004	-8.466
Melons	0.065	0.060	0.058	0.061	0.055	0.048	0.057	0.053	0.007	3.547
Grapes	0.106	0.102	0.107	0.105	0.098	0.105	0.098	0.100	0.005	1.306
Fresh-cut Fruit	0.203	0.206	0.221	0.210	0.192	0.145	0.153	0.163	0.047	14.416
Greens	0.102	0.095	0.147	0.115	0.061	0.058	0.065	0.061	0.053	23.798
Fresh-cut Salads	0.253	0.196	0.221	0.223	0.170	0.165	0.161	0.165	0.058	24.339
Salad Veggies	0.099	0.094	0.090	0.094	0.083	0.082	0.084	0.083	0.011	15.146
Major Veggies	0.113	0.094	0.095	0.101	0.074	0.069	0.069	0.070	0.030	19.412
Chinese Veggies	0.178	0.186	0.191	0.185	0.116	0.121	0.124	0.120	0.065	32.796
Yellow Veggies	0.082	0.080	0.082	0.082	0.085	0.081	0.082	0.083	-0.001	-0.520
Quantity										
Citrus	42275.9	31946.9	36086.8	36769.8	39225.3	30761.1	26164.4	32050.3	4719.6	1.819
Apples	58049.0	38826.2	50003.4	48959.5	43453.9	29520.6	24497.6	32490.7	16468.8	5.823
Berries	24284.6	13590.1	20098.3	19324.4	10477.3	5521.9	7114.8	7704.7	11619.7	7.906
Soft Fruit	38846.0	23216.1	30914.3	30992.1	17607.0	17035.2	13283.5	15975.2	15016.9	6.245
Bananas	93125.6	78883.0	89489.4	87166.0	72522.9	58498.7	54061.8	61694.5	25471.5	13.013
Melons	42105.7	32970.8	43800.8	39625.8	49465.6	45060.7	33780.0	42768.8	-3143.0	-0.577
Grapes	29354.9	26121.4	30291.9	28589.4	22901.8	20288.7	16240.5	19810.3	8779.1	4.331
Fresh-cut Fruit	2413.9	1062.6	1128.9	1535.2	782.8	102.1	415.6	433.5	1101.7	18.196
Greens	8569.3	6686.8	7391.1	7549.0	14385.3	24467.0	11345.7	16732.6	-9183.6	-13.755
Fresh-cut Salads	18456.2	18483.3	22946.6	19962.1	18212.2	12031.0	15721.3	15321.5	4640.6	11.011
Salad Veggies	85998.9	64633.4	90866.0	80499.4	73230.6	47687.4	52508.4	57808.8	22690.6	12.041
Major Veggies	122162.0	112909.4	152485.8	129185.7	213055.3	152839.3	169005.0	178299.8	-49114.1	-6.560
Chinese Veggies	63947.0	29040.5	39290.7	44092.7	37672.9	35618.4	31470.6	34920.6	9172.1	4.324
Yellow Veggies	5993.9	2457.7	3511.1	3987.6	1232.0	601.7	920.2	918.0	3069.6	15.369

Table 2. Prices Paid in Higher- and Lower-income Stores

Variable	High Income		Low Income		Differences		
	AVG $	AVG $	AVG $	AVG $	AVG DIFF $	AVG DIFF $	Z-tests
	Ounces	Pounds	Ounces	Pounds	Ounces	Pounds	(Ounces)
Price							
Citrus	0.0815	1.3033	0.0686	1.0973	0.0129	0.2060	7.6984
Apples	0.0739	1.1818	0.0634	1.0142	0.0105	0.1676	10.3087
Berries	0.2125	3.3999	0.1792	2.8674	0.0333	0.5325	5.3480
Soft Fruit	0.1051	1.6814	0.099	1.5861	0.0060	0.0953	3.0756
Bananas	0.0305	0.4876	0.0345	0.5517	-0.0040	-0.0641	-8.4657
Melons	0.0609	0.9745	0.0534	0.8548	0.0075	0.1197	3.5472
Grapes	0.1050	1.6800	0.1002	1.6031	0.0048	0.0768	1.3060
Fresh-cut Fruit	0.2102	3.3627	0.1632	2.6109	0.0470	0.7518	14.4157
Greens	0.1147	1.8357	0.0614	0.9825	0.0533	0.8533	23.7977
Fresh-cut Salads	0.2231	3.5690	0.1654	2.6457	0.0577	0.9233	24.3390
Salad Veggies	0.0943	1.5087	0.0831	1.3289	0.0112	0.1798	15.1458
Major Veggies	0.1007	1.6113	0.0704	1.1266	0.0303	0.4847	19.4120
Chinese Veggies	0.1851	2.9616	0.1204	1.9265	0.0647	1.0352	32.7963
Yellow Veggies	0.0816	1.3059	0.0827	1.3234	-0.0011	-0.0175	-0.5202

Table 3. Empirical Results for Time Series Cross-Section Regression (double-logarithmic model with price and quantity variables measured in ounces)

Dependent Variables[a]

