Price and Expenditure Elasticities for Vegetables in an Urban Food Desert[1]

Dave D. Weatherspoon

Assa S. Dembélé

Lorraine J. Weatherspoon

Marcus A. Coleman

James F. Oehmke[2]

Abstract

Food deserts are associated with lower quality diets and higher obesity rates. Vegetable consumption is key to a healthy diet, reduced obesity and improved health outcomes. Existing research provides little guidance for improving such food environments due to lack of adequate consumption data. This paper addresses this by estimating vegetable demand elasticities for a food-desert community in Detroit, relying on data from a natural experiment. Expenditure played a greater role in determining purchasing behavior than prices. Both elasticities were larger than the national average. Consequently, any policy that increases income or reduces prices could have a significant impact.

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[2] Drs. Weatherspoon are Professor and Associate Professor respectively, Ms. Dembélé, Mr. Coleman are graduate students, Mrs. Satimanon is a Ph.D. candidate, and Dr. Oehmke is Professor Emeritus, all from Michigan State University.

Introduction

A food desert is often described as a location where there are few to no supermarkets or other retailers that offer fresh fruits and vegetables (FFV) or other healthy food products (Moore and Diez Roux 2006; Morland et al. 2002). The lack of supermarkets is sometimes explained as the consequence of inadequate societal amenities including inadequate public safety services, unsatisfactory transport infrastructure, substandard local labor and other factors that raise the cost of operating a supermarket. A competing hypothesis is that retailers operating in food deserts do not offer healthy food choices because the local residents are on the lower end of the socio-economic scale and therefore do not have the money to buy healthy foods, do not have the education to understand the importance of healthy eating, and for cultural and other reasons prefer not to eat healthy foods. The food desert literature provides only limited testing of this competing hypothesis because of the lack of data on consumer purchases in food deserts. This paper helps to fill the gap in the literature by using a unique dataset to quantify inner-city Detroit, food-desert consumer preferences. The unique data come from register receipts from a non-profit food retail outlet (Peaches & Greens) in the Piety Hill community of Detroit that specializes in fresh produce and other healthy foods. This study is an extension of Weatherspoon et al. (2012) in which fresh fruit price and expenditure elasticities were estimated. In that paper expenditure elasticities were found to be positive and significant and the own price elasticities were negative and significant, indicating that food-desert consumers responded to economic factors in the same manner as the general population. The main difference between those findings and the general literature on consumer preference is that Weatherspoon et al. (2012) found that several fruits were luxury goods. This paper hypothesizes similar findings for vegetables in Detroit's food desert, and empirically tests this hypothesis.

Living in low-income neighborhoods, especially urban food deserts has been shown to be associated with poor dietary intake, decreased fruit and vegetable consumption and higher obesity rates (Larson, Story, and Nelson 2009; Turrell et al. 2002). Low availability and poor access to supermarkets in such areas are touted as primary reasons for the disproportionately high rates of overweight and obesity, and comorbidities among low-income populations and certain ethnic minorities in the United States (Morland et al. 2002). Furthermore, the literature establishes a link between vegetable prices and weight (Powell and Chaloupka 2009).

Residents of urban food deserts pay higher prices for lower quality foods (Cummins and Macintyre 2006). This makes food insecurity more prevalent and may negatively impact the consumption of fruits and vegetables (Seligman, Laraia, and Kushel 2010). This is of great concern because cost and availability of food may mediate the relationship between neighborhood environment and diet quality, and subsequently obesity.

Bodor et al. (2007) suggest that small neighborhood stores that sell fresh produce can help attenuate the severity of overweight and obesity among local residents in urban food deserts. In their study conducted in four different sites in the U.S., an increased consumption of fruits and vegetables was recorded when a small neighborhood store with healthy food options existed within 100 meters of the neighborhood. This notion is further strengthened by the findings of Rose and Richards (2004), who examined food store access and household fruit and vegetable consumption among individuals receiving food stamps. They showed an increased consumption of fruits and similar trend with vegetables among individuals who traveled only one versus five miles to reach a store. Overweight and obesity problems in low-income populations are not limited to adults, but are also a growing problem among children and adolescents. In a study of middle school students, African American youth were more likely to consume foods of low nutrient density, and less likely to eat fruits and vegetables (F&V) (Fahlman et al. 2010).