	Citrus		Apples		Berries	
Store Variables						
Store 2	.078	(.792)	-.028	(-.537)	-.105	(-.801)
Store 3	.31	(.392)	-.078	(-1.939)**	-.183	(-2.038)**
Store 4	-2.292**	(-6.612)*	-.966	(-3.114)*	-.862	(-2.953)*
Store 5	-2.134**	(-5.904)*	-1.206	(-3.756)*	-1.237	(-3.704)*
Store 6	-2.386**	(-6.632)*	-1.278	(-4.001)*	-.969	(-2.931)*
Other Variables						
Produce Sales	.709	(5.379)*	.813	(9.337)*	1.508	(6.948)*
Quantity Lagged	.006	(.454)	.016	(1.379)	-.037	(-1.816)**
Constant	2.142**	(1.264)	-1.229	(-1.062)	-5.895*	(-2.168)**
Price Variables						
Citrus A[b]	-1.405	(-14.527)*	-.013	(-.349)	.131	(1.364)
Citrus B[c]	-.822	(-6.873)*	-----	-----	-----	-----
Apples A[b]	.097	(.829)	-1.539	(-16.231)*	.239	(1.414)
Apples B[c]	-----	-----	-.273	(-2.459)**	-----	-----
Berries A[b]	.155	(2.893)*	.069	(2.095)**	-1.968**	(-21.671)*
Berries B[c]	-----	-----	-----	-----	-.148	(-1.298)
Soft Fruit A[b]	.206	(2.622)*	.121	(2.631)*	.084	(.737)
Soft Fruit B[c]	-----	-----	-----	-----	-----	-----
Bananas A[b]	.051	(.624)	.031	(.525)	-.298	(-2.474)*
Bananas B[c]	-----	-----	-----	-----	-----	-----
Melons A[b]	.159	(3.613)*	.114	(4.143)*	.008	(.121)
Melons B[c]	-----	-----	-----	-----	-----	-----
Grapes A[b]	.159	(3.254)*	.037	(1.162)	.127	(1.690)**
Grapes B[c]	-----	-----	-----	-----	-----	-----
Fresh-cut Fruit A[b]	.090	(1.204)	.049	(1.451)	-.157	(-1.501)
Fresh-cut Fruit B[c]	-----	-----	-----	-----	-----	-----
Greens A[b]	.076	(.954)	.039	(.902)	.211	(2.132)**
Greens B[c]	-----	-----	-----	-----	-----	-----
Fresh-cut Salad A[b]	-.011	(-.075)	-.246	(-2.612)*	.142	(.615)
Fresh-cut Salad B[c]	-----	-----	-----	-----	-----	-----
Salad Vegetables A[b]	.191	(.810)	.110	(.733)	.388	(1.114)
Salad Vegetables B[c]	-----	-----	-----	-----	-----	-----
Major Vegetables A[b]	.232	(2.003)**	.117	(1.642)**	-.058	(-.327)
Major Vegetables B[c]	-----	-----	-----	-----	-----	-----
Chinese Vegetables A[b]	-.211	(-2.008)**	-.056	(-.999)	.106	(.775)
Chinese Vegetables B[c]	-----	-----	-----	-----	-----	-----
Yellow Vegetables A[b]	-.014	(-.163)	-.151	(-3.217)*	.539	(4.204)*
Yellow Vegetables B[c]	-----	-----	-----	-----	-----	-----

[a] Numbers in parentheses are t-ratios for the associated parameters.
[b] Indicates the price elasticity estimate for all stores.
[c] Indicates the difference between the price elasticity for lower income stores and all stores.
* Indicates statistical significance at the .01 level.
** Indicates statistical significance at the .10 level.

Table 3. (continued)

Dependent Variables[a]

	Soft Fruit		Bananas		Melons	
Store Variables						
Store 2	-.226	(2.156)**	.032	(1.078)	-3.55*	(-2.100)**
Store 3	.001	(.007)	.074	(3.264)*	-.327	(-2.731)*
Store 4	-1.329	(4.411)*	-1.440	(-8.355)*	-1.445	(-3.588)*
Store 5	-1.238	(3.782)*	-1.564	(-8.911)*	-1.497	(-3.461)*
Store 6	-1.379	(4.169)*	-1.605**	(-9.157)*	-1.246	(-2.934)*
Other Variables						
Produce Sales	1.153	(7.212)*	.537	(11.029)*	1.396	(5.586)*
Quantity Lagged	.053	(2.558)*	.014	(2.661)*	.117	(5.354)*
Constant	-5.283*	(-2.579)*	2.615*	(4.022)*	-13.809	(-4.420)*
Price Variables						
Citrus A[b]	.288	(3.941)*	.037	(1.567)	.332	(2.424)**
Citrus B[c]	-----	-----	-----	-----	-----	-----
Apples A[b]	.292	(2.018)**	-.108	(-2.511)*	.397	(1.878)**
Apples B[c]	-----	-----	-----	-----	-----	-----
Berries A[b]	.058	(.885)	.024	(1.238)	-.074	(-.798)
Berries B[c]	-----	-----	-----	-----	-----	-----
Soft Fruit A[b]	-1.254	(-11.546)*	-.056	(-1.929)**	-.294	(-2.033)**
Soft Fruit B[c]	-.353	(-3.273)*	-----	-----	-----	-----
Bananas A[b]	.125	(1.149)	-.568	(-14.995)*	-.013	(-.083)
Bananas B[c]	-----	-----	-.429	(-8.985)*	-----	-----
Melons A[b]	-.109	(-2.029)**	-.004	(-.260)	-1.987**	(-17.804)*
Melons B[c]	-----	-----	-----	-----	-.271	(-2.508)*
Grapes A[b]	-.124	(-2.004)**	-.021	(-1.169)	.030	(.329)
Grapes B[c]	-----	-----	-----	-----	-----	-----
Fresh-cut Fruit A[b]	-.134	(-1.620)**	-.123	(-4.722)*	-.044	(-.407)
Fresh-cut Fruit B[c]	-----	-----	-----	-----	-----	-----
Greens A[b]	-.292	(3.647)*	-.029	(-1.088)	-.228	(-1.606)**
Greens B[c]	-----	-----	-----	-----	-----	-----
Fresh-cut Salad A[b]	-.109	(-.628)	-.032	(-.562)	-.308	(-1.140)
Fresh-cut Salad B[c]	-----	-----	-----	-----	-----	-----
Salad Vegetables A[b]	.087	(.301)	-.199	(-2.342)**	-1.183	(-2.771)*
Salad Vegetables B[c]	-----	-----	-----	-----	-----	-----
Major Vegetables A[b]	-.367	(-2.575)*	.139	(3.178)*	-.354	(-1.721)**
Major Vegetables B[c]	-----	-----	-----	-----	-----	-----
Chinese Vegetables A[b]	.077	(.725)	-.009	(-.262)	-.012	(-.068)
Chinese Vegetables B[c]	-----	-----	-----	-----	-----	-----
Yellow Vegetables A[b]	.085	(.807)	-.043	(-1.406)	.453	(3.442)*
Yellow Vegetables B[c]	-----	-----	-----	-----	-----	-----