Weatherspoon et al. (2012) state that part of the issue is the lack of understanding of urban food desert consumers by retailers of all size and organizational structure. There has been a dearth of economic analysis of the consumer history, trends, and limitations that would assist retailers in tailoring their formats to enhance the offerings of healthy food items in these areas. There are two primary reasons why this is the case. First, since no supermarket chains are located in these areas, scanner data either does not exist or is not available. Second, in most states, electronic benefits card (EBT) card expenditures are not publically available for consumer demand analysis. Hence, there are few sales data opportunities to analyze the consumption behavior of these residents. Without data, determining where to locate and the appropriate product mix for retailer offerings is difficult to determine.

The specific objective of this paper is to determine the expenditure-, own- and cross-price elasticities of vegetables sold in one of Detroit's food deserts. The next section will put the Detroit food desert setting in perspective. It is followed by the data and methods sections. The results and conclusions are presented last.

Detroit's Food Desert in Perspective

Detroit is a salient example of an urban food desert - arguably America's oldest and largest. With a population of 713,777 (82.7% African-American) in 2010 (U.S. Census Bureau 2011), it is estimated that one-half of the Detroit's residents live in a food desert (Gray 2008). The city is characterized by a large income disparity with a Gini coefficient of 0.488 ±

0.01 (U.S. Census Bureau 2011) and a median household income of $28,357 (2006-2010) as compared to the state of Michigan at $48,432 (U.S. Census Bureau 2011). Over 34% of Detroit's population lives below the poverty level (U.S. Census Bureau 2011).

Detroit has an unemployment rate of 22.7%, which is one of the highest in the U.S. (Michigan Department of Technology, Management and Budget 2010) and in 2008, Forbes magazine ranked the city among the top 10 fastest dying cities in America (Zumbrun 2008). Detroit has also been characterized as America's fifth most obese city (Centers for Disease Control 2010; Ruiz 2007).

Detroit has no full-service supermarket chains operating within its bounds. The last full-service market (Farmer Jack, an A&P subsidiary) closed in 2007 (Smith and Hurst 2007; Duggan 2010). Therefore, many inner-city Detroit consumers shop at non-mainstream grocery outlets, such as convenience and liquor stores. M. Gallagher (2007) estimates that in 2007 fringe retailers, such as gas stations, liquor stores, party stores, dollar stores, bakeries, pharmacies, and convenience stores offering a limited, if any, choice of nutritious foods, comprised 92% of Detroit's food stamp retailers. Neal (2006) classifies Detroit as a McCulture desert - an area with few, highly standardized fast food establishments (and has no other regional or national food chains). Neal (2006) also notes Detroit's uniqueness as a food desert location given that the city is highly urbanized.

Detroit's inadequate public transportation system exacerbates its food access problems - a light rail train only covers only the downtown area and a limited number of bus routes links the center to the more affluent suburban food oases. Each shopping trip provides an inconvenience to the consumer, as it requires walking to and from a bus stop, transferring and carrying bags. Travel distances in Detroit are large due to the city's vast expanse of 139 square miles which once supported a population over 2 million. Today, the city is marked by 40 square miles of vacant/abandoned land, which is equivalent to the size of San Francisco (J. Gallagher 2009). The lack of adequate transportation is especially problematic given Detroit's high proportion of disabled persons - 19.5% as compared to the 11.9% found in the rest of the U.S. (U.S. Census Bureau 2011) - as this population is more likely to have difficulty grocery shopping, especially if major travelling is required.

The study area, Piety Hill, is a 92% African-American, inner-city Detroit neighborhood, roughly bounded by John C. Lodge Freeway, Clairmount Street, Woodward Avenue and Euclid Street (see Figure 1). The approximately 2,300 residents span all ages, from young singles to families to senior citizens. Piety Hill's mean income is lower than 96% of US neighborhoods; its childhood poverty rate of 38% which is higher than 90% of US neighborhoods (NeighborhoodScout.com). A more micro custom report (MAPAS) for the ¼ mile radius circle centered in the neighborhood revealed a poverty rate that exceeds 60% for the 18-64 year age group. Only 20% of the population holds an Associate's degree or higher and 27% of the population neither finished high school nor obtained a General Equivalency Diploma (MAPAS). Reported violent crime rates are three times the Detroit and over 11 times the national average (NeighborhoodScout.com). Prior to the introduction of Peaches & Greens (P&G) in 2009, the neighborhood's single food retail outlet was a windowless, gated corner store with a single sign that advertised liquor, beer-wine and lotto tickets. From the study site it takes 56 minutes by bus to reach a full service supermarket, according to Google Maps, where 49% of households do not own a car (NeighborhoodScout.com).