[a] Numbers in parentheses are t-ratios for the associated parameters.
[b] Indicates the price elasticity estimate for all stores.
[c] Indicates the difference between the price elasticity for lower income stores and all stores.
* Indicates statistical significance at the .01 level.
** Indicates statistical significance at the .10 level.

Table 3. (continued)

Dependent Variables[a]

	Grapes		Fresh-cut Fruit		Greens	
Store Variables						
Store 2	.440	(4.907)*	-.421	(-3.627)*	.038	(.538)
Store 3	.349	(5.183)*	-.593	(-6.471)*	.105	(1.891)**
Store 4	-.655	(-3.216)*	.040	(.084)	.678	(2.086)**
Store 5	-.286	(-1.267)	-1.634**	(-2.998)*	1.438	(4.227)*
Store 6	-.519	(-2.321)**	-.555	(-.996)	.659	(2.004)**
Other Variables						
Produce Sales	1.114	(7.661)*	.391	(2.099)**	.753	(6.819)*
Quantity Lagged	-.025	(-1.654)**	.081	(3.647)*	-.018	(-.156)
Constant	-2.599*	(-1.348)	4.887*	(2.031)**	2.369**	(1.655)**
Price Variables						
Citrus A[b]	.098	(1.547)	.070	(.731)	.027	(.525)
Citrus B[c]	-----	-----	-----	-----	-----	-----
Apples A[b]	.411	(3.361)*	-.130	(-.886)	-.009	(-.105)
Apples B[c]	-----	-----	-----	-----	-----	-----
Berries A[b]	.212	(3.851)*	-.006	(-.091)	.031	(.768)
Berries B[c]	-----	-----	-----	-----	-----	-----
Soft Fruit A[b]	.077	(.971)	.015	(.157)	.051	(.835)
Soft Fruit B[c]	-----	-----	-----	-----	-----	-----
Bananas A[b]	.128	(1.323)	-.148	(-1.398)	.034	(.435)
Bananas B[c]	-----	-----	-----	-----	-----	-----
Melons A[b]	-.002	(-.053)	.207	(3.517)*	.124	(3.405)*
Melons B[c]	-----	-----	-----	-----	-----	-----
Grapes A[b]	-1.395	(-24.921)*	.139	(2.511)*	.047	(1.108)
Grapes B[c]	-.312	(-4.991)*	-----	-----	-----	-----
Fresh-cut Fruit A[b]	.017	(.280)	.232	(1.577)	.013	(.285)
Fresh-cut Fruit B[c]	-----	-----	.356	(1.309)	-----	-----
Greens A[b]	-.037	(-.482)	-.023	(-.223)	-.369	(-5.047)*
Greens B[c]	-----	-----	-----	-----	-.018	(-.156)
Fresh-cut Salad A[b]	-.092	(-.595)	.759	(3.417)*	-.062	(-.531)
Fresh-cut Salad B[c]	-----	-----	-----	-----	-----	-----
Salad Vegetables A[b]	-.047	(-.199)	.454	(1.669)**	.638	(3.196)*
Salad Vegetables B[c]	-----	-----	-----	-----	-----	-----
Major Vegetables A[b]	.079	(.626)	-.195	(-1.163)	-.011	(-.126)
Major Vegetables B[c]	-----	-----	-----	-----	-----	-----
Chinese Vegetables A[b]	-.025	(-.253)	.146	(.987)	-.055	(-.742)
Chinese Vegetables B[c]	-----	-----	-----	-----	-----	-----
Yellow Vegetables A[b]	.077	(.893)	-.233	(-2.402)**	-.102	(-1.514)
Yellow Vegetables B[c]	-----	-----	-----	-----	-----	-----

[a] Numbers in parentheses are t-ratios for the associated parameters.
[b] Indicates the price elasticity estimate for all stores.
[c] Indicates the difference between the price elasticity for lower income stores and all stores.
* Indicates statistical significance at the .01 level.
** Indicates statistical significance at the .10 level.

Table 3. (continued)

Dependent Variables[a]

	Fresh-cut Salad		Salad Vegetables		Major Vegetables	
Store Variables						
Store 2	.030	(.866)	.026	(.709)*	.040	(.655)
Store 3	.179	(6.655)*	.087	(3.248)*	.740	(1.739)**
Store 4	-.492	(-3.141)*	-.074	(-.264)	.580	(2.426)**
Store 5	-.730	(-4.511)*	-.276	(-.982)	.414	(1.653)**
Store 6	-.497	(-3.017)*	-.138	(-.493)	.519	(2.066)**
Other Variables						
Produce Sales	.635	(11.327)*	.805	(15.331)*	.986	(10.095)*
Quantity Lagged	.007	(1.002)	-.006	(-1.015)	-.048	(-3.741)*
Constant	2.019**	(2.750)*	1.172	(1.730)**	-.742	(-.569)
Price Variables						
Citrus A[b]	-.102	(-4.068)*	.024	(.742)	.005	(.111)
Citrus B[c]	-----	-----	-----	-----	-----	-----
Apples A[b]	-.131	(-2.868)*	.028	(.653)	-.219	(-2.622)*
Apples B[c]	-----	-----	-----	-----	-----	-----
Berries A[b]	.031	(1.481)	.048	(2.251)**	.095	(2.456)*
Berries B[c]	-----	-----	-----	-----	-----	-----
Soft Fruit A[b]	.006	(-.192)	.066	(.187)	-.124	(-2.194)**
Soft Fruit B[c]	-----	-----	-----	-----	-----	-----
Bananas A[b]	.008	(.238)	.019	(.580)	-.021	(-.319)
Bananas B[c]	-----	-----	-----	-----	-----	-----
Melons A[b]	.057	(3.159)*	.039	(2.065)**	.109	(3.206)*
Melons B[c]	-----	-----	-----	-----	-----	-----
Grapes A[b]	.005	(.252)	.006	(.314)	.091	(2.268)**
Grapes B[c]	-----	-----	-----	-----	-----	-----
Fresh-cut Fruit A[b]	.101	(3.94)*	-.011	(-.437)	.023	(.549)
Fresh-cut Fruit B[c]	-----	-----	-----	-----	-----	-----
Greens A[b]	-.024	(-.832)	-.026	(-.832)	.088	(1.804)**
Greens B[c]	-----	-----	-----	-----	-----	-----
Fresh-cut Salad A[b]	-.907	(-12.217)*	.102	(1.819)**	-.284	(-2.527)*
Fresh-cut Salad B[c]	-.205	(-2.192)**	-----	-----	-----	-----
Salad Vegetables A[b]	.140	(1.473)	-.938	(-8.496)*	.135	(.739)
Salad Vegetables B[c]	-----	-----	-.043	(-.389)	-----	-----
Major Vegetables A[b]	.005	(.109)	.035	(.764)	-1.323	(-12.740)*
Major Vegetables B[c]	-----	-----	-----	-----	.098	(1.035)
Chinese Vegetables A[b]	.027	(.697)	-.007	(-.185)	-.072	(-1.088)
Chinese Vegetables B[c]	-----	-----	-----	-----	-----	-----
Yellow Vegetables A[b]	.066	(2.059)**	-.019	(-5.95)*	.261	(4.127)*
Yellow Vegetables B[c]	-----	-----	-----	-----	-----	-----

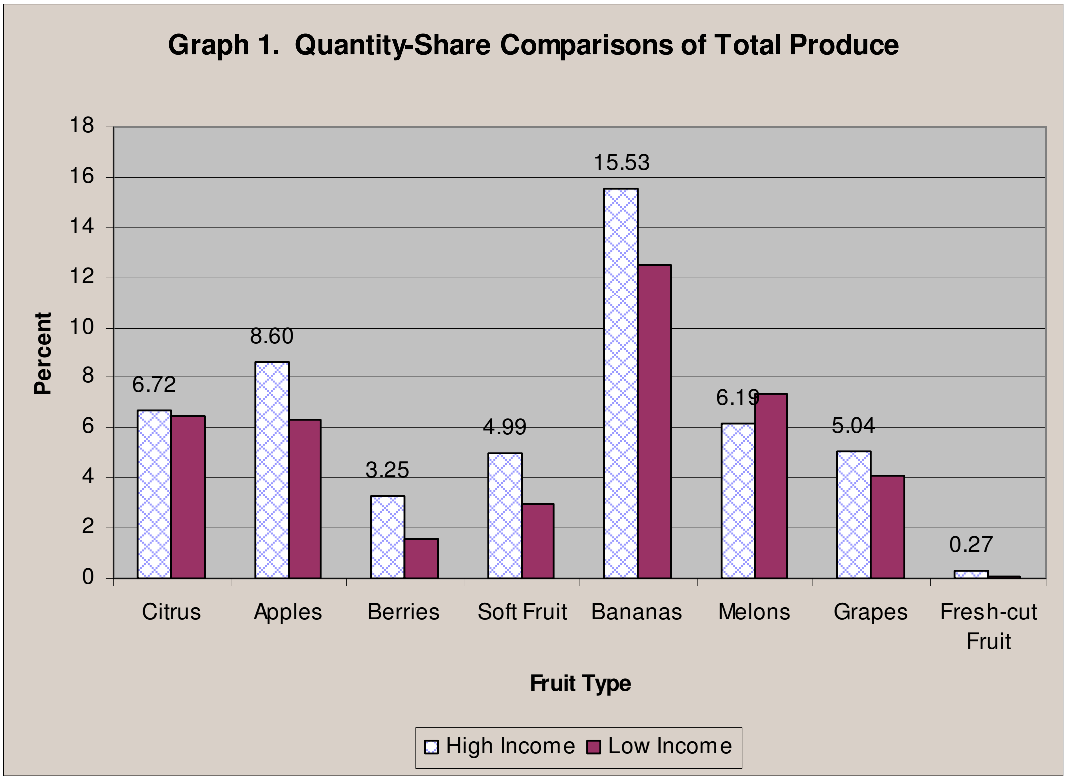
[a] Numbers in parentheses are t-ratios for the associated parameters.
[b] Indicates the price elasticity estimate for all stores.
[c] Indicates the difference between the price elasticity for lower income stores and all stores.
* Indicates statistical significance at the .01 level.
** Indicates statistical significance at the .10 level.