Data

The natural experiment consisting of the opening of a nonprofit green grocer, P&G, in the former severe food desert of Piety Hill provided the opportunity to explore food desert residents' consumption behavior. Sales receipts were provided from July 2009 to November 2011. The data included quantity, price, date, time and transaction number for 13 vegetables[1]. During this time, the store was open 123 calendar weeks or 570 days, and made a weekly average revenue from FFV of $ 187. On average, 109 transactions at $2 each were carried out each week. Average weekly sales figures of FFV by month are presented in

Table 1. These figures suggest that Piety Hill residents are indeed taking advantage of P&G FFV offerings. The table also shows that vegetable sales make up only 19% of total FFV sales. In other words for every vegetable that is purchased approximately 4.3 fruit are purchased. Apart from preferences, we hypothesize that this is related to storage and preparation issues facing residents without cooking or refrigeration facilities. In a companion survey, 48% of interviewees stated that their inability to cook or store as the major

impediment to FFV consumption (Coleman et al. 2011). This seems to be corroborated by the fact that top selling vegetables are all easy to consume and require no cooking or preparation.

Table 2 provides weekly average quantities sold and average prices for the individual vegetables. The most frequently sold vegetables were tomatoes (113 weeks), peppers (100 weeks), and lettuce (95 weeks) at average prices of $0.76/tomato, $0.55/pepper, and $1.17/ head of lettuce. The average quantities in which they were sold are 1.97 tomatoes, 1.64 peppers and 1.05 heads of lettuce.

During the data collection period, the Fair Food Network (fairfoodnetwork.org) managed a program, in which P&G participated, called "Double up Food Bucks". Double up Food Bucks participation was simple:

1. Visit the Bridge Card (EBT) booth at their market.
2. Participant would then receive an equivalent amount, up to $20, of Double Up Food Bucks tokens.
3. Participants must spend their tokens on Michigan-grown FFV at that market.

This program ran from September – October, 2009; August-October, 2010; and June to October 2011. Participating in this program essentially reduced the price of Michigan FFV by half. Consequently, total FFV sales doubled during this period. The effects of the program can be clearly seen in Figure 2. It was strong for FFV as a whole but minor and statistically insignificant for FV alone[2]. The reasons for the insignificance for vegetables most likely the storage and preparation issues detailed above. During the time the program was in place in 2011, transactions increased by nearly 30% and the average spend per transaction by 18%, compared to the same weeks in the previous year. This finding reaffirms Gustavsen and Rickertsen's (2006) conclusion that income support could play an important, but limited, role in increasing the vegetable consumption of low-income consumers.

Overall, the sales numbers from P&G show that food desert consumers will indeed consume FV if offered a quality product at normal and definitely below normal prices. This is consistent with the results of Wrigley, Warm and Margetts (2003), who also found increased F&V consumption in a previously underserved neighborhood in the United Kingdom after the introduction of a new food retailer.

Method of Analysis: Rotterdam Model

The Rotterdam Model was first developed and applied to consumer demand problems in the mid to late 1960s (Barten 1964; Barten 1968; Barten 1977; Theil 1965; Theil 1975; Theil 1976). This model has been widely applied to consumer demand studies. The advantages of the Rotterdam Model over other approaches such as the translog and AIDS models are its direct derivation from economic theory and ease of estimation (it can be estimated in a linearized form) and interpretation. Furthermore, theoretical restrictions are easily imposed and by first differencing the variables, unit roots can be eliminated.

This study utilizes a system wide Rotterdam approach and is estimated in the absolute price form (Theil 1980). It relies on multistage budgeting under the assumption of block independence (Theil 1976; Theil 1980) or weak separability (Barten 1977). Under block independence it is assumed that consumers allocate income independently among broad groups of goods, which are taken to be additively separable. Accordingly, the consumers' utility functions are also additive in groups S_g, $g = 1,...,n$. The demand for good i in group

S_g can then be derived conditionally on the demand for the group. In the final stage expenditure on the group is taken to be predetermined and the goods are not assumed to be separable within the group, so that cross-price elasticities are relevant. For example consumers allocate income among food, transportation, education, and etc. (stage 1), and within the food group, in turn, among FFV, meat, and other foods (stage 2). In stage 3 the predetermined expenditure on the vegetables group is allocated among individual vegetables, such as lettuce and cucumbers.