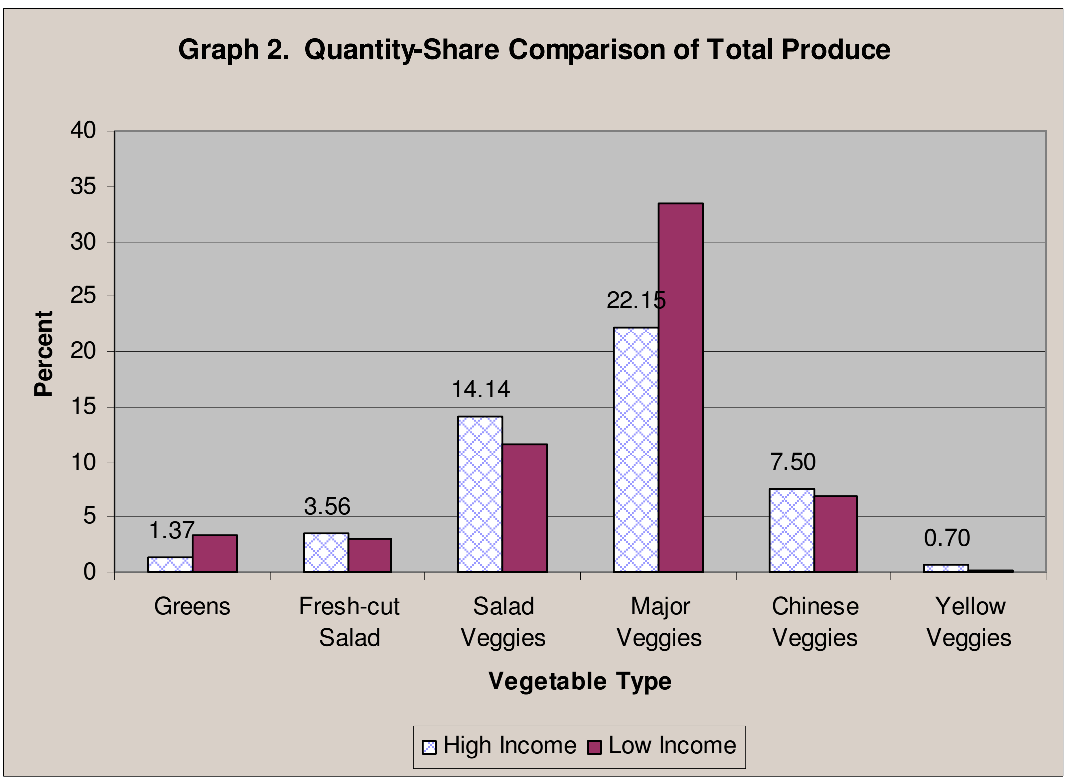
Table 3. (continued)

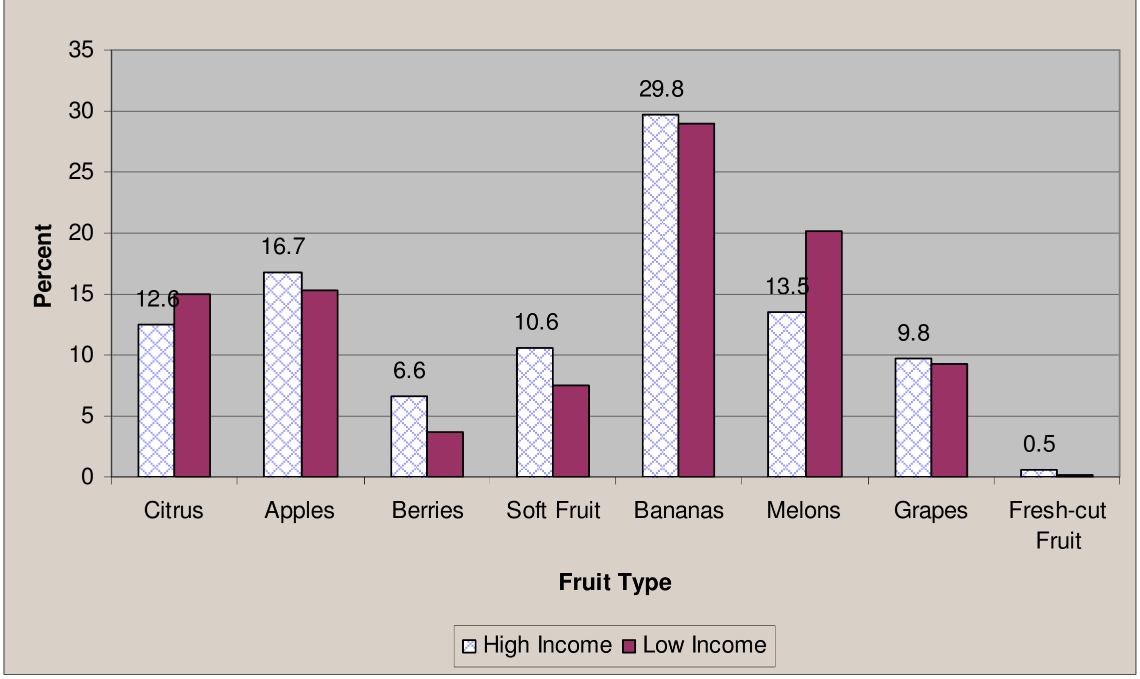
Dependent Variables[a]

	Chinese Vegetables		Yellow Vegetables	
Store Variables				
Store 2	-.443	(-7.169)*	-.625	(-6.647)*
Store 3	-.343	(-6.652)*	-.397	(-5.433)*
Store 4	-.884	(-3.566)*	-1.473	(-5.709)*
Store 5	-.741	(-2.904)*	-2.276**	(-8.097)*
Store 6	-.819	(-3.234)*	-1.725**	(-6.291)*
Other Variables				
Produce Sales	.839	(9.592)*	.703	(5.291)*
Quantity Lagged	-.033	(-2.995)*	-.024	(-1.385)
Constant	.561	(.480)	-.923	(-.552)
Price Variables				
Citrus A[b]	-.015	(-.362)	-.094	(-1.577)
Citrus B[c]	-----	-----	-----	-----
Apples A[b]	-.293	(-3.868)*	.109	(1.048)
Apples B[c]	-----	-----	-----	-----
Berries A[b]	-.009	(-.288)	.045	(.850)
Berries B[c]	-----	-----	-----	-----
Soft Fruit A[b]	-.085	(-1.719)**	-.004	(-.053)
Soft Fruit B[c]	-----	-----	-----	-----
Bananas A[b]	.089	(1.418)	-.013	(-.183)
Bananas B[c]	-----	-----	-----	-----
Melons A[b]	.015	(.503)	-.041	(-1.009)
Melons B[c]	-----	-----	-----	-----
Grapes A[b]	.053	(1.605)**	.007	(.154)
Grapes B[c]	-----	-----	-----	-----
Fresh-cut Fruit A[b]	-.042	(-1.365)	-.013	(-.192)
Fresh-cut Fruit B[c]	-----	-----	-----	-----
Greens A[b]	-.048	(-.908)	.009	(.144)
Greens B[c]	-----	-----	-----	-----
Fresh-cut Salad A[b]	.019	(.188)	.171	(1.364)
Fresh-cut Salad B[c]	-----	-----	-----	-----
Salad Vegetables A[b]	.191	(1.226)	.102	(.467)
Salad Vegetables B[c]	-----	-----	-----	-----
Major Vegetables A[b]	-.285	(-3.846)*	.330	(3.061)*
Major Vegetables B[c]	-----	-----	-----	-----
Chinese Vegetables A[b]	-.425	(-5.209)*	.182	(2.145)**
Chinese Vegetables B[c]	-.172	(-1.468)	-----	-----
Yellow Vegetables A[b]	-.097	(-1.954)**	-1.478	(-14.024)*
Yellow Vegetables B[c]	-----	-----	-.177	(-1.965)**

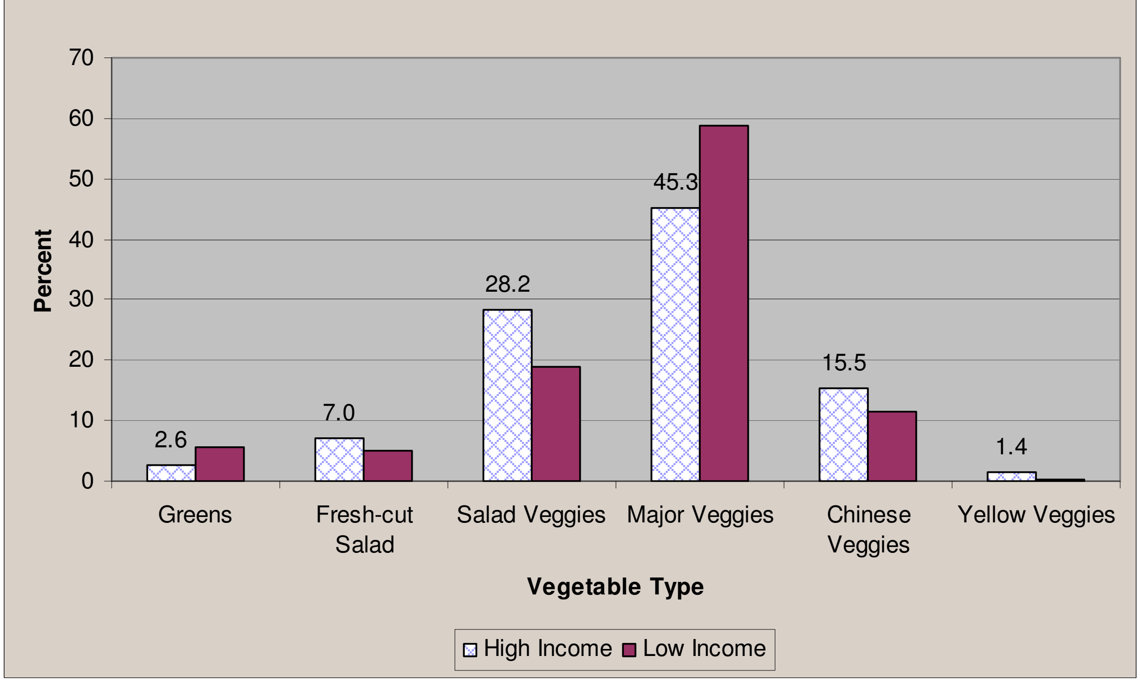
[a] Numbers in parentheses are t-ratios for the associated parameters.
[b] Indicates the price elasticity estimate for all stores.
[c] Indicates the difference between the price elasticity for lower income stores and all stores.
* Indicates statistical significance at the .01 level.
** Indicates statistical significance at the .10 level.