The Rotterdam Model is usually applied as a differentiated system of equations to address non-stationarity. The conditional demand equation for vegetables can be written as follows (time subscripts are suppressed):

$$(1)\quad w_i \log q_i = \theta_i \log Q + \sum_j \pi_{ij} \log p_j \ ,$$

Where $i, j \in \{1,...,N\}$ are indexes of fresh vegetable (FV) products; $w_i = p_i q_i / x$ is the expenditure share for product i; $x = \sum_i p_i q_i$ is (nominal) expenditure; $q_i = (q_i, \ldots, q_N)$ is a vector of product quantities demanded; θ_i is the expenditure parameter relating increases in FV expenditure to purchases of FV product i, $\log Q = \sum_i w_i \log q_i$ is the Divisia quantity index[3]; π_{ij} is the (conditional) Slutsky price parameter measuring the effect of price j on purchases of product i; and $p_i = (p_1, \ldots, p_N)$ is a vector of retail prices. Expenditure and price parameters θ_i and π_{ij} are assumed to be constant.

The theoretical demand restrictions in the Rotterdam model are as follows (Mountain 1988):

Homogeneity $\sum_j \pi_{ij} = 0$,

Symmetry $\pi_{ij} = \pi_{ji}$

Adding-up $\sum_i \pi_{ij} = 0$ and $\sum_i \theta_i = 1$.

The conditional average expenditure elasticity is calculated as $\eta_i = \theta_i / w_i$. The conditional average Slutsky (compensated) price elasticities (s_{ij}) are calculated as: $s_{ij} = \pi_{ij} / w_i$. Conditional average Cournot (uncompensated) elasticities are calculated as: $\varepsilon_{ij} = \pi_{ij} / w_i - (\theta_i / w_i) * w_j$. All elasticities are calculated at sample means.

To operationalize the model, the data were aggregated by calendar week in order to minimize the number of zeros due to non-expenditures on specific vegetables during a given transaction. The weekly aggregate q, p and Q were divided by the number of transactions for that week so that the estimation was based on the weekly average consumer. This resulted in a data set with T=121 weekly observations. The model was then estimated for the 3 most frequently sold vegetables (tomatoes, peppers and lettuce)[4] in a 4-equation system (the fourth equation being other vegetables). The fourth equation was dropped for estimation purposes to avoid singularity of the error covariance matrix (Barnett 1979; Barten 1969). The parameters for the fourth equation were recovered using the theoretical demand restrictions listed above. The actual number of observations for the operationalized model was 62 due to differencing and the absence of purchases of either tomatoes, peppers or lettuce in some weeks. The model was estimated in STATA with nonlinear seemingly unrelated regression (nlsur), which converges to maximum likelihood under the iterated feasible generalized nonlinear least squares (ifgnls) option (Poi 2008) (www.stata.com).

Results

Model Performance

The model was estimated for the three most frequently sold vegetables (tomato, pepper and lettuce) and all other vegetables. The homogeneity and symmetry conditions were tested for following Seale, Sparks and Buxton (1992) and could both not be rejected. Therefore, homogeneity and symmetry were imposed in addition to adding-up, leading to 53 degrees of freedom. The log likelihood value of this model was 375.44. A Wald test was performed to test the significance of the model. The joint hypothesis of all parameters being equal to zero could be rejected at the 0% level (chi2(9) = 290.36). The system-wide R^2 (Schmitz and Seale 2002; Seale Jr, Sparks, and Buxton 1992) was 0.65. In accord with economic theory, the own price parameters were all negative and significant (with the exception of “other vegetables”, which was not significant), and the expenditure parameters were positive and significant. Overall, 10 of the 14 estimated parameters were statistically significant.

Expenditure Parameters and Elasticities

The (conditional) expenditure parameters are reported in column 6 of table 3. All estimated expenditure parameters were positive, indicating normal goods (Theil 1980). Both the expenditure parameters and elasticities for tomatoes and other vegetables were statistically significant at the zero percent level, for pepper and lettuce at the 0.1% level. In all cases, the expenditure elasticity was greater than ½; for tomatoes and pepper it was greater than one (1.59 and 1.46 respectively), indicating luxury goods (Theil 1980); for lettuce it was 0.63 and for other vegetables 0.71, suggesting an inelastic demand response in both cases. Hence, income plays an important role in the purchasing decision for all vegetables offered. While the lettuce expenditure elasticity equals the one found by You, Epperson and Huang (1996), the tomato and pepper elasticities are significantly larger: while they are in the inelastic range for the average American, they are elastic for Piety Hill consumers.