Graph 1. Quantity-Share Comparisons of Total Produce
Percent
18
16
14
12
10
8
6
4
2
0
6.72
8.60
3.25
4.99
15.53
6.19
5.04
0.27
Citrus
Apples
Berries
Soft Fruit
Bananas
Melons
Grapes
Fresh-cut Fruit
Fruit Type
High Income
Low Income

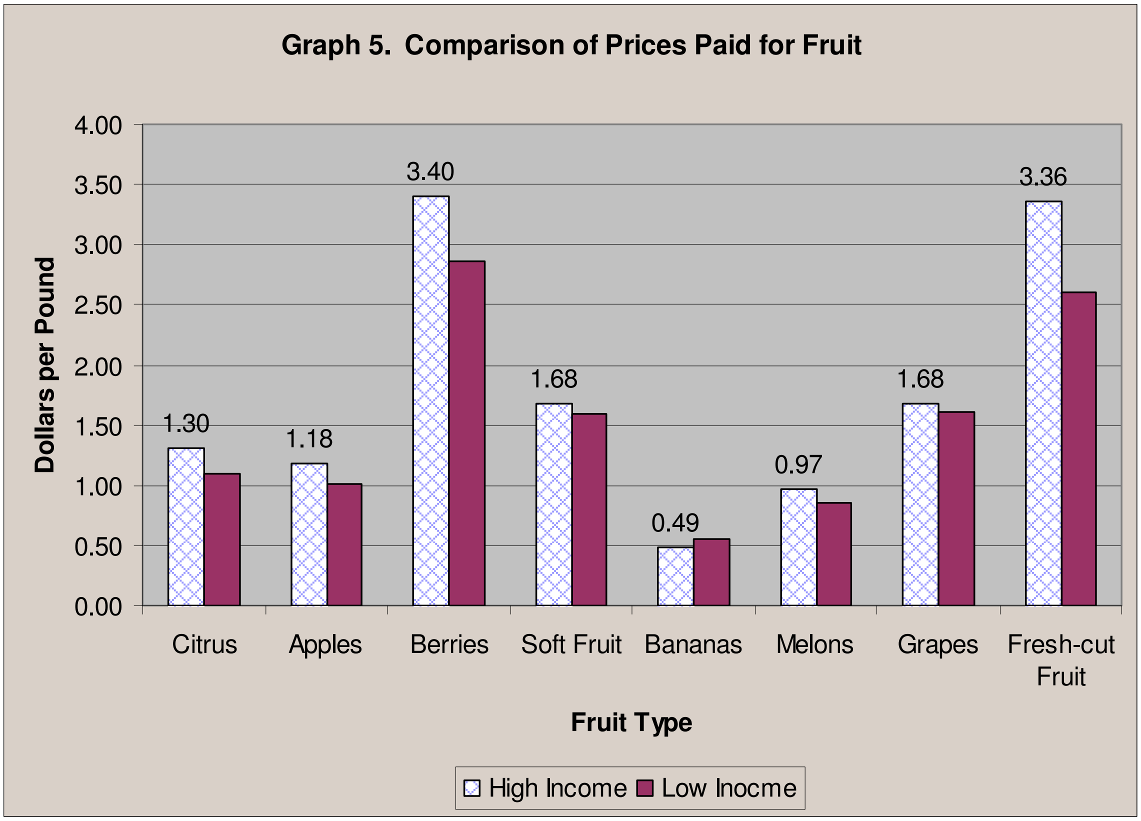

Graph 2. Quantity-Share Comparison of Total Produce
Percent
40
35
30
25
20
15
10
5
0
1.37
3.56
14.14
22.15
7.50
0.70
Greens
Fresh-cut Salad
Salad Veggies
Major Veggies
Chinese Veggies
Yellow Veggies
Vegetable Type
High Income
Low Income

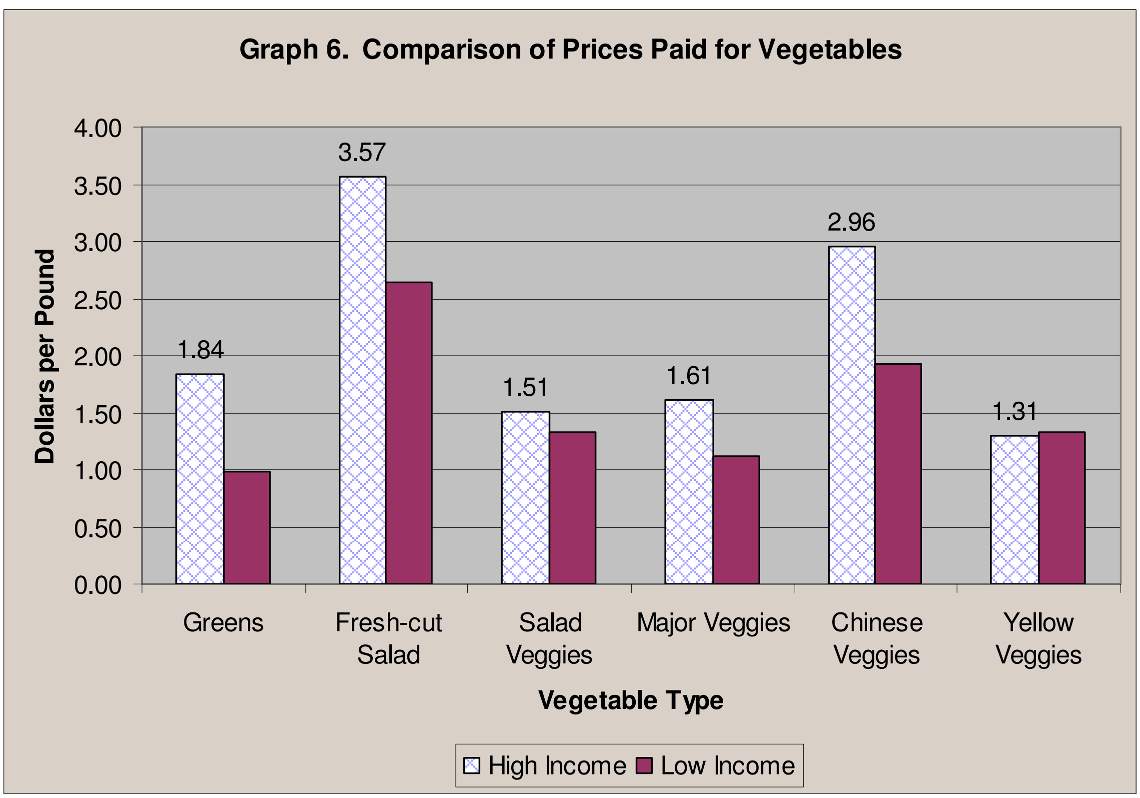


Graph 3. Quantity-Share Comparisons of Fruit



Graph 4. Quantity-Share Comparisons of Vegetables


Graph 5. Comparison of Prices Paid for Fruit
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Dollars per Pound
1.30
1.18
3.40
1.68
0.49
0.97
1.68
3.36
Citrus
Apples
Berries
Soft Fruit
Bananas
Melons
Grapes
Fresh-cut Fruit
Fruit Type
High Income
Low Inocme


Graph 6. Comparison of Prices Paid for Vegetables
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Dollars per Pound
1.84
3.57
1.51
1.61
2.96
1.31
Greens
Fresh-cut Salad
Salad Veggies
Major Veggies
Chinese Veggies
Yellow Veggies
Vegetable Type
High Income
Low Income

References

Balusu, Chandra. “Nutrient-dense Foods Key to Healthful Diet.” *Poughkeepsie Journal.com*, January 11, 2006.

Drewnowski, Adam and N. Darmon. “The Economics of Obesity: dietary Energy Density and Energy Cost.” *American Journal of Clinical Nutrition*, Vol. 82, pp. 265S-273S, 2005.

Drewnowski, Adam and S.E. Specter. “Poverty and Obestiy: The Role of Energy Density and Energy Costs.” *American Journal of Clinical Nutrition*, Vol. 79, pp. 6-16., 2004.

Guthrie, Joanne F., Claire Zizza and Nancy Raper. Fruit and Vegetables: Their Importance in the American Diet” Food Consumption, Vol. 15, 1. USDA, ERS, Jan.- June, 1992, pp. 35-39.

Jones, E., and B. W. Mustiful. "Purchasing Behavior of Higher- and Lower-Income Shoppers: A Look at Breakfast Cereals." *Applied Economics*, 28(1996): 131-137.

Liebtag, ES and PR Kaufman. “Exploring Food Purchase Behaviors of Low-income Housheolds.” *Current Issues in Economics of Food Markets*, AIB 747-07. Washington, DC: ERS/USDA, June 2003.

Min-Hsin Huang, Eugene Jones and David Hahn. “Determinants of Price Elasticities for Private Labels and National Brands of Cheese.” Forthcoming in *Applied Economics*, 2006.

Nestle, Marion and Michael F. Jacobson. “Halting the Opesity Epidemic: A Public Health Policy Approach.” *Public Health Reports*, Vol. 115, pp. 12-24, 2000.

Rolls, BJ, VH Castellanos and JC Halford. “Volume of Foods Consumed Affects Satiety in Men.” *American Journal of Clinical Nutrition*, Vol. 67, pp. 1170-1177, 1998.

Sisson, Aimee. “Fruit and Vegetable Consumption by Low-Income Americans.” *Nutritional Noteworthy*, Vol. 5, pp. 1-5, 2002.

Wilde, Parke E., Paul E. McNamara and Christine K. Ranney. “The Effect of Dietary Quality of Participation in the Food Stamp and WIC Programs.” USDA, Food and Nutrition Research Report Number 9, September 2000.