Price Parameters and Elasticities

The conditional Slutsky price parameters are reported in columns 2-5 of Table 3. All estimated own price parameters were negative, as expected. Tomato, pepper and lettuce own price parameters and elasticities were significant at the zero percent level, own price of all other vegetables was not significant.

Two types of elasticities can be calculated from Slutsky parameters: Slutsky and Cournot elasticities. Slutsky (compensated) elasticities represent pure substitution effects while Cournot (uncompensated) elasticities comprise both income and substitution effects (Frisch 1959). They are reported in Table 4 and were calculated at the sample mean. Tomato, pepper and lettuce own price Slutsky elasticities were negative and statistically significant at the zero percent level. A 1% decrease in own price would lead to 0.42% increase in tomato consumption, a 0.73% increase in pepper consumption and a 0.57% increase in lettuce consumption. All elasticities are in the inelastic range. The Slutsky own price elasticity for all other vegetables was very small and not statistically significant, indicating that their own price is not important in the purchasing decision.

Cournot own price elasticities (Table 4) were negative and significant at the zero percent level for all vegetables. Since the Cournot own price elasticity includes real income effects it was markedly larger, in absolute terms, than the respective Slutsky elasticity for all vegetables. This underlines the importance of income in this community. However, all elasticities still remained in the inelastic range indicating a less than proportional demand response. Specifically, if their own price decreased, tomato consumption would increase by 0.81%, pepper consumption by 0.88%, lettuce consumption by 0.63% and consumption of all other vegetables would increase by 0.42%. These own price responses were in the same order of magnitude as the ones found by You Epperson and Hunag (1998; 1996), however, while they were still in the inelastic range, they were much larger for Detroit food desert residents. This means that, with respect to the vegetable group, food desert consumers are much more price sensitive than the average American.

Slutsky cross-price parameters (Table 3) characterize cross-relationships between goods. The tomato-pepper, tomato-lettuce and pepper-lettuce relationships were positive and significant at the zero, one and 5% levels, respectively, meaning that these goods are net substitutes. The according Slutsky cross prices elasticities are reported in Table 4. Nine Cournot cross price elasticities (Table 4) were significant. The tomato-lettuce (α=0.1) cross price elasticity was negative and significant, indicating a gross complementary relationship. The pepper-tomato and lettuce-pepper combinations were both positive and significant at the 10% level, suggesting gross substitutes. Other vegetables were found to be gross complements for tomatoes, peppers and lettuce ($\alpha \leq 0.05$).

Conclusions

The present study on food desert residents' consumption behavior is unique in that it was able to use retail-level data from a natural experiment in Detroit for the estimation of expenditure and price elasticities for vegetables in a low-income, minority, urban population.

The sales figures showed that food desert consumers did indeed purchase FV when they were offered at normal to low prices and good quality. This is consistent with findings from a similar natural experiment in the United Kingdom (Wrigley, Warm, and Margetts 2003). FFV sales and both the number of transactions and the average spend on FFV per transaction increased markedly when the "Double up Food Bucks" program was in place. This corroborates the findings of Gustavsen and Rickertsen (2006). who suggest that income support could increase vegetable consumption among low income populations in Canada. However, there is an indication that food storage and preparation issues may limit FV consumption significantly. This is corroborated by the fact that the "Double up" program had little effect on vegetable purchases alone.

All expenditure elasticities were found to be positive and statistically significant, while the own price elasticities were negative and significant. These findings are consistent with prior research (You, Epperson, and Huang 1996; You, Epperson, and Huang 1998). Similarly to the results found for fresh fruits in Weatherspooon et al. (2012) Detroit food desert residents have the same basic preferences as average American consumers, but with greater emphasis, especially with respect to income. As income increased by 1%, expenditures increased by more than 1% for tomatoes and peppers, implying that these are luxury goods within the vegetable group in this community. The food desert residents were also found to be more price responsive for all vegetables.

This result has major policy implications for urban food desert areas: if total vegetable costs[5] are lowered for these consumers, they will purchase them at a much higher rate than they currently do. Since higher vegetable consumption is linked to lower obesity and overall risks, this result also has implications for addressing the obesity crisis in inner cities. Policy reform for the reduction of obesity in food deserts must first and foremost address the transactions costs to attaining a basket of vegetables and the exorbitant retail prices for them in most food deserts. However, other issues limiting consumption need to be taken into account.

Improving access to normally priced vegetables of good quality may not be that difficult. The opening of P&G in Piety Hill effectively reduced both the local retail price and the overall cost of vegetables, by lowering the transaction costs for residents with previously latent demand. Thus increasing the number of retailers that offer vegetables in such areas may reduce prices and thereby increase consumption. As these food desert residents were shown to have similar preferences as the average American, indeed consumed FFV when offered and were shown to be more price responsive than the average consumer these products may in fact provide a profit opportunity in this and similar locations. However, when designing retail strategies caution is necessary: introducing large stores could have an adverse effect on healthy food access by forcing existing stores out of business. Clarke, Eyre and Guy (2002) found that in locations of low mobility, such as Detroit, opening a number of smaller stores may be more conducive.

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[1] P&G also sells fruit and miscellaneous groceries such as eggs, but these were not inlcuded in the analysis.

[2] Because the effect of this program on vegetable consumption was statistically insignificant it was not included in the econometric analysis. The notable difference in sales stems from strongly increased fruit purchases during the times the program was in place.

[3] The Divisia quantity index can also be interpreted as the logarithmic change in money income deflated by the price index as derived by (Theil 1980).

[4] Each of these vegetables was purchased in over 93%, 82% and 78% of the data weeks, respectively.

[5] By definition, food deserts present higher access costs than non-food desert locations. This, coupled with the argument that the quality of FV sold in these areas is usually poor, results in the true costs for fresh produce in these areas being much higher for an average quality vegetable.

Figure 1. Map of Detroit and the study area

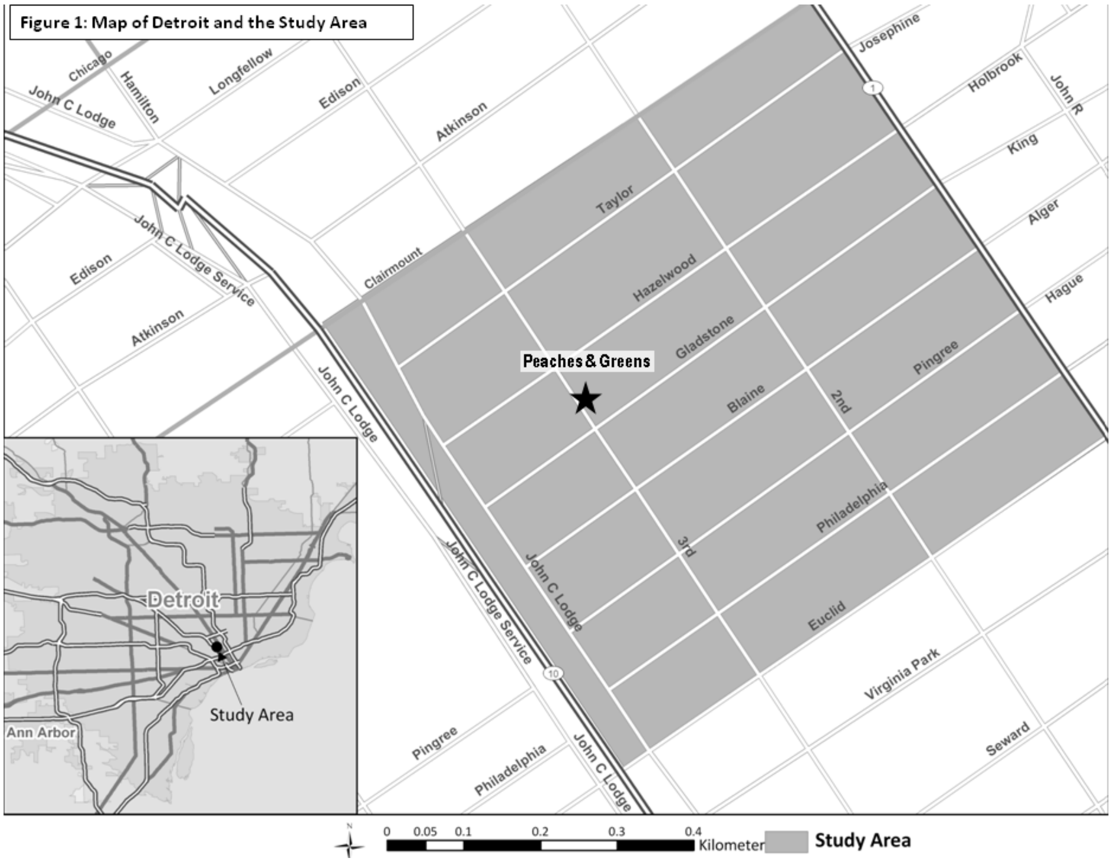

Table 1. Average weekly revenue, number of units sold and number of transactions, 2009-2011

Month	Ave. weekly revenue			Ave. # of units sold/week			Ave. # of transactions/ week	Average Spend/ Transaction
	FFV	Fruits	Veg.	FFV	Fruits	Veg.		
07/09	283.38	253.77	29.61	354.97	305.06	39.13	102.50	3.38
08/09	359.27	312.42	46.85	511.79	424.91	69.38	136.00	3.11
09/09	281.70	240.31	41.39	416.44	342.94	64.22	112.40	2.76
10/09	227.10	188.60	38.50	357.33	295.35	49.81	91.75	2.90
11/09	253.72	170.48	83.24	446.45	290.44	136.55	118.00	2.53
12/09	162.18	102.84	59.34	284.37	185.73	88.57	61.25	2.82
01/10	113.07	77.51	35.56	231.79	166.75	55.92	60.50	2.30
02/10	97.17	73.81	23.36	197.76	150.56	39.74	55.25	2.27
03/10	136.61	101.18	35.44	245.55	189.86	46.04	82.20	2.11
04/10	112.34	88.61	23.73	192.05	154.88	28.86	71.75	1.67
05/10	176.84	146.27	30.57	306.95	253.93	40.72	126.25	1.72
06/10	191.32	154.38	36.95	269.35	219.91	42.13	158.75	1.58
07/10	184.35	162.77	21.58	278.23	238.26	31.25	187.50	1.52
08/10	207.00	181.03	25.97	261.32	219.46	34.00	167.60	1.64
09/10	202.07	167.16	34.91	270.67	225.34	39.75	120.75	1.97
10/10	164.40	136.37	28.04	231.77	196.63	28.75	93.50	2.32
11/10	86.41	72.05	14.36	119.37	99.49	18.00	55.40	1.94
12/10	53.77	42.10	11.67	116.81	100.00	14.00	38.25	1.81
01/11	58.24	37.38	20.86	74.25	44.74	26.00	44.33	1.95
02/11	93.70	80.69	13.01	88.48	68.75	17.50	51.50	2.60
03/11	78.80	66.08	12.72	64.75	42.50	20.74	57.00	1.98
04/11	100.46	85.25	15.21	98.25	72.02	23.40	73.60	2.02
05/11	136.19	101.44	34.76	175.56	119.54	49.50	98.00	2.17
06/11	220.65	201.89	18.76	242.19	213.19	24.80	178.00	1.93
07/11	353.75	290.44	63.31	504.07	413.00	86.81	235.25	2.10
08/11	312.64	257.89	54.75	514.49	443.39	67.30	175.80	2.13
09/11	318.00	258.15	59.85	492.58	405.50	86.64	161.20	2.36
10/11	283.10	189.44	93.66	439.74	327.98	114.33	138.00	2.45
11/11	128.83	89.39	39.43	212.88	171.44	44.24	79.80	2.32
Mean	**187.49**	**151.87**	**35.62**	**278.83**	**223.73**	**48.61**	**109.39**	**2.18**

Figure 2. Weekly FFV revenue in $

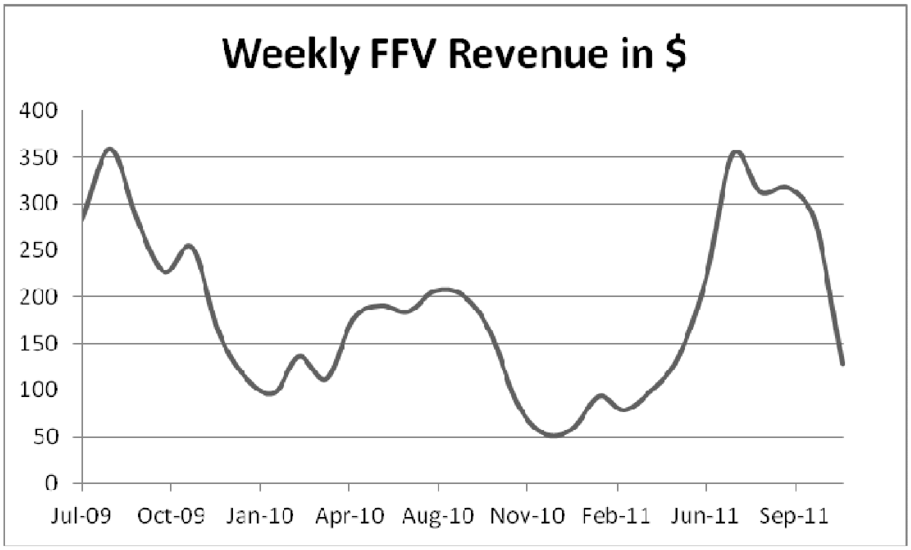

Table 2. Weekly vegetable purchases

Variable	# Weeks sold	Price/Qty	Mean	Std. Dev.	Min	Max
Tomato	113	**P**	0.76			
		Q	1.97	0.98	0.91	8
Pepper	100	**P**	0.55			
		Q	1.64	0.72	1	6
Lettuce	95	**P**	1.18			
		Q	1.05	0.22	1	2.76
Garlic	83	**P**	0.33			
		Q	2.13	0.77	1	3
Carrot	73	**P**	1.37			
		Q	1.00	0	1	1
Cucumber	66	**P**	0.50			
		Q	1.65	0.34	1	2.6
Sweet potato	61	**P**	0.77			
		Q	2.30	1.00	1	4.92
Cabbage	53	**P**	0.54			
		Q	3.13	2.01	1	7.84
Celery	30	**P**	1.27			
		Q	1.04	0.09	1	1.33
Corn	26	**P**	0.34			
		Q	4.13	0.97	3	6
Onion	22	**P**	0.47			
		Q	3.01	0.05	3	3.22
Collard greens	19	**P**	0.42			
		Q	2.67	1.72	0.99	7
Spinach	7	**P**	1.99			

		Q	1.30	0.37	1	2

Table 3. Parameter estimates, homogeneity, adding up and symmetry imposed

	Conditional Slutsky Coefficients π_{ij}				**Expenditure Coefficients**
Vegetables (1)	**Tomato (2)**	**Pepper (3)**	**Lettuce (4)**	**Other (5)**	**θ_i (6)**
Tomato	**-0.1030231*** **	**0.0621414*** **	**0.0206802*** **	0.0202014	**0.3946048*** **
	(0.0177439)	(0.0131901)	(0.006101)	(0.0154237)	(-0.0536071)
Pepper		**-0.0777408*** **	**0.0254212** **	-0.0098218	**0.1569389*** **
		(0.018547)	(0.0103774)	(0.01446)	(0.0463753)
Lettuce			**-0.0532113*** **	0.0071099	**0.0585738*** **
			(0.01171)	(0.005956)	(0.0180086)
Other				-0.0174896	**0.3898825*** **
				(0.0201996)	(0.0561827)

Standard errors are reported in parentheses, ***p<0.01, **p<0.05, *p<0.1

Table 4. Conditional Slutsky (compensated), Cournot (uncompensated) and expenditure elasticities

	Cournot Price Elasticities ε_{ij}				**Expenditure Elasticity**
Vegetables (1)	**Tomato (2)**	**pepper (3)**	**Lettuce (4)**	**other (5)**	**η_{ij} (7)**
Tomato	**-0.8105876*** **	0.0800713	**-0.0643558***	**-0.7984482*** **	**1.59332*** **
	(0.0592147)	(0.0634467)	(0.0331969)	(0.1559213)	(0.2164527)
Pepper	**0.2170576***	**-0.881976*** **	0.1012605	**-0.9000071*** **	**1.463665*** **
	(0.1156572)	(0.1878619)	(0.1061864)	(0.2939296)	(0.4325112)
Lettuce	0.0665286	**0.206261***	**-0.6319806*** **	**-0.2720019** **	**0.6311929*** **
	(0.0530575)	(0.1134113)	(0.1309626)	(0.1383276)	(0.1940613)
Other	**-0.1382498*** **	**-0.0934722*** **	**-0.052634*** **	**-0.4215484*** **	**0.7059045*** **
	(-0.1382498)	(0.0285323)	(0.0145899)	(0.0770017)	(0.101722)
	Slutsky Price Elasticities s_{ij}				
Tomato	**-0.4159828*** **	**0.2509123*** **	**0.0835019*** **	0.0815686	
	(0.0716458)	(0.0532586)	(0.0246346)	(0.0622773)	
Pepper	**0.5795516*** **	**-0.7250371*** **	**0.2370864***	-0.091601	
	(0.1230156)	(0.1729759)	(0.096783)	(0.1348584)	
Lettuce	**0.2228511*** **	**0.2739396***	**-0.5734069*** **	0.0766162	
	(0.0657451)	(0.1118272)	(0.1261874)	(0.064182)	
Other	0.0365758	-0.0177828	0.0128728	-0.0316658	
	(0.0279255)	(0.0261806)	(0.0107837)	(0.0365726)	

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